THE CARNEGIE ATLAS OF GALAXIES

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Volume II

by

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Codes used in the short tables accompanying the illustrations throughout the atlas are summarized on pages 8—9. Notations employed ***in*** *the classifications of galaxy type are treated in chapter 3 (e.g.. pp. 14, 18).*

The endpapers depict the several telescopes where most of the images ***printed*** *in this atlas were obtained. At the front of Volume I are vieivs of the 100-inch Hooker Telescope, Mount Wilson Observatory, California. At the back of Volume I are scenes showing the 60-inch telescope at Mount Wilson. (The solar toiver telescopes are also seen in the outdoors print.) Shoivn at the front of Volume 11 is the 200-inch Hale Telescope at the Palomar Observatory, California. At the back of Volume 11 are scenes at the Carnegie Institution's Las Campanas Observatory: close vieivs are provided of the 2.5-meter du Pont Telescope and the 1.0-meter Sivope Telescope.*

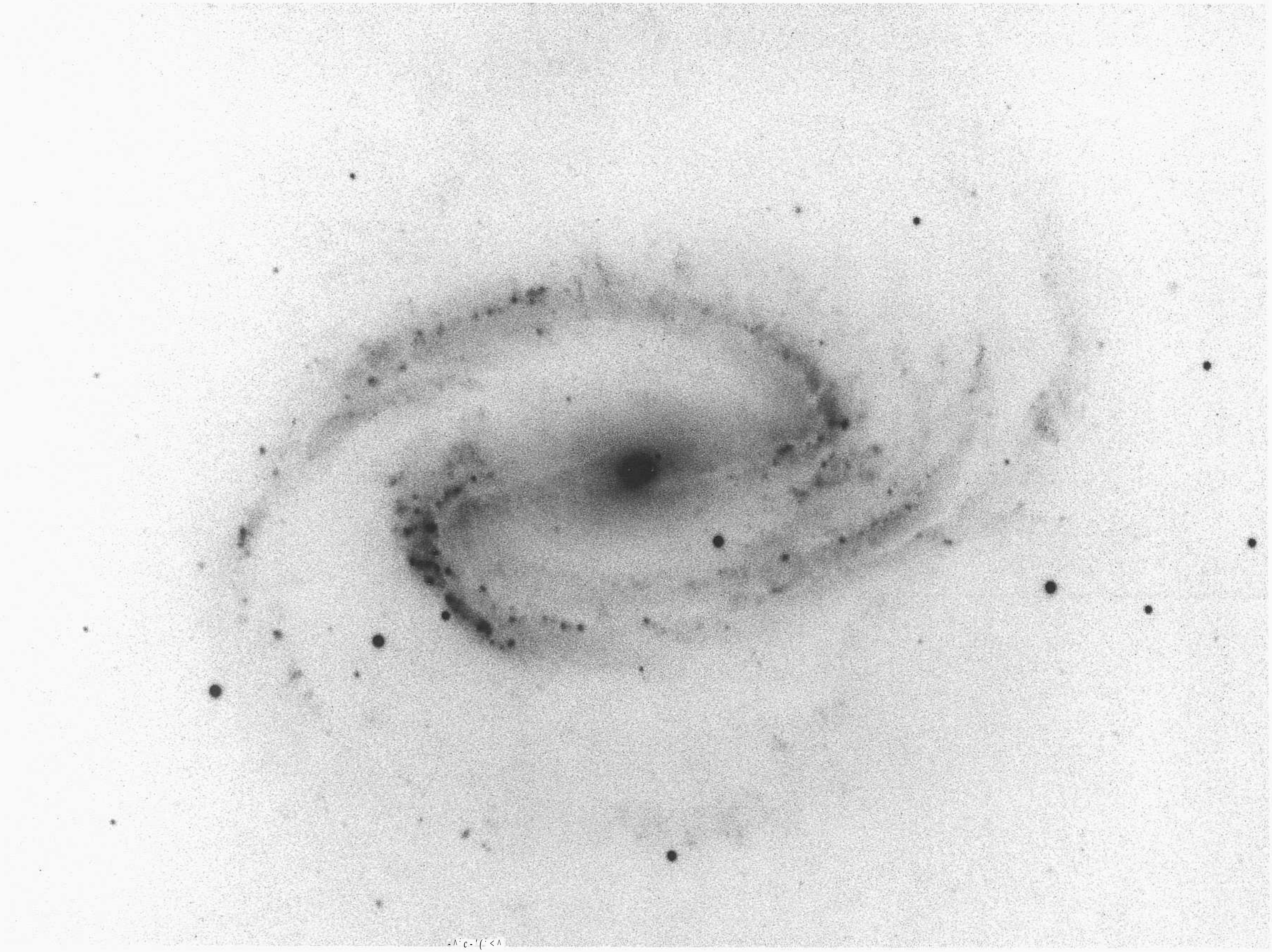
The galaxy shown on the cover of Volume 1 is ***NQC*** *5746. Depicted on the cover of Volume II is NGC 2997.*

This second (1996) printing of the atlas is identical to the first printing except for a small number of incidental corrections.

CHAPTER 5 (continued)

THE ATLAS

PANEL
154



The SBb Classification Section

NGC 1300 **SBb(s)L2** **HA, p. 45**
PH-75-H **panel** S8
Oct 14/15, 1950
103aO
30 **min**

NGC 1300 is the prototype **for the** spiral pattern where the arms spring from the ends of the bar. Most galaxies **of this** spiral-arm subclass (s) have **grand** design arms rather **than a filamentary,** multiple-armed MAS pattern where **the** arms generally begin tangent to an almost-complete ring (which defines the (r) subclass). The arms in NGC 1300 are tightly wound **but** not as tightly as in NGC 3185 (Sa; panel 99) where **they** nearly overlap after each arm unwinds by half a revolution to form an almost-complete inner ring.

SBb(s) galaxies like NGC 1300 have several distinctive features characteristic of the class. (1) The bar is well formed and prominent. (2) In most SBb(s) types two *straight* dust lanes exist within the bar, each on the outside of the otherwise smooth bar: the lanes **are** on symmetrically opposite sides of the central amorphous center. In every case, the dust lanes *are on the sides of the bar that lead the rotation,* the direction of the **rotation** being judged from the sense of the spiral pattern. (3) Recent star formation is generally most robust in the arms near the ends of the bar. The increased star-formation **rate** near these two points is clearly evident in the arms and outer tips of the bar in NGC 1300. shown by the many bright knots that are **probably** small I1II regions. None of the **candidate Mil** regions resolve at the 2" level. The redshift of NGC 1300 is $v_0 = 1526$ km s"[1].

These several characteristic features have been reproduced in a series of theoretical **studies** concerned with the **hydrodynamic** response of the gas in the disk to the presence of the rotating bar. Following pioneering work by Prcndergast (1962), detailed **bydrodynamica]** models of the velocity field and the presence of shocks in the gas in the neighborhood of the bar have been made. The early papers that predict the velocity **field** in **detail** are **by** Huntley (1978). Huntley, Sanders, and Roberts (1978), Roberts, Huntley. and van Albada (1979), Peterson and Huntley (1980). and Huntley (1980). A review up to 1983 is given by Prendcrgast (1983).

The comparison **of** tile **calculated models** with the observed features in **NGC** 130(1 is generally so close that it can be said **that the** straight dust lanes in **SBb(s)** types and the **enhanced star-formation rate** at the ends of the **bar are** both understood. The **features** are **related** to the shock **properties** of the gas at these points.

In **viewing** the SBb galaxies in this section and in the SBc **section** later, it is useful to keep in mind the three conclusions ol Prendergast (1983):

> *(l) **Weak** bars give **open** spiral **patterns** which extend through**out** the gas; stronger bars give spirals which emerge at sharp angles to the bar. [added here: as in NGC 1300]*
>
> *(2) The gas response leads the bar. by an angle which is greater the weaker the bar.*
>
> *(3) Strong bars favor the appearance of strong shocks within the bar. **When** they occur, they lie near the leading edge, which is just where they should be if the identification of shocks and dust lanes is correct.*

The four galaxies on this panel are of luminosity class I; the spiral pattern is very well defined, i.e., the geometrical entropy is very low. In every case the arms start near the ends of the bar, as in NGC 1300, rather than tangent to an almost-complete internal ring, although close inspection is required in NGC 3992 (lower right) to avoid an incorrect first impression that the form here is more (r)-like than (s)-like.

NGC 2935 SBb(s)I.2
CD-815-S
Feb 26/27, 1979
103aO + GG385
15 min

The bar in NGC 2935 is weaker than in NGC 1300, being a central oval rather than a strong straight bar. Consistent with Prendergast's second point quoted on the preceding page, the spiral pattern of the outer arms is more open than in NGC 1300.

Two principal dust lanes exist in the inner oval, each curved into a tight spiral pattern. The underlying luminosity distribution in the oval is smooth: no large current star-formation rate exists there.

Robust star formation is occurring in each of the outer arms along their entire length. The largest HII regions resolve into disks at the 1.5" level. The redshift is v_0 = 2003 km s~'.

NGC 2633 SBb(s)I.3
PH-7705-S
Feb 11/12, 1980
103aO
12 min

The bar in NGC 2633 is an oval within which the current star-formation rate is high. The luminosity distribution is neither amorphous, as in the bar of NGC 1300, nor smooth over most of the oval, as in NGC 2935, above. The pattern is similar to that in NGC 210 (Sb; panel 124), which itself could be classed an SBb if its central disk were an oval rather than an inclined circular disk.

NGC 6951 Sb/SBb(rs)I.3 HA, p. *46*
PH-5374-S
Sep 11/12, 1969
103aO + GG13
25 min

The relative straightness of the two opposite dust lanes within the central disk of NGC 6951 identifies the central region as an oval rather than simply an inclined circular disk. However, the bar (the oval) is weak; the spiral pattern is open, and there is no enhanced star formation at the ends of the bar.

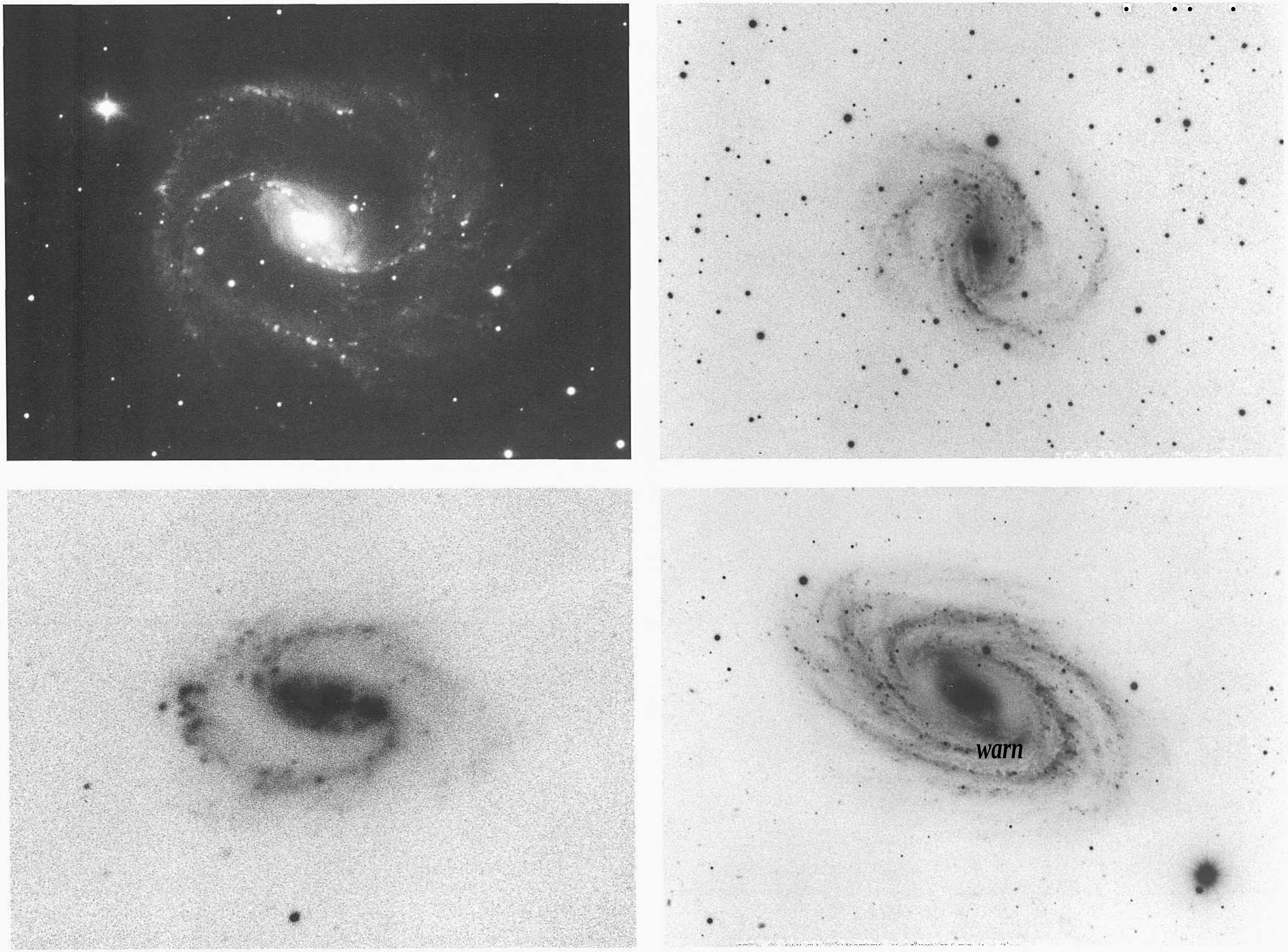
The HII regions in the arms are unresolved at the 1" level. The redshift of NGC 6951 is v_o = 1710 km s~'.

NGC 3992 SBb(rs)I Racine wedge
PH-8027-S
Feb 3/4, 1981
103aO
12 min

The spiral pattern in NGC 3992 is among the most regular known in the sky. Before it fragments, one of the two principal arms can be traced for nearly a complete revolution from its start near the end of the bar. The opposite arm fragments into three segments after unwinding for only about 90°.

The arms do not begin at the tips of the bar but rather at a position about 10° upstream from these ends, i.e., in a direction opposite the direction of rotation (inferred from the sense of the spiral pattern). One of the several calculated hydrodynamical models of Huntley (1980, Fig. 4) reproduces the pattern.

The largest of the many HII regions in the arms resolve into disks at the 1" level. The redshift is v_o = 1134 km s^{-1}.



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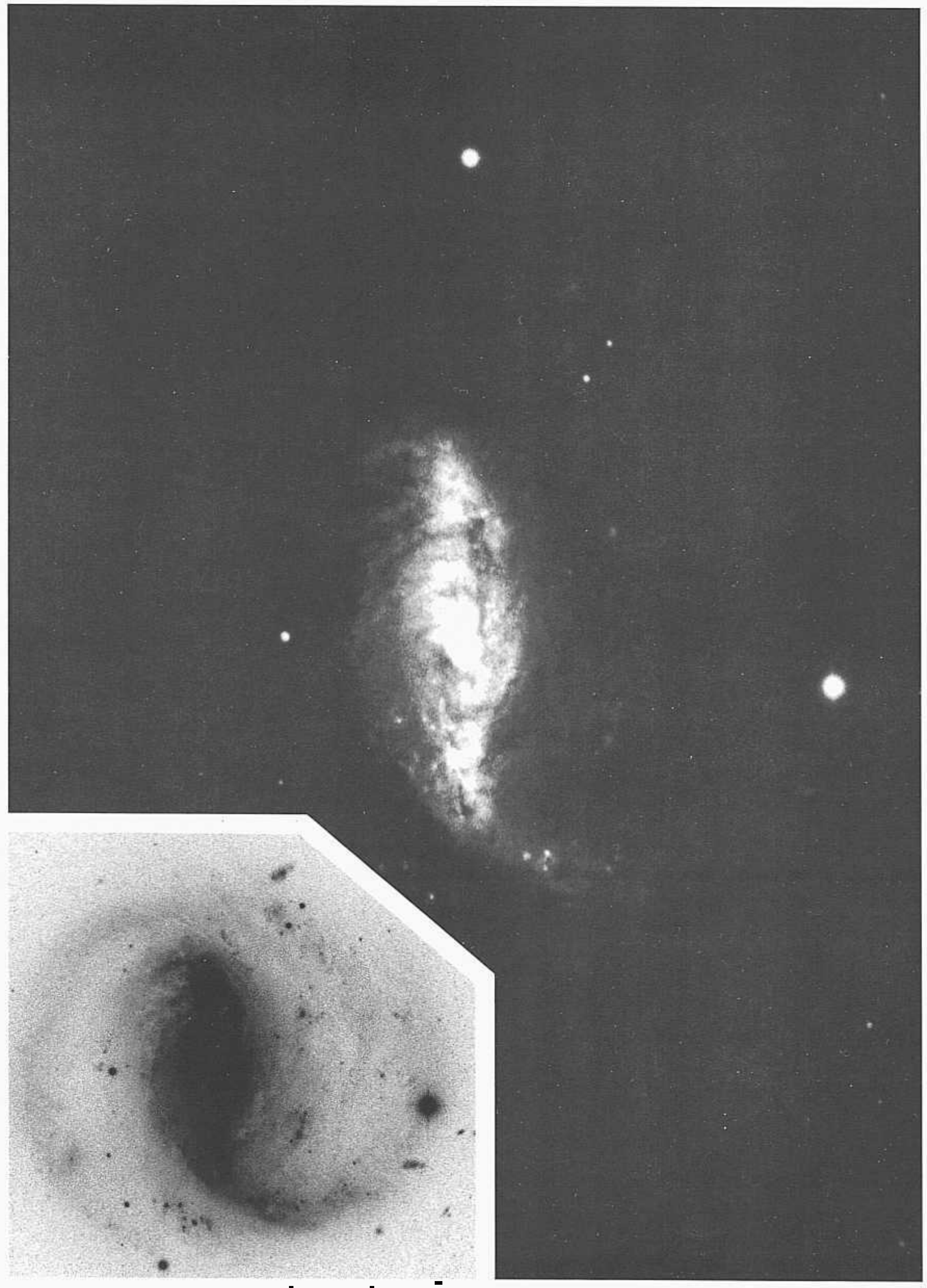


NGC 7552 SBb(8)I-H
CD-1587-S/Br
Aug 11/12, 1980
103aO + GG385
15 min

The same **original** plate was used to make the two prints of **different** contrast of NGC 7552 offered **here. The** low-contrast **print shows the detail of the** intricate **dust pattern in the oval, which** is **the weak bar. The high-contrast print** shows **the generally low-surface-brightness spiral** pattern **of the** (s) type, where the arms begin at the end **of** tin[1] bar (the oval here).

The **two straight** dust lanes **characteristic** of SBb types **are** best seen in **the** low-contrast **print,** which shows the center well. These lanes, as in NGC 1300. start from opposite sides of **the nucleus** and are straight almost to the end of the oval. They are not as well defined as in [\GC 13 00 but are obviously present. It is well **understood that** these lanes are due to hydrodynamic shocks in the gas in response to the gravitational **perturbation** of the rotating bar. The stronger the bar, the stronger are the shocks, according to the calculated models (see Prendergast 1983 **for** a review).

Dust lanes, **curved** into spiral fragments, exist in the central oval starting from the two straight lanes on opposite sides of the oval.

The outer luminous arms shown in the high-contrast print start **from** the ends of the oval. On one side the principal arm branches into three fragments, the inner of which nearly overlaps the other principal arm, which starts from the opposite side of the oval. This arm remains single for the half-revolution over which il can be traced.

Only a few IIII regions exist in the arms, the largest oi which resolve at about the '2" level. **The redshift** is v_Q = 1565 km s~[1].

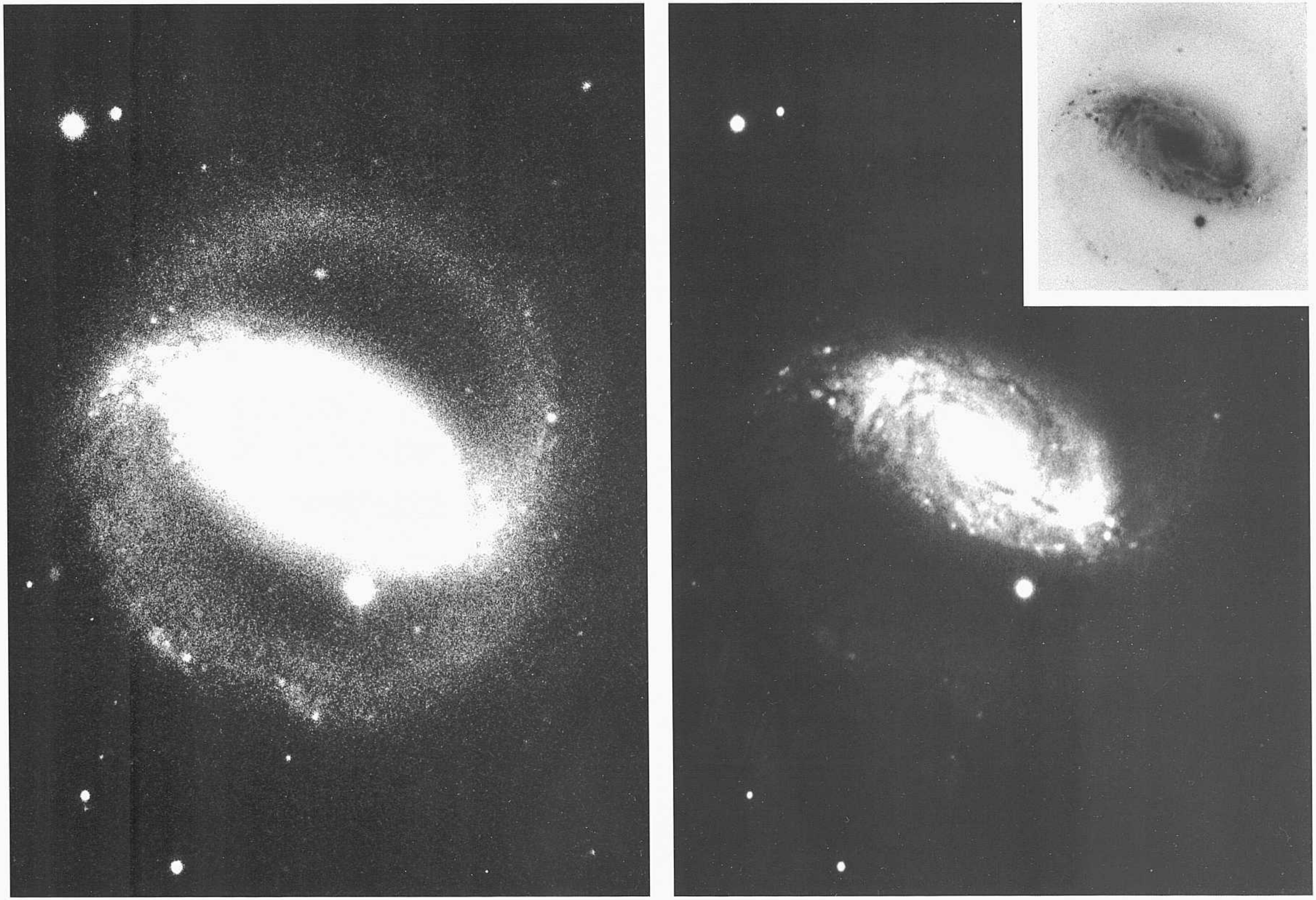
NGC 3504 **Sb(s)/SBb(s)MI** **HA, p. *46***
PH-1169-S **panel 169**
Dec 14/15, 1955
103aO
30 iiiin

NGC 3504 is similar in its general features to NGC 7552 on the preceding panel.

The oval is the weak bar from which the two major luminous arms begin at opposite rim edges. The two characteristic dust lanes beginning at the nucleus can be identified in the low-contrast print, where the detail in the interior of the oval is well seen. One of the lanes is straight for its entire length to the edge of the oval: the other is straight over about half the size of the oval after which it curves into **a** spiral dust fragment.

Two main low-surface-brightness arms begin at opposite ends of the oval, nearly overlapping after each reaches about half a revolution. Very little current star formation is occurring in the smooth outer arms. The **places** having the highest current star-formation rates are at the ends of the oval where the two outer spiral arms begin.

The largest **HII** regions resolve into disks at about the 2" level. The redshift of NGC 3504 is v_o= 1480 km s⁻ \



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PANEL
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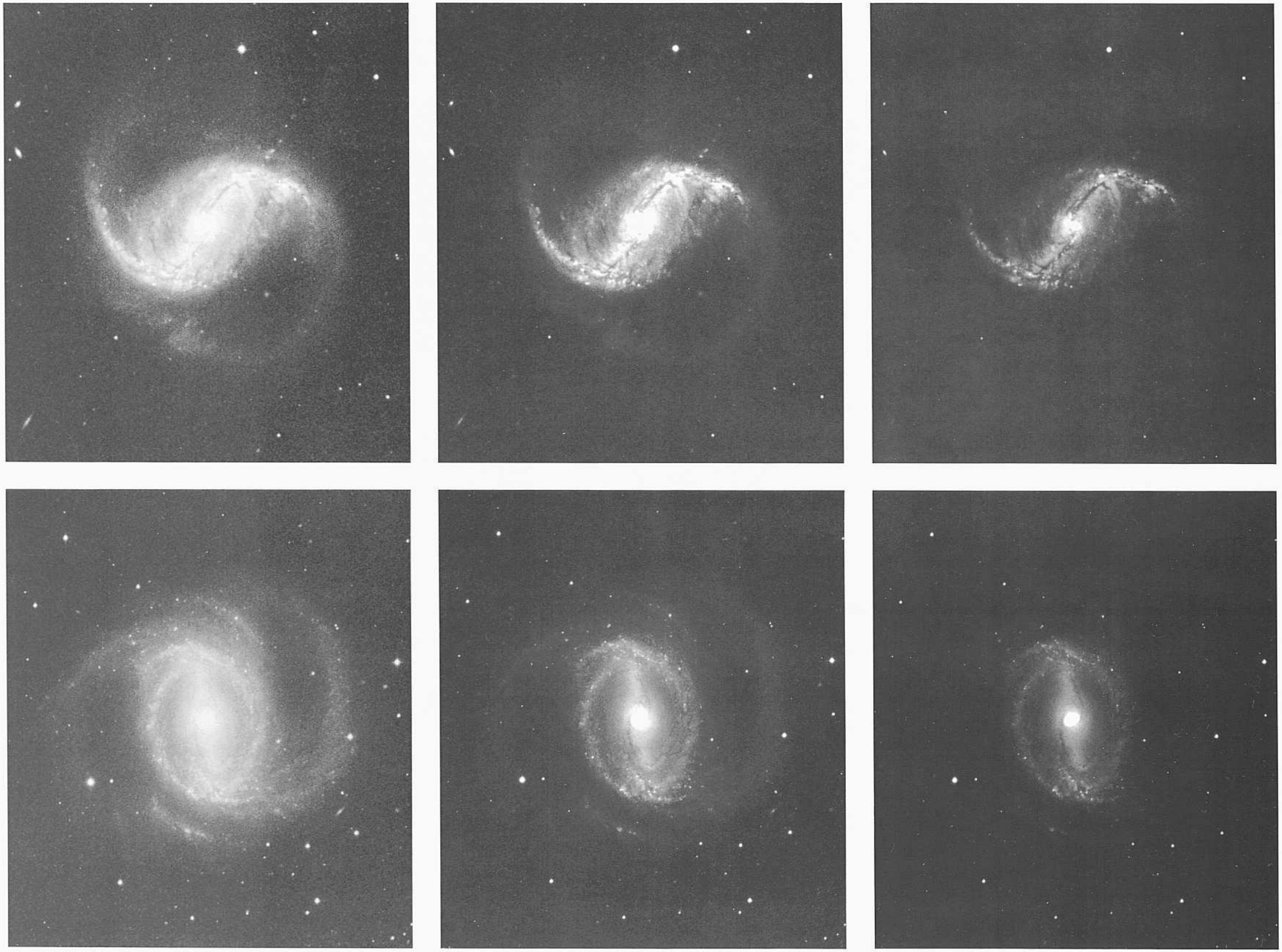


The general features of the two galaxies shown on this panel art' similar to the SBb galaxies on preceding panels, but the spiral patterns are more complex.

NGC986 SBb(rs)I-II panels 169, 170
CD-2007-Bedke/Gregory
Oct 23/24, 1981
103aO + GG385
'15 min

In NGC 986 in **the top** row, **the short-exposure print shows that the bar** is **strong, li** is narrow in **its central, high-luminosity part, along** which, on either side, the two characteristic, **straight, well-defined** dust lanes exist. Two sets of arms emerge from the ends of the **bar. The inner** set spring from **the bar** at a **sharp angle, similar** to the pattern **in** NGC 1300. These nearly overlap alter **half** a revolution, forming **an almost-complete** inner ring, seen best in the middle print.

The two grand **design** outer **arms** also **begin at** the ends of **the** bar at **the** same place as the inner arms. They emerge from the bar at a shallower angle than the inner arms. They are brightest for about **one-eighth of a** turn **from** their beginning, after which the surface brightness becomes much fainter. The highest star-formation rate occurs near the ends of the bar and in the parts of the outer arms nearest **the** bar. The pattern is well **reproduced** in many of the model calculations **described** on panel 1 54 in **the** commentary on NGC 1300.

NGC **1433** **SBh(s)I-II panels 169, 170**
CD-153-S
Feb 3/4, 1978
103aO + GG385
45 nun

The short-exposure print of NGC **143**3 shows the strong bar and **the** two **"shock-produced"** dust lanes on each of the two leading edges of the bar (i.e., leading in **the sense** that we know the **direction** of rotation from **the** sense of **the** spiral **pattern).** Two **bright** grand design, lightly **wound, inner spiral anna begin** *a* the ends **of l**he bur. **similar to the pattern** in **NGC** 1300. The star-formation **rale** is high in the two **inner arms where they nearly overlap at the ends of the bar.** This **overlapping** seems, **on** first **inspection** of **the middle print,** to form an inner ring, **hut the pattern** is simply **one of overlapping, tightly wound** spiral **arms.**

After slightly more than half a **revolution,** these **inner** arms branch hi **form two** sets **of** lower-surface-bright ness **outer** arms. Nole **the** high degree of symmetry of the four- **outer** arms. The set closer to **the broken** "'ing **are** only **two fragments** which unwind **for** only about 30° **before** they can no longer **be** traced.

The small 1111 regions in **the inner** arms do **not resolve at the L" level. The redshifl** of NGC 1433 is $v_{,,}$ - 923 km s"'.

Galaxies on the preceding five panels are of the (s) subtype, have very ordered spiral structures (all are of high-luminosity class), and have spiral arms of the grand design type. Grand design arms almost always occur in the (s) subtype.

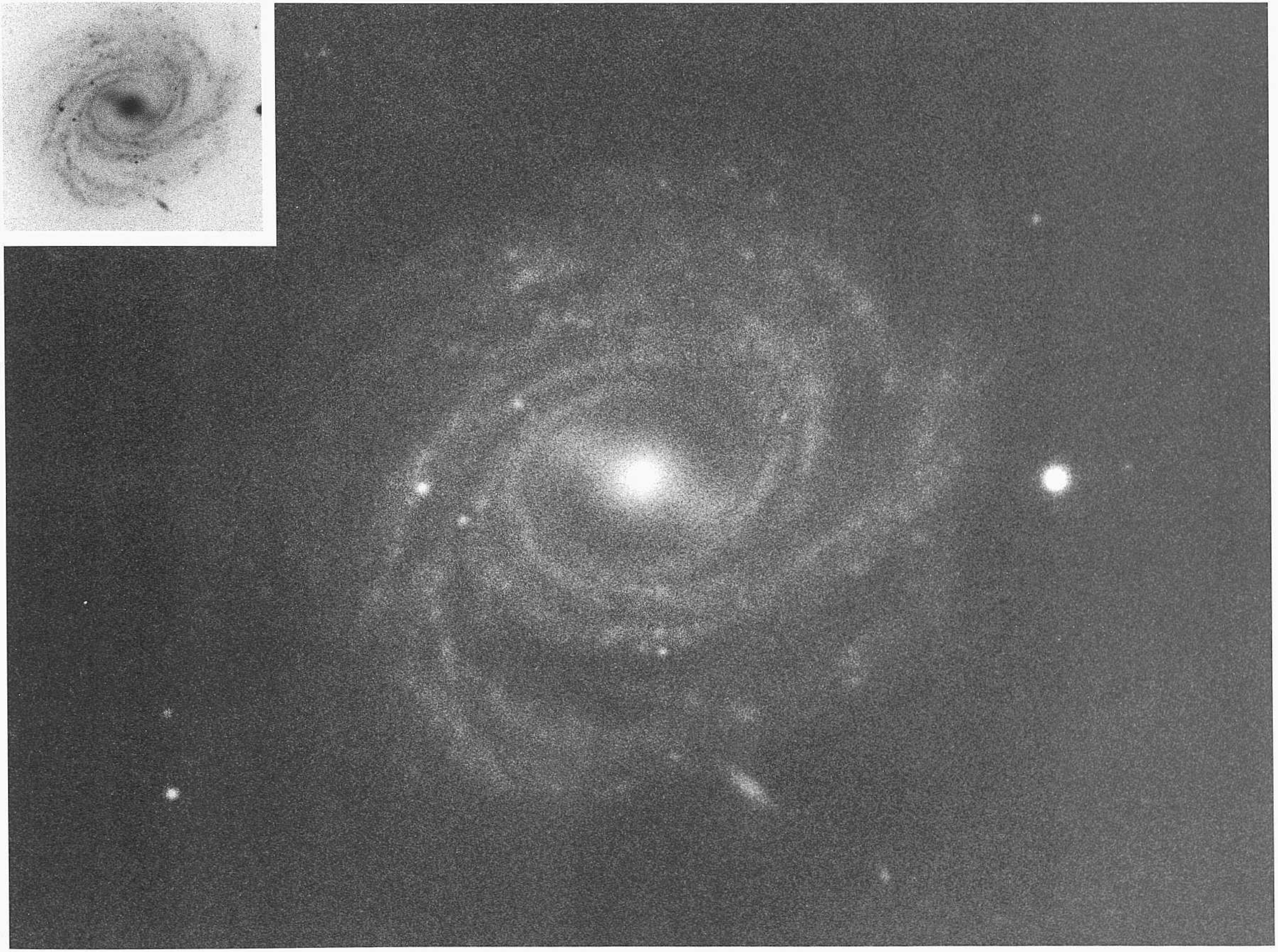
The galaxies on the next five panels are of the (r) subtype. The spiral pattern is invariably of the fragmented, multiple-armed-spiral (MAS) type.

SBb(r) galaxies of luminosity class I are illustrated on the next three panels. Less-regular galaxies (which by definition have a lower luminosity class) are shown on the panels following them.

NGC 1999 **SBb(rs)I** **panel S9**
CD-1835-HB
April 1/2, 1981
103aO + GG385
45 min

NGC 4999 is **the** prototype of the very regular **(high-luminosity** class) multiple-armed-spiral (MAS) type where the arms begin tangent **to** an almost-complete internal ring. Again, to **emphasize** what is often described in these notes, this ring represents the near overlapping of separate arms springing from opposite ends of the bar and approaching one another after each has unwound by half a revolution. The pattern is well seen in NGC 4999. although the near-ring is very nearly complete because the first wrap of the arms is so tight: the separate arms nearly intersect after each has unwound **by** half a revolution.

The bar is strong. The arm pattern is multiple and fragmented. The arms are thin; the **geometrical** entropy is **low.**



PANEL
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PANEL
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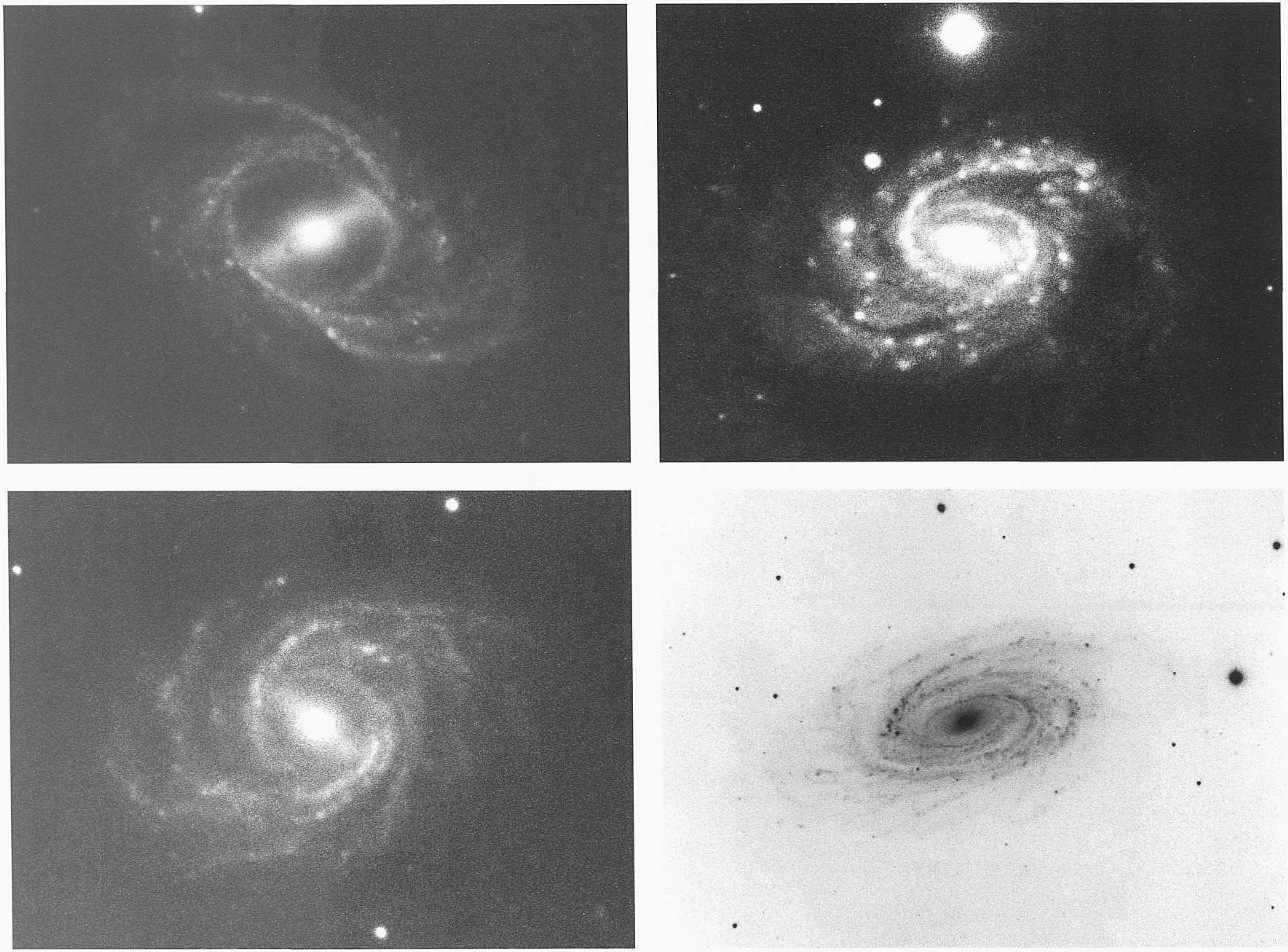


The four galaxies on this pane] have so regular an arm pattern that they are classed as luminosity class 1. All hut NGC 5985 have prominent bars. All have multiple spiral arms, beginning from an almost-complete internal ring. This pattern defines the (r) spiral subtype.

NGC 2523 SBb(r)I
PH-850-S
Nov 2/3, 1954
103aO
30 niin

The arms in NGC 2523 are narrow. One ol the two main arms that would form a grand design pattern branches into two narrow arms starting at about 30° around the ring from the termination of the bar on the ring. The other main arm begins near, but not on, the ring at the place where the bar terminates on the ring. This arm can be traced in its bright part for only about one-fourth turn from its origin at the end of the bar.

The HII regions are unresolved. The redshift of NGC 2523 is v_o = 3638 km s~'.

NGC 5406 SBb(r)I
PH-8100-S
Feb 6/7, 1981
103aO
12 niin

NGC 5406 is a MAS type although the arms are quite well defined. The bar is strong. The central lens containing the bar is smooth, indicating an old stellar population.

The many evident HII regions do not resolve at the l"level. The redshifl of NGC 5406 is high for a Shapley-Ames galaxy, at v_o = 5241 km s^{-1}.

NGC 1832 SBb(r)I
PH-70-II
Oct 13/14, 1950
103aO
30 niin

NGC 1832 is nearly a grand design spiral except that the second principal arm (at the top in the print here) does not exist as a separate arm but consists of fragments starting at progressive places on the nearly complete bright internal ring.

The spiral-arm fragments are all narrow. They are weil defined, explaining the bright luminosity class. Each arm is studded with HII regions, the largest of which resolves at the 2" level. The redshift of NGC 1832 is v_0 = L855 km s~J . At this redshift (in the absence of noise in the Hubble flow), the angular size of the largest 1111 region corresponds to a linear size of 3 60 pse (// = 50), which agrees well with the calibration of Sandage and Tammann (1974a).

NGC 5985 SBl,(r)I
PH-7273-S
July 22/23, 1976
103aO + GG13
25 min

The multiple-arm pattern is especially evident in NGC 5985. The arms are thin and well defined, requiring the highest luminosity classification. A few large HII regions exist in parts of the image. They do not resolve at the 1 " level. The redshift of NGC 5985 is v_n = 2694 km s~[1].

The four galaxies on this panel continue luminosity class I because the spiral arms are so well defined and are thin, and the inter-arm regions are relatively clear.

NGC 3347 SBb(r)I
CD-191-S
Fob 7/8, 1978
103aO + GG385
-15 rain

NGC 3347 is a two-armed spiral of the grand design type despite the fact that the spiral subclass is (r) because of what appears, at this high inclination angle, to be an internal ring.

The two principal arms have high surface brightness. They are studded with small, generally unresolved HII regions. The redshift of NGC 3347 is v_n = 1201 km s⁻'.

NGC 5792 SBh(rs)I.3
CD-1436-S/Br
March 26/27, 1980
103aO + GG385
45 nun

NGC 5 792 is a highly inclined, well-formed barred spiral with an evident almost-complete inner ring from which the grand design two-armed spiral pattern emerges. The redshift is v_o = 1889 km s"[1].

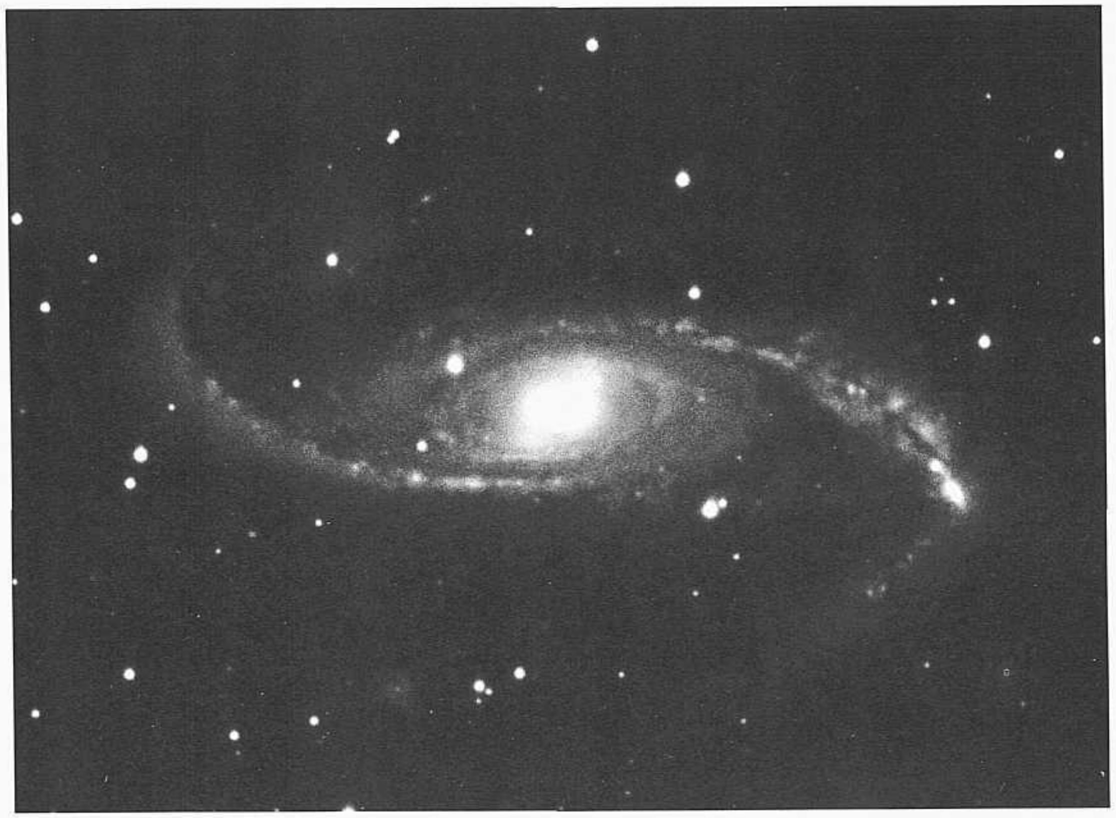
NGC 1512 SBb(rs)I pec pair
CD-184-S
Feb 7/8, 1978
103aO + GG385
45 inin

NGC 1512 is an almost-normal SBb(r) where interaction with NGC 1510 distorts the outer thin arm pattern. Description of the features of this encounter are given by Kinman (19 78), and by Sandage and Brucato (1979).

The nearly complete inner ring in NGC 1512 is composed of two closely overlapping bright, tightly wound spiral-arm segments, which begin at the ends of the bar. This near-ring is of very high surface brightness. Star formation, evidenced by the many HII regions, is most robust in one of the spiral fragments at one end of the bar, seen well in the low-contrast print at the bottom right. The smooth nature of the bar and the single straight dust lane are seen best on the side of the bar where the HH-region density is highest in the associated arm that starts there.

Very faint outer arm fragments exist, associated both with the inner arm structure of NGC 1512 and the perturbing companion, NGC 1510. Parts of these arm fragments are seen in the high-contrast print at the top right but are seen better in the photograph by Kinman (1978), where the pair is also described.

The separation of the pair is 4.9'. The redshift of NGC 1512 is low, at v_0 = 760 km s"'. At the redshift distance of 15 Mpc the projected linear separation of NGC 1512 and NGC 1510 is small at 2 1 kpc, supporting the suggestion that a close encounter is in progress.

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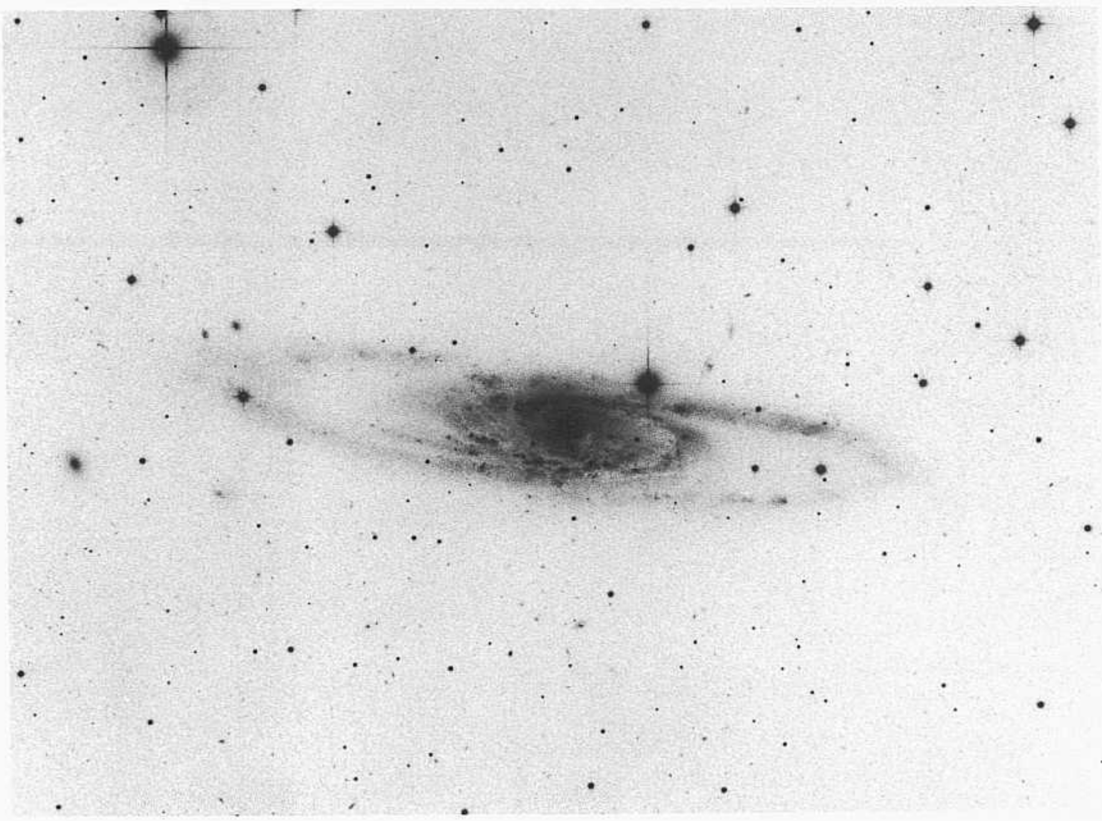
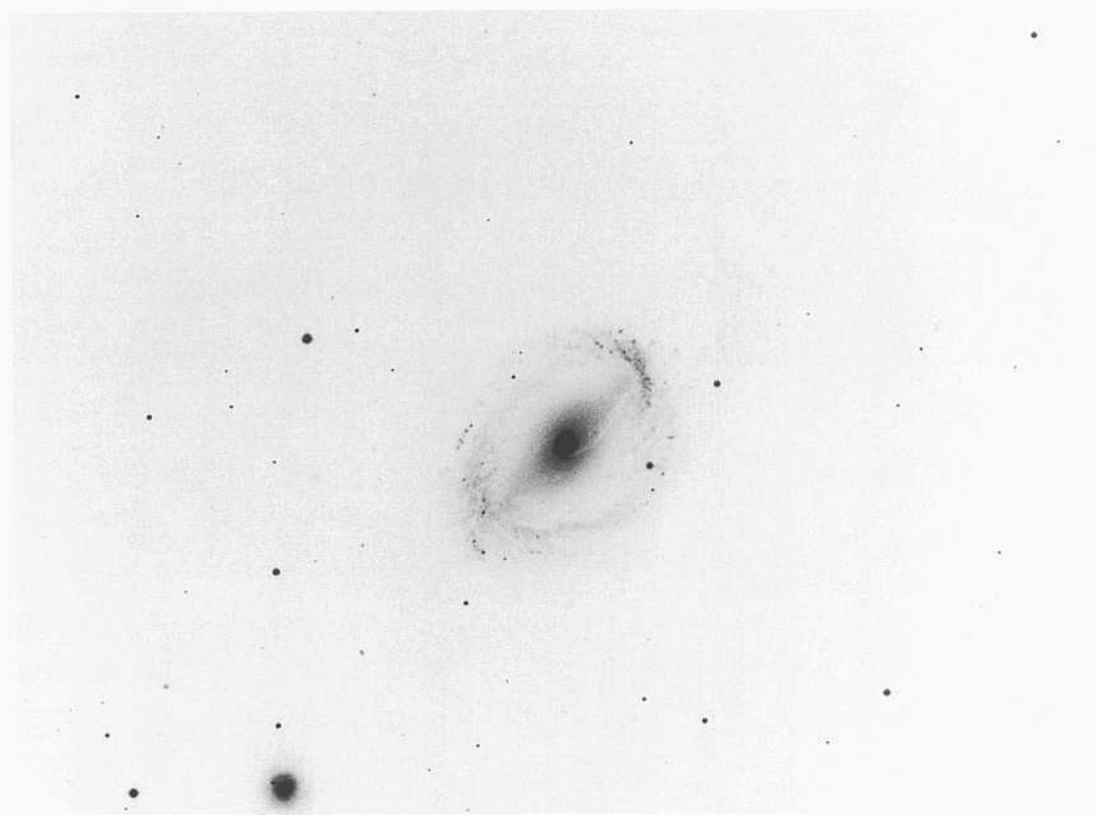

PANEL
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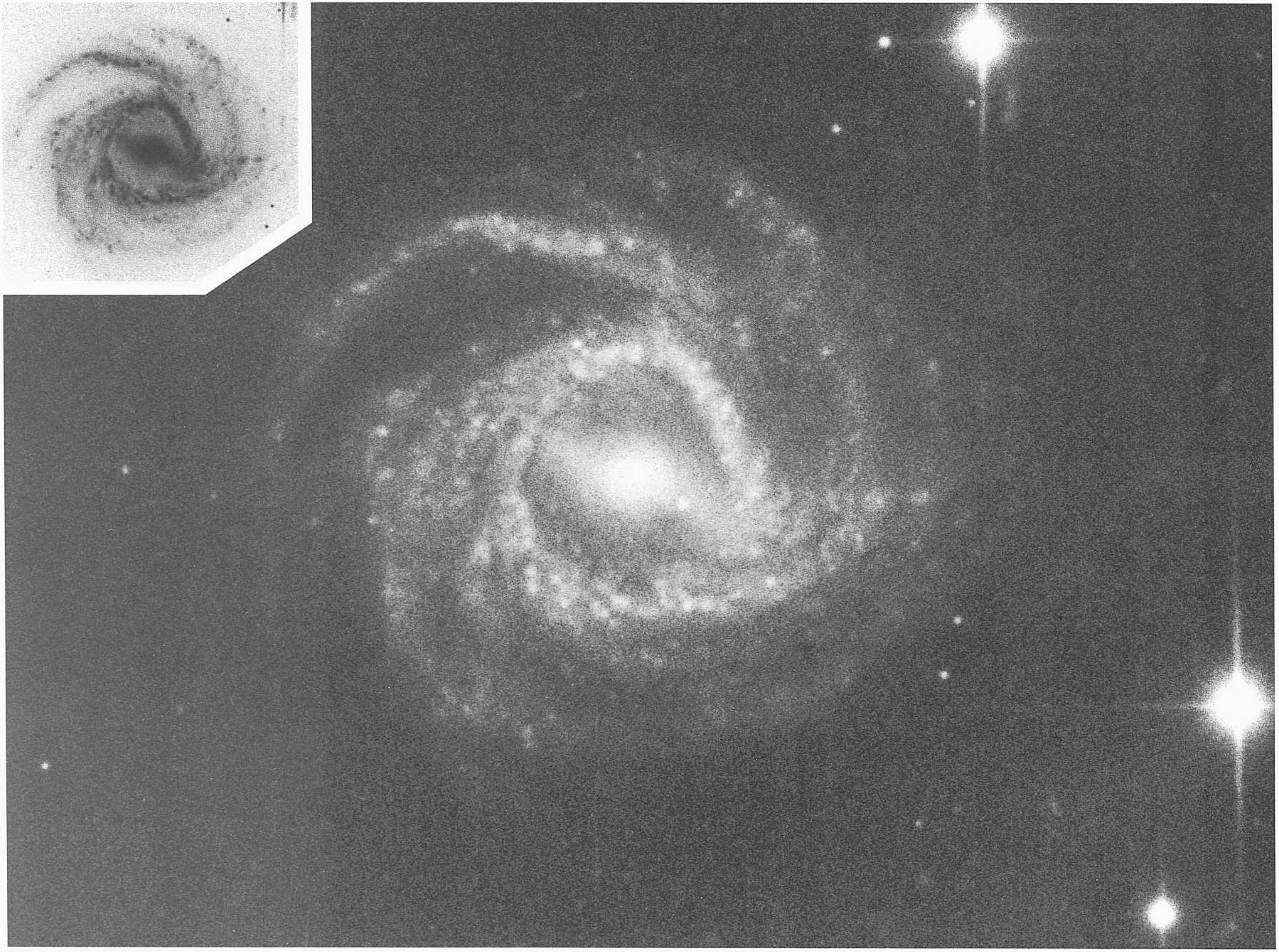


SOlBb galaxies of luminosity class **I-Tl** (along with a few of class **II)** are shown on this and **the next** lour panels. Although the spiral arms are well defined, **the** arms arc **thicker** in these galaxies than in luminosity class I galaxies and, as a consequence, the inter-arm regions are more cluttered with spiral-arm-like matter.

NGC 1902 **S151i(rs)I-ll** **group**
CD-1842-HB
April **2/3,** 1981
103aO
75 min

The apparent internal rin{i in NGC '1902 is the overlapping of two very bright arms of the NGC 1300 type which begin at opposite ends of the bar. Sets of other outer arms also exist, the brightest of which is semi-detached from the bright main inner arm (at the bottom of the print on the facing panel).

Many 1111 regions exist in the bright parts of the several arms and the arm fragments.

NGC 4902 is kinematically associated with a loose group thai includes NGC 4899 (Se; panel 232). 34' to the north. NGC 489 1 (SBbc; panel 205}, 64' to the north, and several other probable members listed in the RC2 . The redshifts are $ti_o(4891) = 2418$ km s"'. $u_o(4899) = 2437$ km s¯\ and $n_o(4902) = 242\,6$ km s¯\ At a mean redshift distance of 48 Mpc (// = 5 0) the projected linear separations from NGC 4902 are 480 kpc and 903 kpc for NGC 4899 and NGC 4891. respectively. This aggregate, then, lias a size nearly the same as the Local Group.

The four galaxies on this panel continue the illustration of SBbI-II barred spirals of the (r) and (rs) subset. The arms are generally multiple (MAS type), although NGC 58 50 also has features of a grand design spiral.

NGC 7329 **SBl»(r)I-II**
CD-1586-S/Br
Aug 11/12, 1980
103aO + GG385
45 mill

The almost-complete inner ring in NGC 7329 is very tight, lint **the overlapping** spiral arms that **compose** it can be traced. The arms composing **the** ring **do not** begin at the end of the bar. as in NGC 1300. **but** rather about 15° downstream (relative to the direction **of** rotation) from these ends. The pattern is reproduced in some of the calculated models **of Huntley** (1978, 1980).

Multiple fragments of arms exist outside the inner ring.

The **redshift** is v,, = 3 043 km s~'.

NGC 5850 **SBb(sr)I-II**
CD-1417-S/Br
March 24/25, **1980**
103aO + GG385
45 min

The pattern of an almost-complete inner ring in NGC 5850 is similar to that in NGC 7329, above. One of the **overlapping** inner arms that forms the ring begins about 15° downstream from one end of the bar. The star-formation rate is high there. Again, this pattern is reproduced in some of the models calculated by Huntley (1978, 19 80) and others cited in the description to NGC 1300 (panel 154).

The fragmented outer arms are extensions of the two tightly wound inner arms, which **form** the- ring after they nearly meet **after** half a revolution. **HH-region candidates** indicate **a moderate** current star-formation rate, especially in **the** inner arms.

A faint straight dust lane along the **outside** edge (in **the direction** leading the rotation, as inferred from the sense of the spiral pattern) is present along one side of the smooth straight bar.

The redshift is r,, = 2 130 km s^{-1}.

NGC2642 **SBb(rs)I-II**
CD-1325-S/Br
March 13/14, 1980
103aO + GG385
45 **min**

The bar **in** NGC 2642 is strong, and the inner arms spring from its ends, as in NGC 1300. The arms branch into multiple fragments soon thereafter.

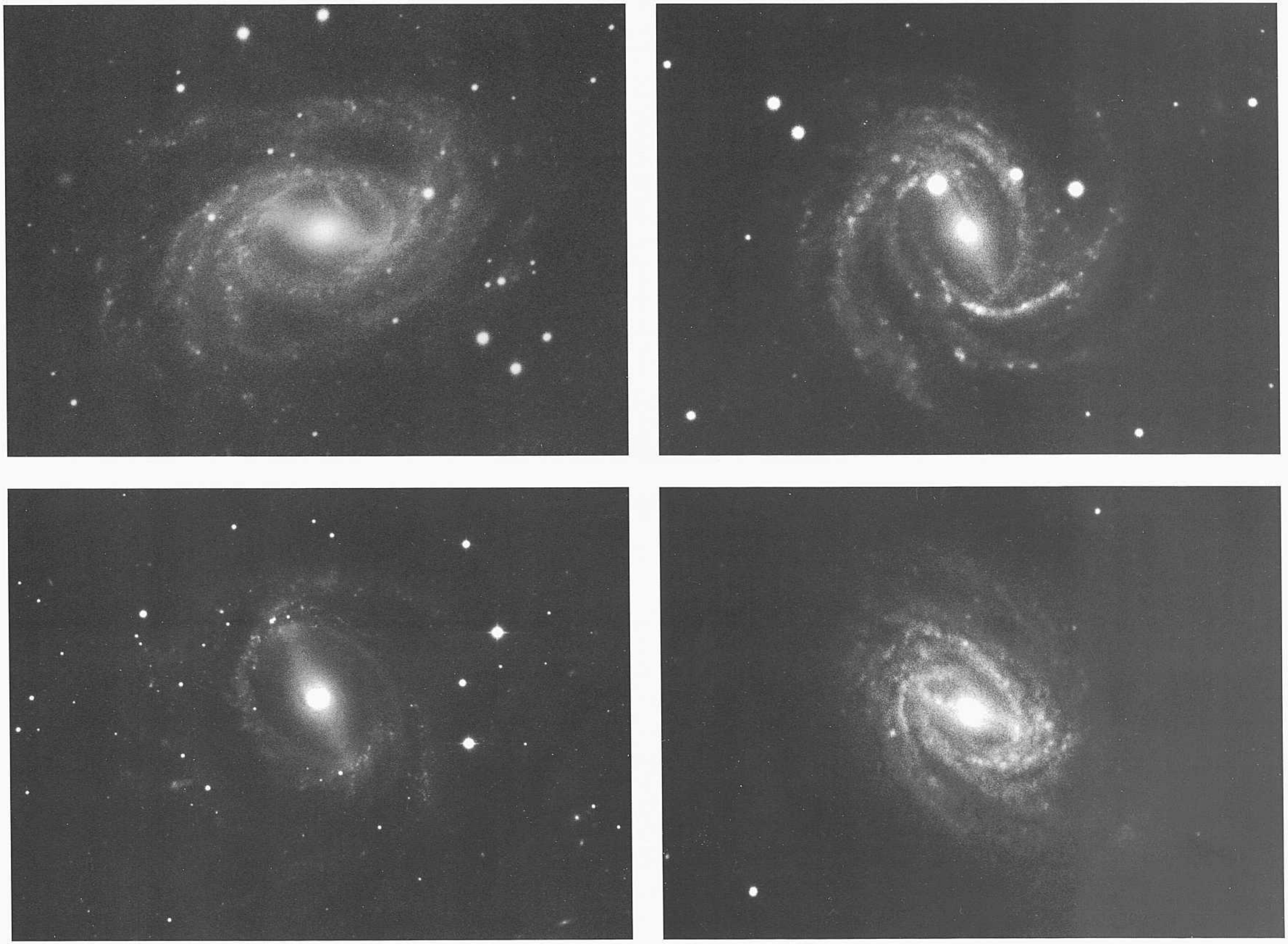
Two weak, straight dust lanes exist along the outside of the smooth bar. as usual in the direction that leads the rotation.

The arms are filled with bright HII regions, the largest of which resolve at the 1.5" level. The redshift of NGC 2 642 is v_n = 42 62 km s~'.

NGC 7723 **SBb(rs)I-II** pair
PH-78-H
Oct 15/16, 1950
103aO
30 **min**

NGC 7723 forms a pair with NGC 7727 (Sa pec: panel 83) that is about 40' northwest. The redshifts are u_o**(7723)** - 1976 km s~' and «$_O$(772 7) = 1973 km s^{-1}. The projected linear separation of the pair is 460 kpc using a redshift distance **of** 39 Mpc (// = 50).

The **characteristic straight** dust lanes exist on the outside of the smooth bar in the direction leading the rotation. The lane on one side is smooth; on the other it is slightly broken. The internal ring from which the MAS spiral pattern begins **is** almost complete.



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PANEL
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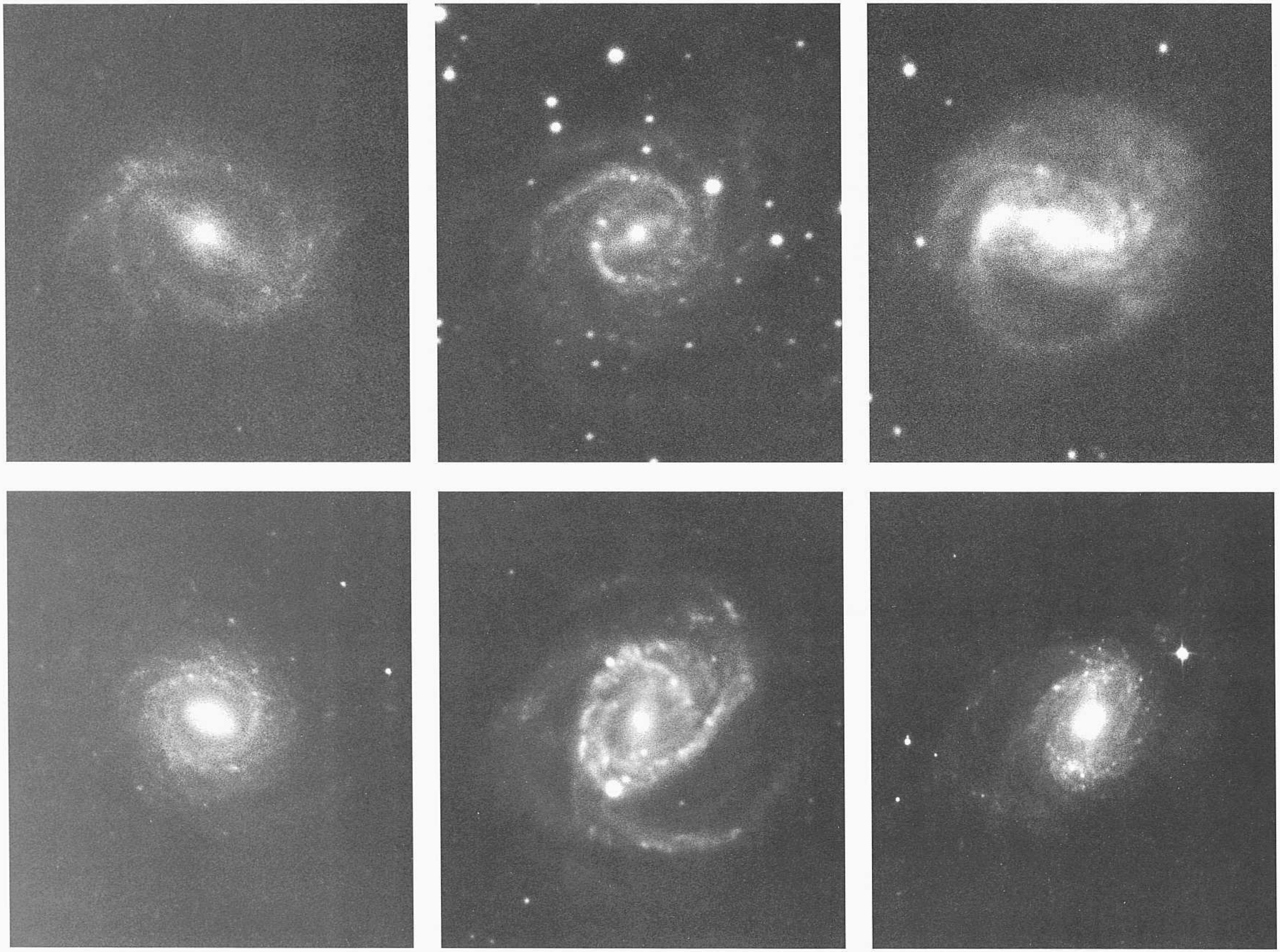


The six galaxies on this panel continue the illustration of SBb galaxies of high (I-II) to moderate (II) luminosity elass; the well-formed arms show minimum disorder in the spiral pattern.

NGC 5347 SBb(s)I-II
PH-8097-S
Feb 6/7, 1981
103aO
12 min

The bar in NGC 5347 is straight, similar to the bar in NGC 1300. but it is not as luminous. The two characteristic straight dust lanes exist in the bar, but they are weak.

The arm pattern is of the NGC 1300 type, where two grand design arms spring from the ends of the bar. They are tightly wound in NGC 5347, giving the incorrect impression at first glance of a complete inner ring. The type is unmistakably SBb(s), but this ease shows the need for high spatial resolution when classifying galaxies of small angular size.

The reclshift is v_0 = 2394 km s"'.

NGC 3681 SBb(r)I-II
CD-1841-HB
April 2/3, 1981
103aO
75 niin

The bar in NGC 3681 is a central oval, not a well-defined feature as in NGC 1300. The classification in the RC2 is that of a transition type between barred and ordinary spiral, denoted SABbc(r).

The arm type is multiple (MAS) and fragmented. A set of high-surface-brightness inner arms exists, together with a set of low-surface-brightness outer arms.

HII regions occur in both arm sets. They are unresolved at the 1" level. The redshift of NGC 3681 is v_0 = 1135 km s"'.

NGC 5156 SBb(rs)I-II
CD-2141-S
March 22/23, 1982
103aO + GG385
30 min

The bar in NGC 5156 is well formed and ends on the rim of one of the best-defined almost-complete rings in the RSA. The arms do not start exactly from the ends of the bar as in NGC 1300, but instead begin from about 50° downstream from each bar tip. This large downstream position (see previous descriptions of this phenomenon in this section) cause different arm segments to nearly overlap, creating the impression of a complete inner ring. The pattern is reproduced in some of the models of Huntley (1980) by changing the fraction of the total mass that is in gas.

NGC 782 SBb(r)I-II
CD-1999-Bedke/Gregoiy
Oct 22/23, 1981
103aO + GG385
46 niin

The pattern of the almost-complete inner ring in NGC 782 is nearly identical to that in NGC 5156, above: the same description applies.

A set of three faint outer arms exists, starting at different points on the almost-complete inner near-ring.

NGC 5757 SHh(rs)ll
CD-I 171-Hr
Aug 23/24, 1979
103aO + GG385
45 mill

The spiral arms in NGC 5757 are not well defined. They are thick ami somewhat chaotic. They primarily spring from the ends of a bar in the general style of NGC 13011. bill are less well defined.

The several Illl-regiou candidates are unresolved at the 1" level. The redshift of NGC 5757 is u_0 = 2598 km s̄ \

NGC 4639 SB1)(:)II VCC 1943
CD-818-S
Feb 26/27, 1979
103aO + \Vr2c
45 min

NGC 4639. a member of the Virgo Cluster, has a redshift of u_0 = 860 km s"'. Many of ils 1111 regions are concentrated in the spiral arms, where they begin at the ends of the liar. The largest of these regions resolves into disks at the 3" diameter level.

Three of the lour galaxies on this panel combine features of (s) and (r) subtypes of spiral arms. All are of high-luminosity class I-II because of the regularity of the spiral pattern.

NGC 2712 SBh(s)I-II
PH-7955-S
Nov 8/9, 1980
103aO
12 min

The bar in NGC 2712 is moderately weak and is partially curved. The spiral pattern has three principal arms, two of which spring from the ends of the bar. The third begins at the middle of the bar and winds outward in fragments traceable for a total unwind of about 300°. overlapping the inner arm that begins at the opposite end of the bar for much of its final path. The largest HII region in the arms resolves at the 3" level. The redshift of NGC 2712 is v_o = 1892 km s .

NGC 4593 SBb(rs)I-II HA, p. *48*
CD-1400-S/Br
March 22/23, 1980
103aO
75 min

NGC 4593 has a strong straight bar with a characteristic straight dust lane along one of the leading edges (leading the rotation, whose sense is inferred from the sense of the spiral pattern).

A nearly complete inner ring is formed by the arms. One arm begins at the same distance from the center as where the bar terminates but at a position downstream by about 15°. The other principal arm begins at the end of the bar, as in NGC 1300.

The redshift is u_o = 2505 km s^{-1}. The galaxy is in the southern extension of the Virgo Cluster at a declination of —5°, near the ridge of the supergalactic plane.

NGC 5135 SBbpec
CD-2179-S
March 28/29, 1982
103aO + GG385
15 min

The dust lanes in the bar of NGC 5135 are themselves curved into a spiral pattern similar to, but not as extreme as, the famous case of NGC 4314 (SBa; Hubble Atlas, p. *44:* panels 95, 106 here). The faint spiral arms begin in an (s)-type NGC 1300 pattern from the ends of the bar. The brightest 1111 region candidates occur in one of the arms close to its beginning near the end of the bar. The largest of these resolves into a disk at about the 1" level. The redshift of NGC 5135 is v_o = 3906 km s"'.

The absolute magnitude of the galaxy is bright, at M_B = -22.5 (// = 50).

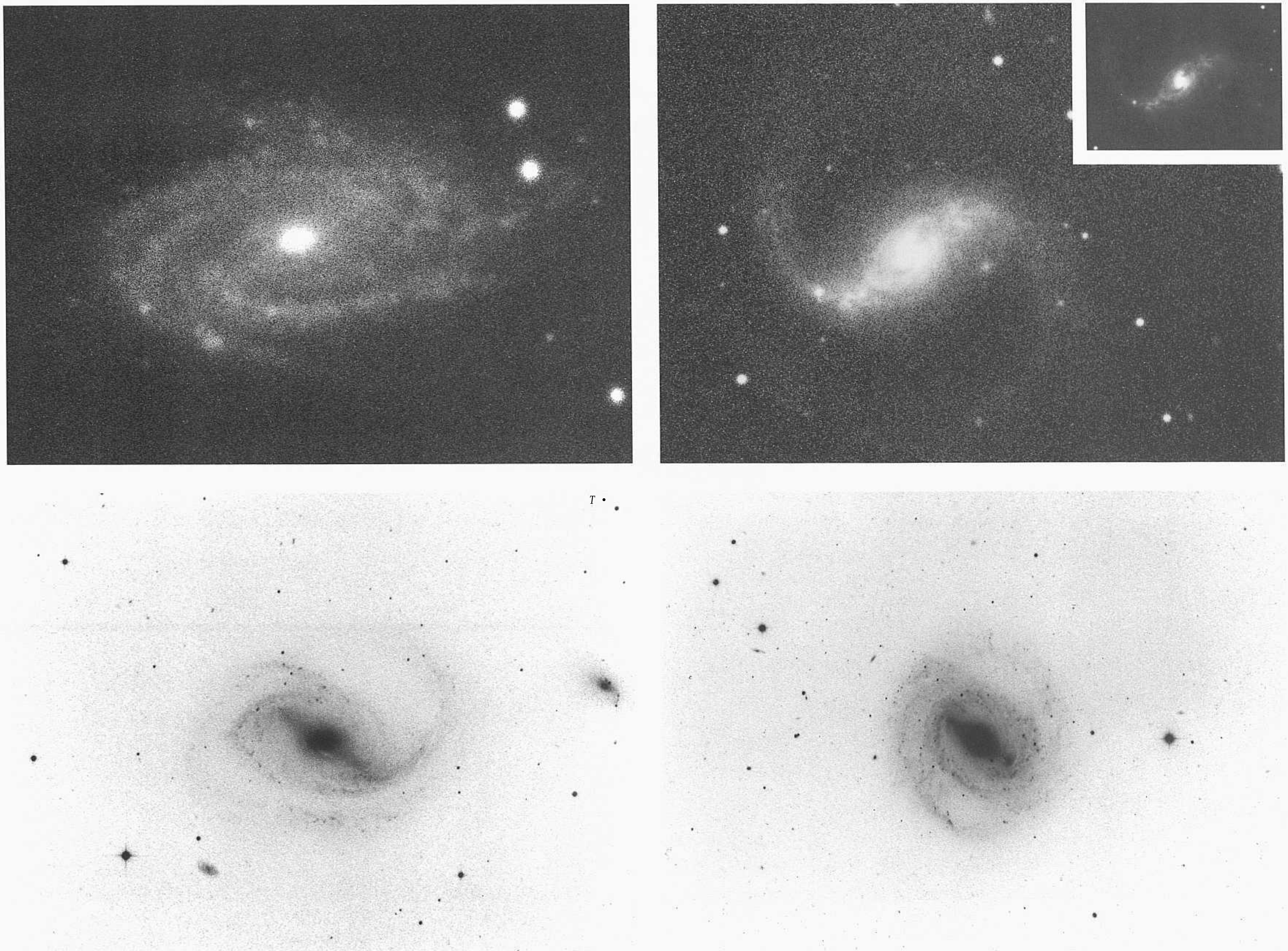
NGC 4394 SBb(sr)I-II VCC 857
PH-425-MH HA, p. *47*
April 16/17, 1952
103aO
30 min

The bar in NGC 4394 is strong, but absent are the straight dust lanes along the leading edges seen in other SBb galaxies having strong bars. Instead there is a series of dust lanes close to one of the leading edges of the bar. (The leading edge on the other side may be on the far side of the image: a symmetrical pattern in the dust that may exist is undoubtedly hidden behind the bulge, similar to the pattern in other galaxies.)

The dust lanes near the bar on the assumed near side have a pitch angle to their spiral pattern quite different from the pitch angle of the outer Luminous spiral arms. This pattern in the dust may outline the vectors of the velocity field near the bar that is determined by thi' hydrodynamic response of the gas to the rotating bar. The pattern seen here closely resembles the velocity maps near the bar that have been calculated in some of the models cited in the description of NGC 1300 (panel 154).

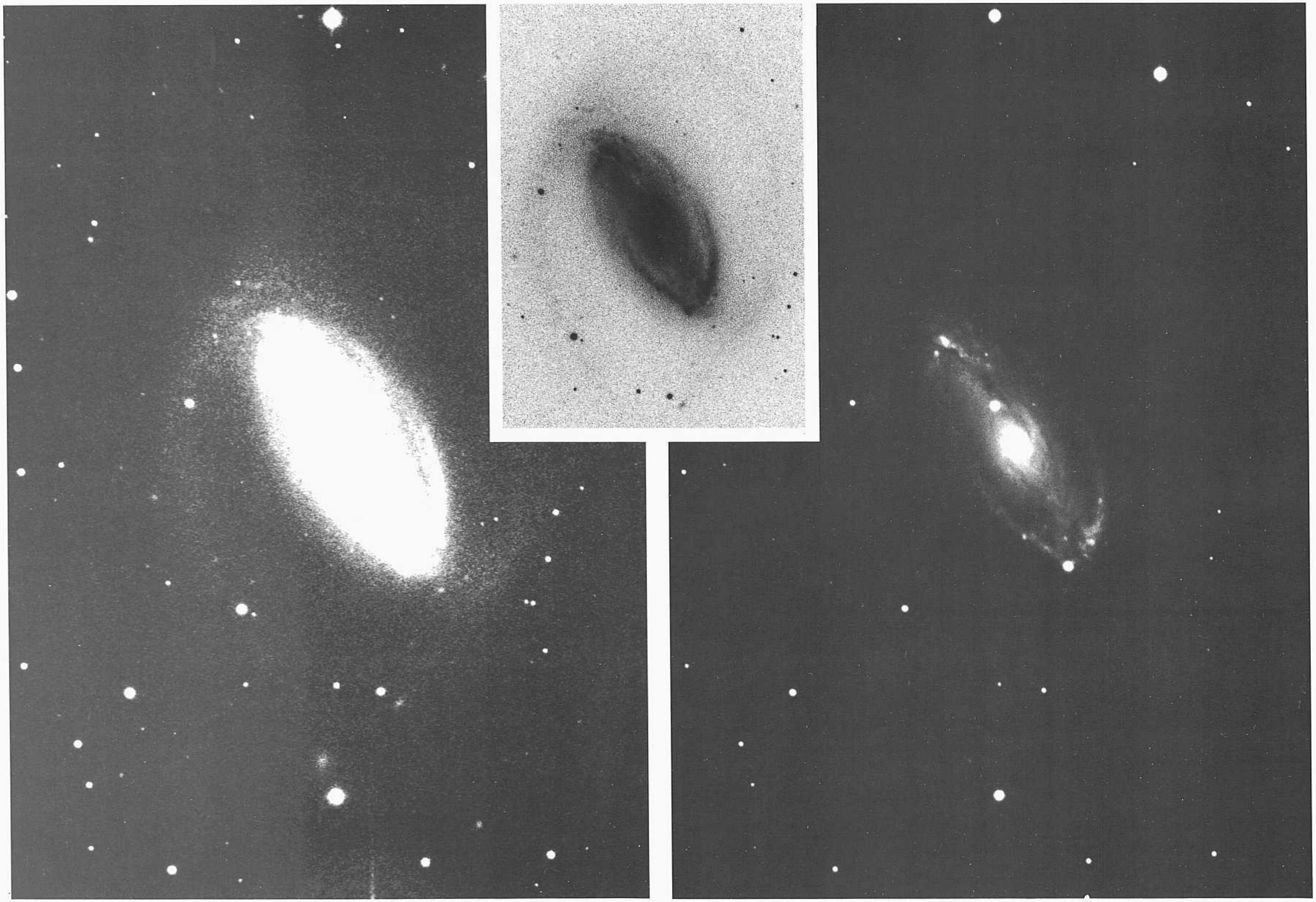
The spiral pattern of the luminous arms in NGC 4394 is intermediate between the (s) and the (r) subtypes, noted here by the mixed designation of (rs).

NGC 4394 is in the region of the Virgo Cluster north of the center of subcluster A around NGC 4486. Its redshift is u_o = 853 km s^{-1}.



PANEL
165

PANEL
166



NGC 5728 sm><s)ll
CD-226-S
IV!) 13/14, 1978
103aO + GG385
15 miii

The bar in NGC 5728 is weak, is a **light oval,** and lias **considerable internal structure in dust.**

Two sets of spiral arms **exist. The very-high-surface-brightness inner set spring from the ends of the l>ar. as in NGC 1 300,** and **arc \er\ Light!)** wound, nearly **overlapping out* another after half** a **revolution. The impression of near-overlap is enhanced here** because **of** I he hijili **inclination angle to** the **line of si^bl.**

Two straight dust lanes **exist on** each **of the leading edges of the bar.** One lane **is more visible** than **the other, presumahl)** because **of** the usual **different projection effects It** lie **normal asymmetry** of dust **patterns) on the** near and **the far sides.** Besides **the straight** dust lanes **on the leading** bar edges, spiral **dusl** lanes exist within **the** bar oval, as seen **on** the near side in **the** low-contrast **print.**

1111 regions are **present** in the inner arms near their **beginnings at** the **end of** the bar.

A set **of very-low-surface-brightness regular** outer arms exist, also **beginning** at the ends of **the** bar. seen only in the **high-contras!** print.

The **redshift** is v_Q = 2K0I) **km** s"'. The absolute **magnitude of** the **galaxy** is **bright at** $.W_($ = -22.5.

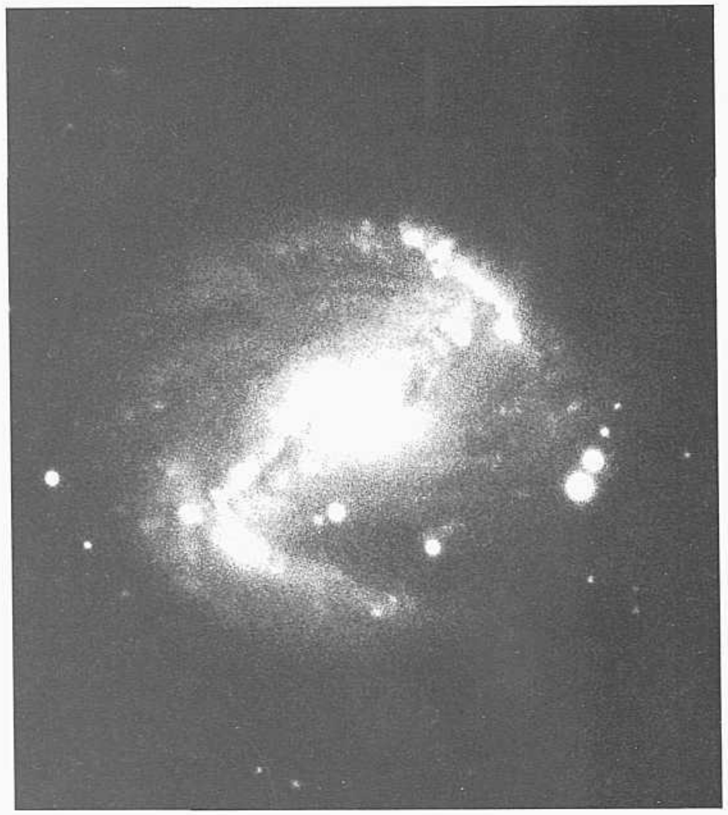
NGC 613 SBb(rs)II
CD-443-Rose
Aug 9/10. 1978
103a0 + \Yr2c
90**min**

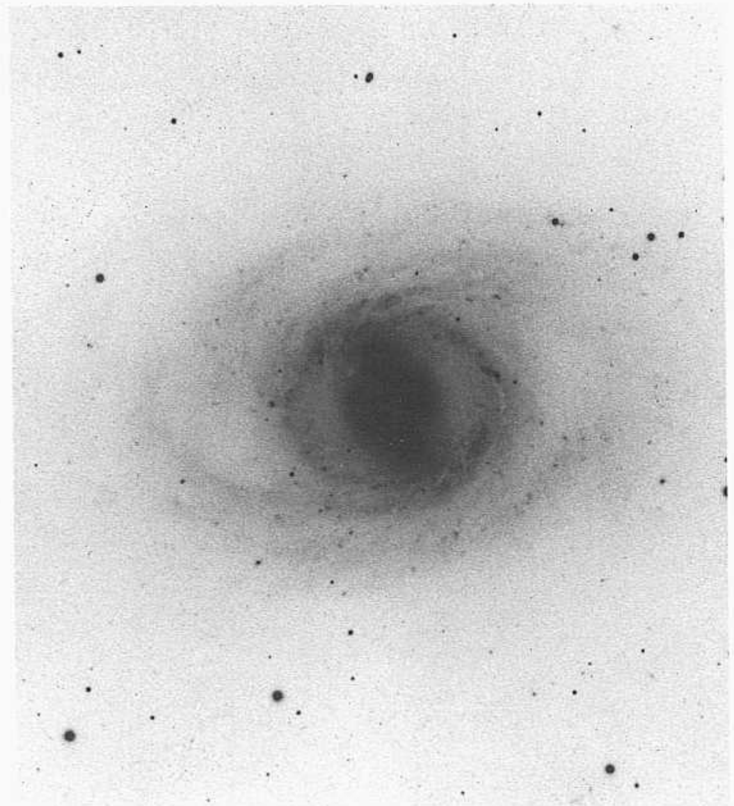
The bar in NGC 613 is a strong (high-surface-brightness) oval. The characteristic two straight dust lanes on opposite sides of the oval are evident. Each lane is on the leading edge of [lie oval as judged from the direction of rotation determined by the sense of the spiral pattern. Other dust lanes at the outer boundary of the oval are curved into spiral patterns at sharp pitch angles which differ from the pitch angles of the outer spiriil arms. 'The various patterns of inner luminous arms and inner dust lanes have a striking resemblance to maps of velocity fields based on calculations of the hydrodynamic response of gas to the rotating bar (or oval) gravitational potential, as cited in the description of NGC 13110 (compare **Huntley** 1980 with earlier references).

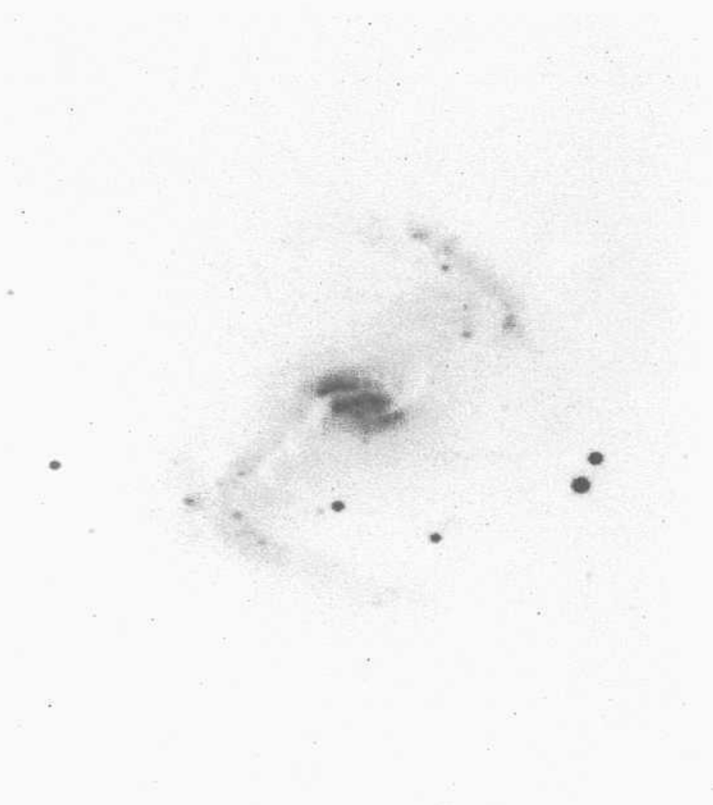
The high surface brightness of the arms and Ilie man) 1111-region candidates show a moderate-to-large current star-formation rale. The largest **1111** regions resolve at the 3" level. The redshift of NGC 613 is v_o = 1534 km s"'. The absolute magnitude is bright, at *M%* = —22.2 *H* = 50|.

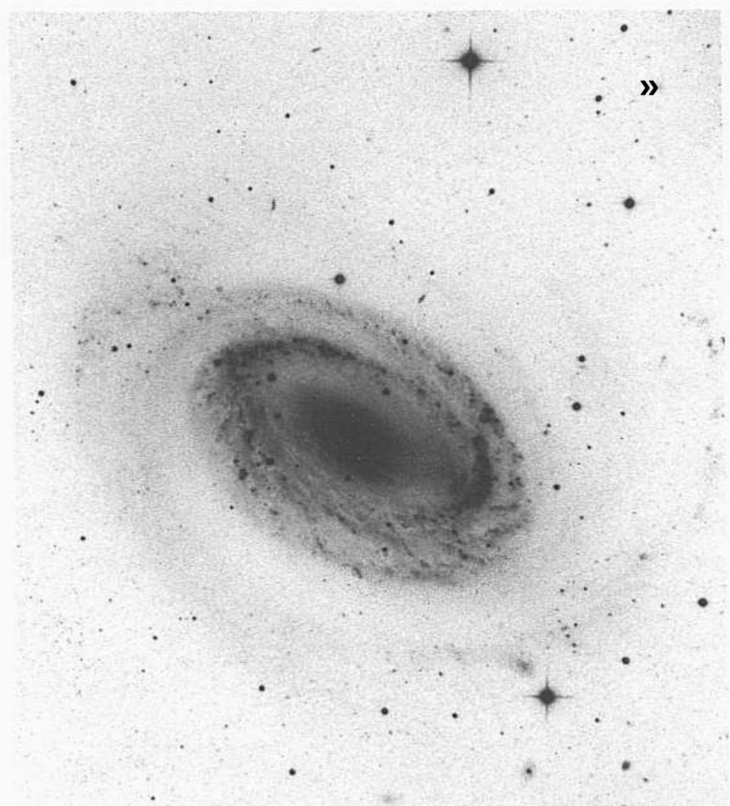
PANEL
167

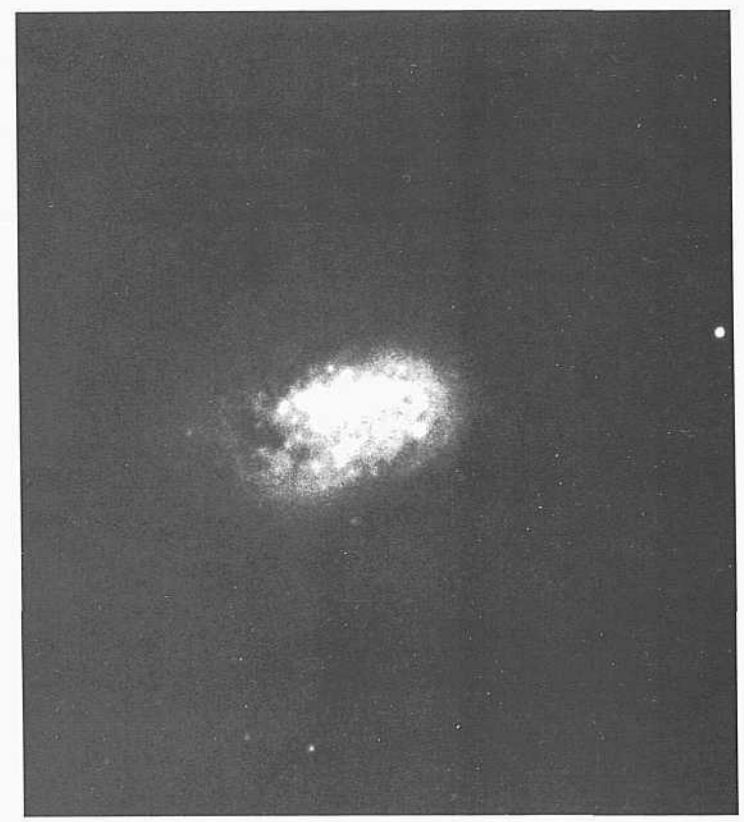
PANEL
168











The five galaxies on this panel arc of later luminosity class than most of the previous galaxies in this section. The arm pattern is generally less well defined, the arms arc thicker, and the inter-arm region is more lieavih filled with spiral-arm material.

NGC 5383 **SBh(s)II** **HA, p.** ***46***
PH-8099-S
Feb 6/7, 1981
103aO
12 niin

High- and low-contrast prints of NGC 5383. shown here anil below, arc made from different original plates, one with the Palomar Hale 200-inch and the other with the Mount Wilson 60-inch telescopes.

The most prominent feature of NGC 5 383 is the characteristic two-lane dust pattern along the bar. One o(the lanes is very straight; the other has curves in its passage from the center to the end of the liar.

The arms that begin in an (s)-type NGC 1300-like pattern are brightest near their junction with the ends of the bar. Low-surface-brightness fragments of arms exist as branches (twigs?) inside (i.e.. ('loser to the bar) the positions of the two major arms.

The redshift is $v_{,,}$ = 2322 $kn_1 s^{-1}$.

NGC 5383 SBb(s)II HA, p. *46*
S-195-Pease
April 3/4, 1913
probably blue
180 min

The Mount Wilson plate used here was taken by the legendary astronomer Francis Pease, engineer extraordinary, who designed the Mount Wilson 60-inch and 100-inch reflectors and did much of the early design of the Palomar 200-inch telescope.

The nature of the dust pattern in the center of NGC 53 83 is well seen in the low-contrast print here of the central regions. One lane passes in front of the nucleus, the other behind it. This form may he present in all SBb galaxies having straight dust lanes, but is seldom seen with the clarity that is provided by the particular viewing aspect given us with NGC 5383. The detail is also well seen in the Hubble Atlas print, made from the same Mount Wilson 60-inch plate used here.

NGC 3351 **SBb(r)II** **HA, p.** ***48***
PH-315-S panel 170
Jan 8/9, 1953
103aD + GG11
30 miii

NGC 335 1 is seen almost lace on. The details of the nearly complete inner ring are well ^*vrn* at this viewing angle. The two main inner arms spring from the end of a very strong bar. They nearly meet after each has turned by 180°, giving the impression ol a true ring, yet the structure is clearly broken, being composed oi two separate spiral segments.

The outer arms, of low surface brightness, are multiple and are branched into separate fragments, none of which can be separately traced for more than about one-quarter revolution.

Star formation is only moderate in these outer arms. The I III regions are few and are small. The redshift of NGC 3351 is small, ill v_0 = 641 km s^{-1}. yet the stellar content is not well resolved.

The high-surface-brightness inner arms forming the usual near-ring pattern are well seen in the Hubble Atlas print where, however, the extensive low-surface-brightness outer arm pattern is largely invisible, it is well seen in the print here.

NGC 4725 Sb/SBb(r)II HA, p. *21*
H-2156-H
Jan 2/3, 1941
Cr-Hi-Sp-Sp
80 niin

The bar is not well defined in NGC 4725. It is a region of enhanced luminosity but still of low surface brightness, elongated across the centra] lens. (See the print in the Hubble Atlas for good detail of this region.)

The inner, high-surface-brightness spiral pattern forms one of the most complete near-rings of any galaxy in tin[1] RSA. Star formation is hlgh in this near-ring. Many bright UII regions exist, as well as a number ol faint small ones. A few of these in the outer faint-surface-brightness arms resolve into disks at the 3" level. The redshift of NGC 4725 is v_o = 1 167 kms~\

Very-faint-surface-brightness outer arms are branched. The principal one of these arms is an extension of a bright inner arm that forms part of the nearly complete inner ring. 'Phis arm branches into two, which then travel together for another 200° of unwind.

NGC 6300 SHh(s)II pec
CD-1479-S/Rr
May 1 1/12, 1980
103aO + GG385
15 miii

NGC 6300 is in low galactic latitude *{b* = -14°), ami ma) have Galactic dust silhouetted against its face.

The original plate from which the print here is made was obtained in poor seeing, clearly seen from the size of the stellar images.

The bar is ill defined bul evidcntl) is straight. The arms spring from opposite sides of outer regions, far from the nucleus and. evidently, from the ends of a bar.

Dust is evident, but. again, some of what is seen may lie of superposed Galactic origin. The arms are branched, one alter about half a rev olution from its origin on the bar. The other arm branches twice, once after about 15° of unwind and again after about a one-quarter additional turn. Outer, low-surface-brightness fragmented multiple arms are extensions of the bright inner arms.

NGC 5691 S(B)b pee **III:**
CD-1391-S/Br
March 21/22, **1980**
L03aO
75 miii

The classification of NGC 56V 1 is uncertain. There is a suggestion of a bar in a region ol enhanced luminosity buried in the disk: hence the S(B) tentative classification is given. A weak spiral pattern exists together with dust patches and knots which are presumed to he 1111 regions. The chaos is high; hence the low luminosity class, by definition, is assigned. However, the absolute magnitude is still moderately bright at M_{fi} = -20.3. The redshift is v_0 = I76K km s~[!].

SUMMARY OF THE SBb CLASSIFICATION SECTION (PROTOTYPE EXAMPLES)

The galaxies on this and the following panel are **illustrated** as summaries **of similarities** in the basic **forms of** outer arm structure (this page) and characteristics of strong bars (next panel). Four of the five galaxies shown on these two panels have been illustrated in previous panels **of** this SBb section.

The images **of** all four galaxies on this page have been overprinted to show the structure of the faint-surface-brightness grand design outer arms; the central barred regions are mostly burned out but are shown on the next panel.

The outer arm pattern in all four cases here is highly symmetric on reflection **of** any part **of** the pattern through the center.

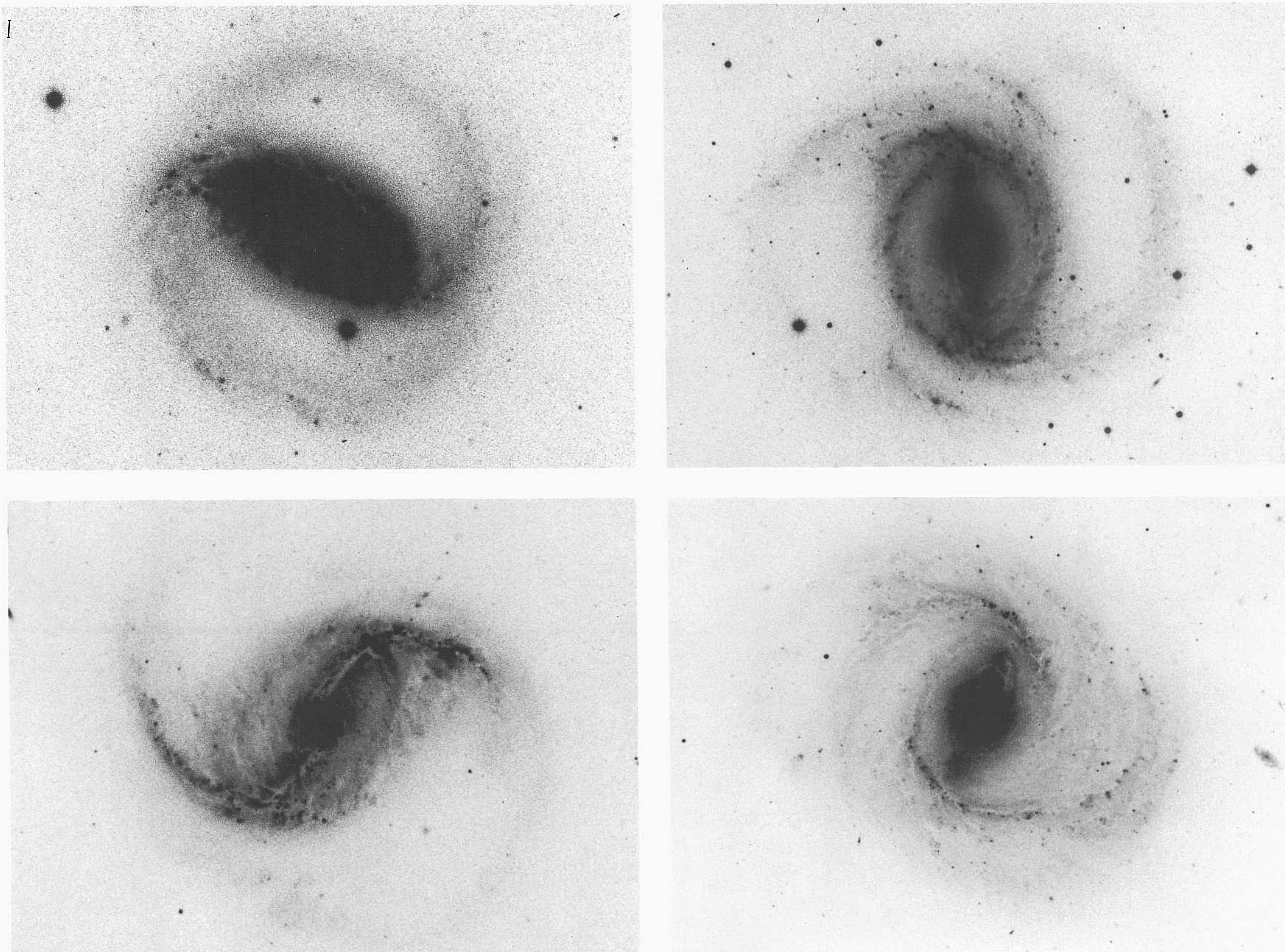
The two main outer arms can each be traced for about a half revolution, at which point they come close to, but are slightly outside, the point on the bar where the opposite arm begins, forming an almost-complete outer ring. The closest to a completed outer ring occurs in NGC 3504, at the upper left.

NGC 3504 **Sb(s)/SBb(s)I-n** HA, p. 46
PH-1169-S panel 157
Dec **14/15,** 1955
103aO
30 niiii

NGC 1433 SBb(s)I-H panels 158, 170
CD-177-S
Feb 6/7, 1978
103aO + GG385
45 niin

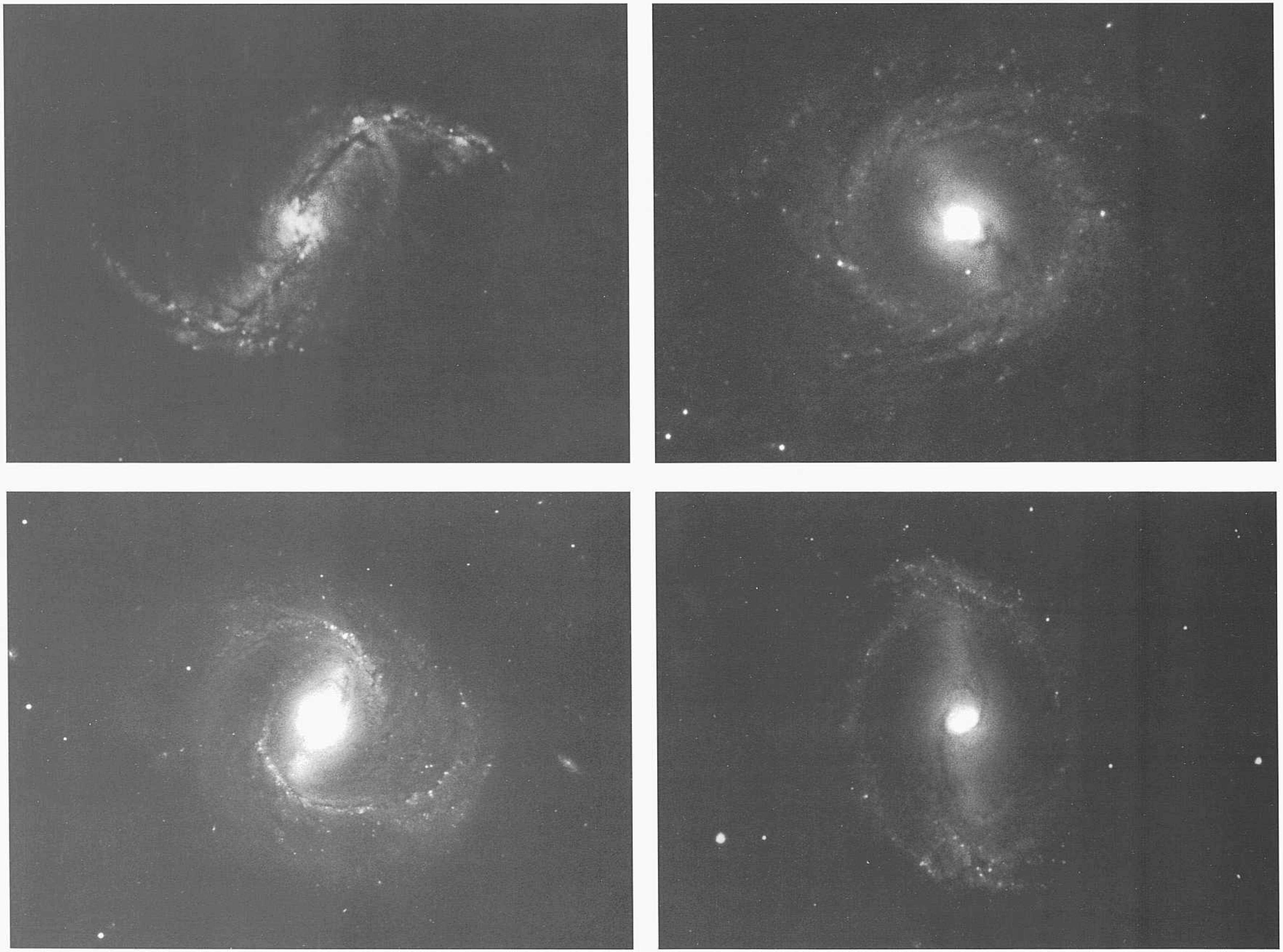
NGC 986 SBl)(:s)I-II panels 158, 170
CD-2007-Bedke/Gregory
Oct 23/24, 1981
103aO + GG385
45 mill

NGC 4548 SBb(is)I-II VCC 1615
CD-756-S HA, p. *48*
Feb 4/5, 1979 panel 170
103aO + Wr2c
50min



PANEL
169

PANEL
170



Each of the four galaxies on this last panel of the SBb section have strong bars **from** whose ends the outer spiral pattern begins. There are no true complete inner rings in any of these four galaxies, although the near-overlapping of the first set of high-suriace-brightness inner arms in NGC 3351 and NGC 1433 in the right-hand column gives such a first impression. Yet close inspection shows that each set of inner arms begins from the ends of the bar in the manner of NGC 1300 (panels 154, S8).

The characteristic straight dust lanes at the two leading edges (relative to the direction of the rotation determined by the sense of the spiral **pattern)** of **the** bar are well seen in NGC 986, at the **upper** left. Similar. 1>111 less **pronounced** and less straight lanes exist in NGC 4548 (lower left) and NGC 1433 (lower right). Only one such lane exists in NGC 3351 **(upper** right), and it is less regular than in the other galaxies here.

Calculated models ol **the hydrodynamical** response of the gas to a rotating bar, cited in **the description** of NGC 1 300 (panel 154), **reproduce** well **with the patterns** of **the dust** lanes, the central oval **around** the bar. and the outer spiral arms.

NGC 986 SBIi(is)Wl panels 158, 169
CD-2007-Be<lke/Gregory
Oet 23/21, 1981
103aO + GG385
45 mill

NGC 4548 SBh(is)I-II VCC 1615
CD-756-S HA, p. *48*
Feb 4/5, 1979 panel 169
103aO + Wr2c
50 mill

NGC. 3351 **SBb(r)II** HA, p. *Hi*
PH-314-S panel 168
Jan 8/9, 1953
103aO + WG2
15 mill

NGC. 1433 SBb(s)I-D panels 158, 169
CD-177-S
Fcl) 6/7, 1978
103aO + GG385
45 min

The Sbc Classification Section

In this section we show the Shapley-Ames examples of the intermediate class of Sbc, defined simply to be later than Sb and earlier than Sc in the size of the central bulge, the openness of the arms, and the current rate of recent star formation therein.

The galaxies on this and the following pages show spiral arms of the grand design type. They are ordered by luminosity class (geometrical entropy). The Sbc galaxies with filamentary arms are set out on panels 184-192, again ordered by luminosity class. The section closes with Sbc galaxies having interesting dust, or that are nearly on edge, or that comprise interacting pairs or multiples.

NGC **1566** Sbc(s)1.2 Dorado **#53**
CD-1662-S **panel S5**
Dec 30/31, 1980
103aO + GG385
45 min

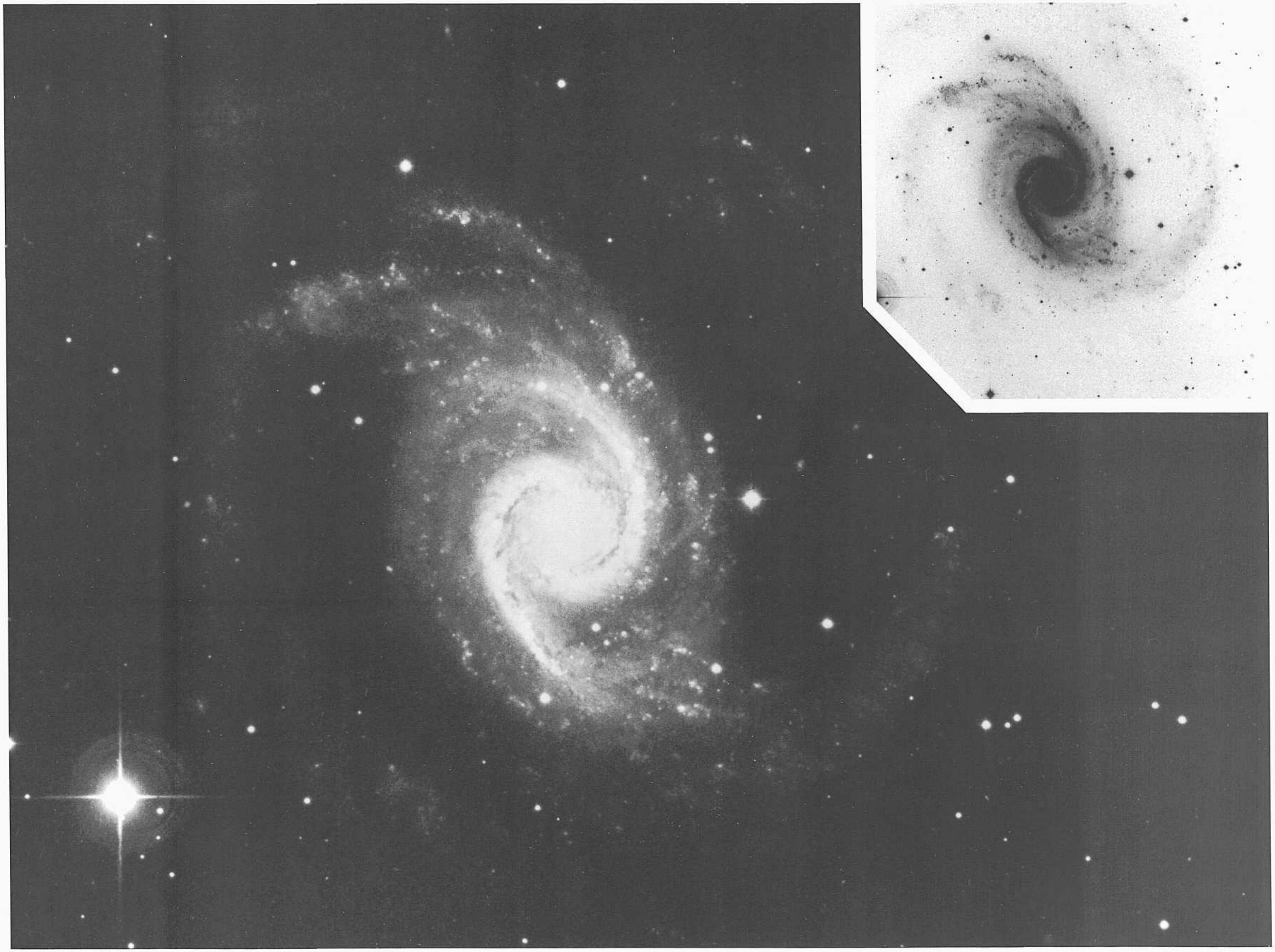
NGC 1566 is an awesome sight. No written description is adequate to convey the scene when the galaxy is viewed through an eyepiece at the focus of a telescope rather than on an electronic screen.

The inner two grand design arms (seen in main print) are of very high surface brightness and are studded with HII regions. Each arm can be traced at high surface brightness for half a revolution of unwind from beginnings on opposite sides on the rim of the central bulge. Dust lanes can be traced closer to the center than the beginning position of the luminous arms.

Sets of low-surface-brightness outer arms with fragmented branches exist outside the two main grand design inner arms. The pattern of the two outermost of these faint arms is highly symmetric; each can be traced for another half revolution.

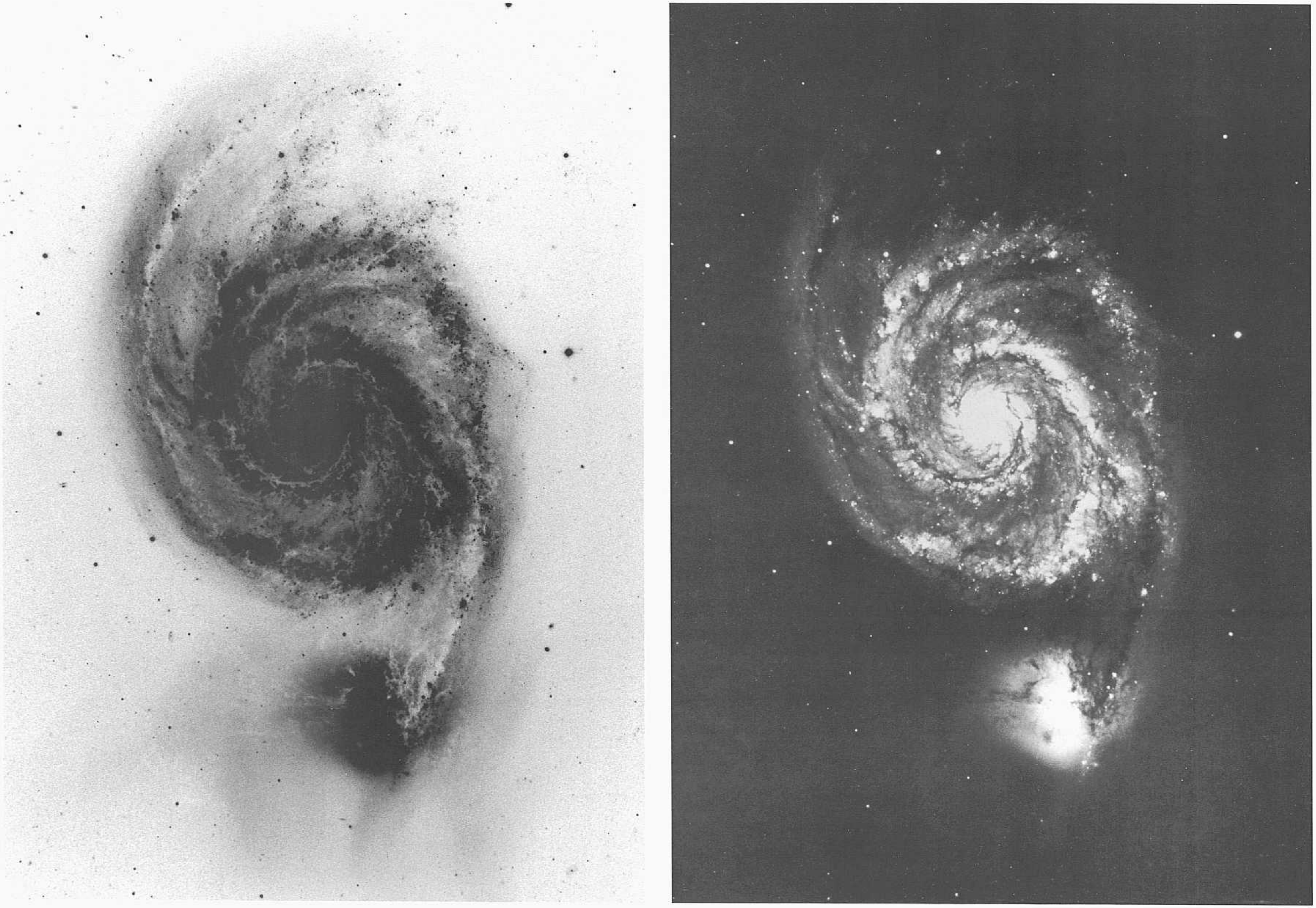
The resolution of the arms into individual stars and HII regions occurs at a slightly brighter level than in the giant spirals of the Virgo Cluster.

NGC 1566 is the brightest galaxy in the Dorado Group (Ferguson and Sandage 1990). The adopted mean redshift of the group is $<v_o> =$ 1056 km s''. The redshift of NGC 1566 itself is «„= 1305 km s''.



PANEL
171

PANEL
172



NGC 5194/5195 Sbc(s)I-II HA, pp. *26, HI*
PH-201-MH SBOi pec M51
May 14/15, 1950 panels 55, 177
103aO
20 min

NGC 5194 (MSI) is similar Lo NGC 1566 on the preceding panel. The surface brightness of the two principal grand design arms is high, seen best in the print on the right. 'This lighter print shows the intricate but well-organized dust lanes inside the two major inner arms. Dust is also present in the inter-arm region, well silhouetted against the background disk lijihl at the rim of the bright central bulge where the short dust lanes emerge almost radially from the bulge before breaking into the general spiral pattern.

The heavy print on the Left shows the smooth luminosity lhat envelops the companion whose classification is outside the classification system, although it has variously been classified as SBO pee and Amorphous. The dust lanes from one of the branched arms of M5 1 are silhouetted against the companion, which obviously is behind the arm that sweeps across its image.

The strength of the. spiral pattern is well shown in the composite photographs given by Zwicky (1955). where the dust pattern is also particularly well seen. The prevalent dust lanes in the central bulge close to the nucleus are shown in a greatly enlarged image of the center on page *31* of the Hubble Atlas.

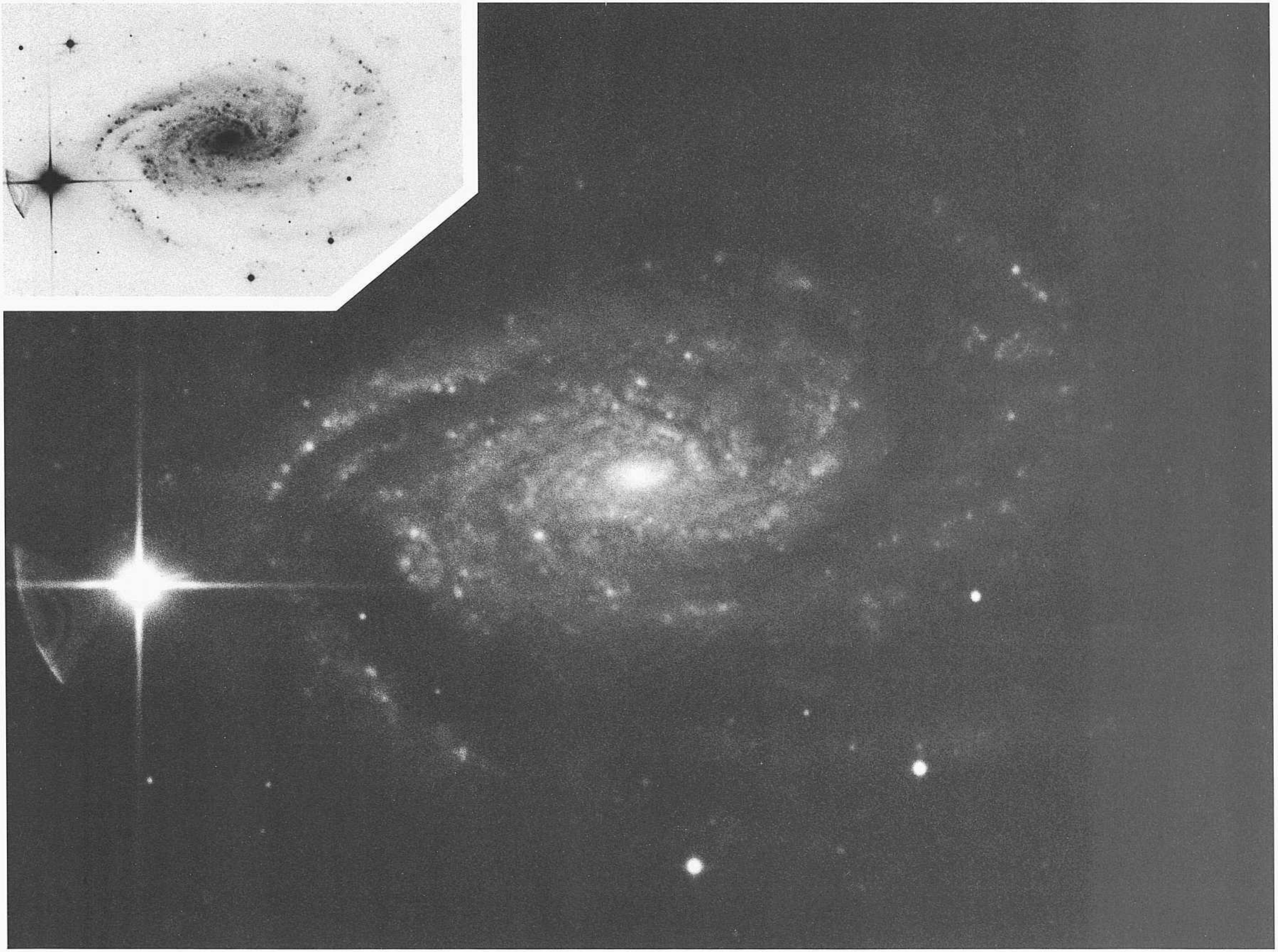
The distance to M5 1 is considerably smaller than the distance to the Virgo Cluster, as judged by the ease of resolution into brightest stars and HII regions. The redshift of M51 is v_0 = 541 km s^{-1}. This value is consistent with the distance modulus of $m - M = 30$, estimated from the ease of resolution into stars.

This agreement shows that any random (non-cosmological) velocity is near zero within the distance of 10 Mpc from the Local Group. This conclusion follows because the velocity-distance ratio (i.e., the local value of the Hubble constant) for M5 1 itself is 54 km s^{-1} Mpc^{-1} using the M51 distance modulus of $m - M = 30$ (D = 10 Mpc). and noting that this local ratio is the same as the *global* value of the Hubble constant (Sandage and Tammann 1990).

NGC 3338 **Sbc(s)I-II**
CD-1711-S
Jan 6/7, 1981
103aO
75 min

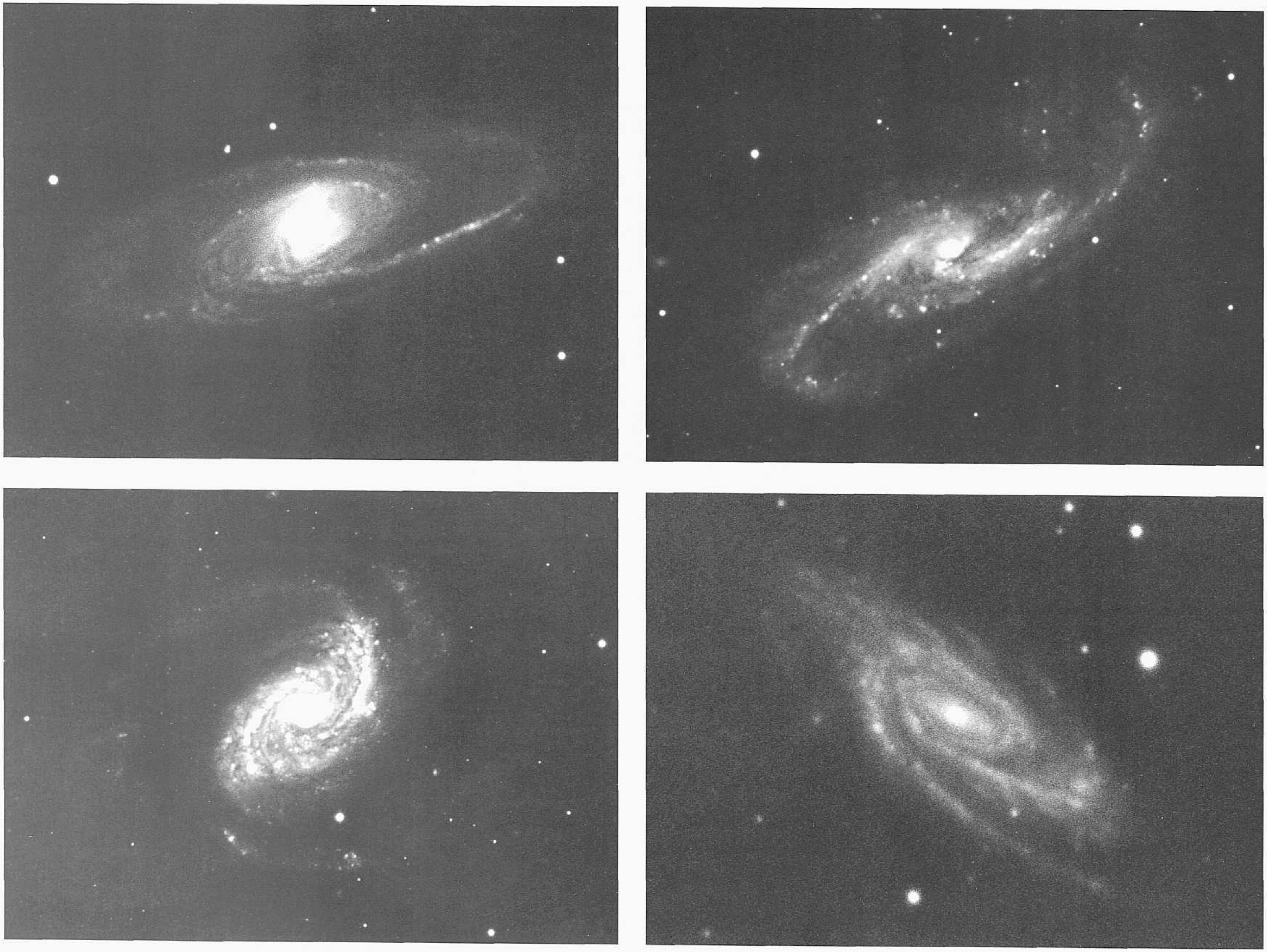
The spiral pattern **of** NGC 3338 is intermediate between **that** of a grand design and **filamentary** (MAS) type. The galaxy is shown **here** in the grand design section because of its similarity to NGC 1566 (panel 17 1) **and** M51 **(preceding** panel). When viewed more face on (by tipping **the print** along **the** minor axis and viewing the page almost edge **on)** the similarity becomes apparent. **There are two** major arms, which specify the grand design, but as in M51 **the** inter-arm regions also contain spiral **fragments.**

The arms in NGC 3338 are thin and well ordered: hence **the** early luminosity class is indicated. The largest of the many HII regions **resolve** at the 2" level. The redshift of NGC 3338 is $v_o = 1171$ km s^{-1}.



PANEL
173

PANEL
174



The spiral patterns of the four galaxies on this panel are of the grand design type; each has two major spiral arms that can be well traced for an unwind of more than a half revolution.

NGC 2713 Sl>c(s)I
CD-1292-S/Br
March 10/11, 1980
103aO + GG385
45 min

The two outer arms in NGC 2713 are very thin, regular, and are not branched into fragments. They can be traced into the center in a tightly wound pattern. A few bright, unresolved HII regions exist in each of the outer arms. The redshift of NGC 2713 is v_0 = 3690 km s~'.

NGC 5248 Sbc(s)I-II HA, p. *33*
PH-209-MH
May 15/16, 1950
I03a0
30 min

The two major spiral arms dominating the inner disk of NGC 5248 have high surface brightness, similar to the pattern in NGC 1566 (panel 171) and M51 (panel 172). The spiral pattern breaks into three fragments of very low surface brightness beyond the rim of the inner disk. The two main spiral fragments of this outer pattern are well defined and can be traced outward for another half revolution.

Resolution into individual stars occurs at apparent magnitude of about B = 22, which is about I mag above the plate limit. The largest of the numerous HII regions resolve at the 3" level. The redshift of NGC 5248 is v_0 = 1049 km s^{-1}.

NGC 4536 Sbc(s)I-U VCC 1562
CD-2139-S
March 22/23, 1982
103aO
50 min

NGC 4536 is one of the largest spirals in the Virgo Cluster region. It is located about 6° smith of the center of Virgo subcluster H around NGC 4472 , and is near the beginning of what was once called the southern extension of the Virgo Cluster, now known as the Virgo Cluster envelope along the supergalactic plane. The redshift of NGC 4536 is y„ = 1646 km s"^{1}.

The spiral pattern is dominated by the two principal spiral arms, clearly of the grand design type. Many HII regions exist in the arms, the largest of which are resolved into disks with core diameters of about 3".

NGC 7124 Sbc(rs)I-U
CD-1554-S/Br
Aug 8/9, 1980
103aO + GG385
45 min

NGC 7124 is one of the most distant galaxies in the Shaplcy-Ames Catalog, having a redshift of u_0 = 4957 km s^{-1} . The spiral pattern is highly organized into the grand design type; there are two principal spiral anus that can each be well traced for slightly more than a half revolution. The HII knots in the arms arc unresolved at the 1" level.

NGC 7038 **Sbc(s)1.8** **Indus Gr**
CD-1157-Br
Aug 22/23, **1979**
103aO + GG385
15 **niin**

Based on the redshift of v_o = 4785 km s^{-1}, NGC 7038 is placed as a member of the NGC 7014 Indus Group, whose mean redshift is $<v_o>$ = 4934 km s¯' (Sandage 1975b): the galaxy is one of the more distant in the RSA.

NGC 7038 is illustrated here in the grand design section because the number of arms is small compared with **the** many fragments present in galaxies of the filamentary (MAS) type, shown later in this section (panels 184-192).

The arms are narrow and are well formed, with only sparse arm material in the inter-arm region explaining the early luminosity class. Much recent star formation is evident in the arms. The numerous HII regions are unresolved at the 1" level, consistent **with** the large redshift distance of 96 Mpc (/-/ = 50).

NGC 5592 **Sbc(s)I-II**
CD-1470-S/Br
May **10/11,** 1980
103aO + GG385
45 niin

NGC 5592 has one prominent, thin, high-surface-brightness arm and the beginning of a symmetrical opposite arm that fragments into a series of low-surface-brightness arm fragments of the filamentary type soon after its beginning near the center.

The redshift is v_0 = 4190 km s'". The several brightest HII regions in the bright arm are unresolved at the 1" level.

NGC 6814 Sbc(rs)I-II **HA,** p. *20*
PH-236-B
Sep 11/12, 1950
103aO + GG11
30 **niin**

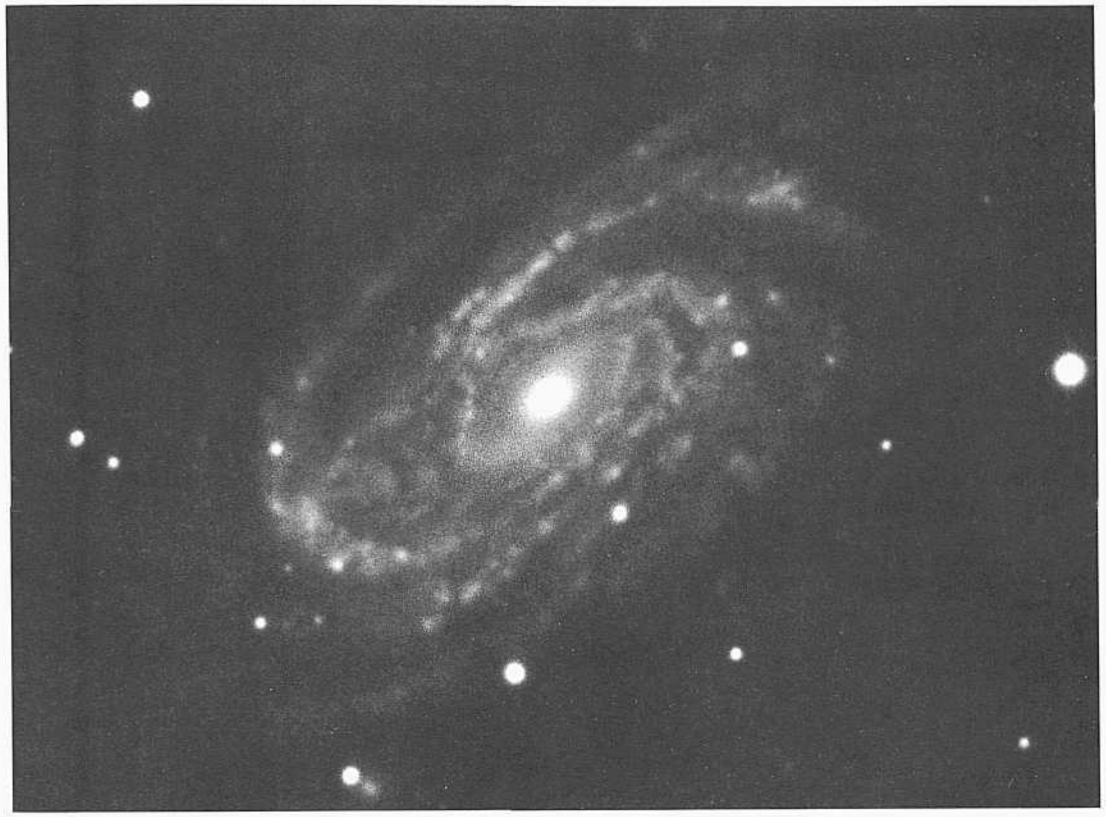
The spiral pattern in NGC 6814 has features of both grand design and multiple-armed (MAS) types. However, the arms are quite well defined as separate entities unlike the arms in pure MAS galaxies, such as NGC 2841 (panels 142, S4, S12). Here, the main arms can each be traced for about half a revolution before they branch and become multiple.

The redshift is v_o = 1643 km **ī¹,**

NGC 7531 **Sbc(r)I-II**
CD-550-S
Oct 2/3, 1978
103aO + GG385
45 mill

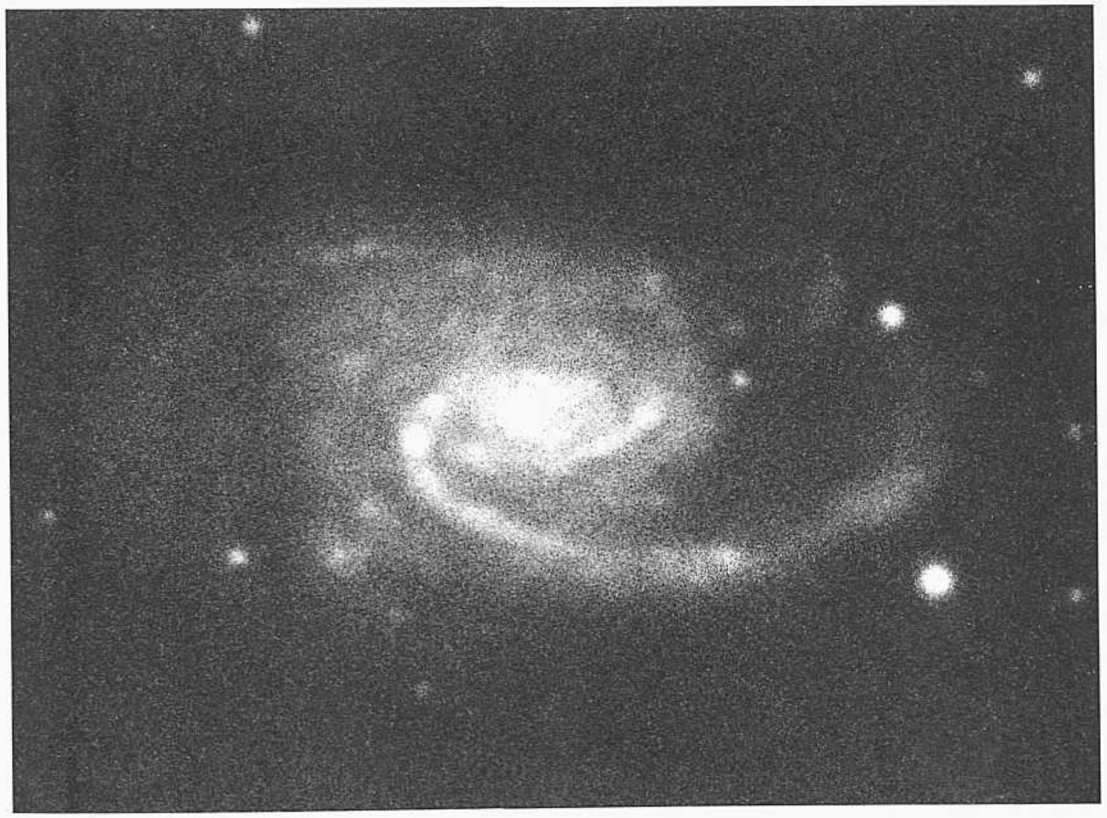
Two main outer arms are each attached to the rim of a high-surface-brightness inner disk, within which a tightly wound luminous spiral pattern also exists. Numerous HII regions are present in the disk arms and in the outer arms as well. The largest of the HII regions resolve at the 2" level. Theredshift of NGC 7531 is v_o- **1607** km s-¹.

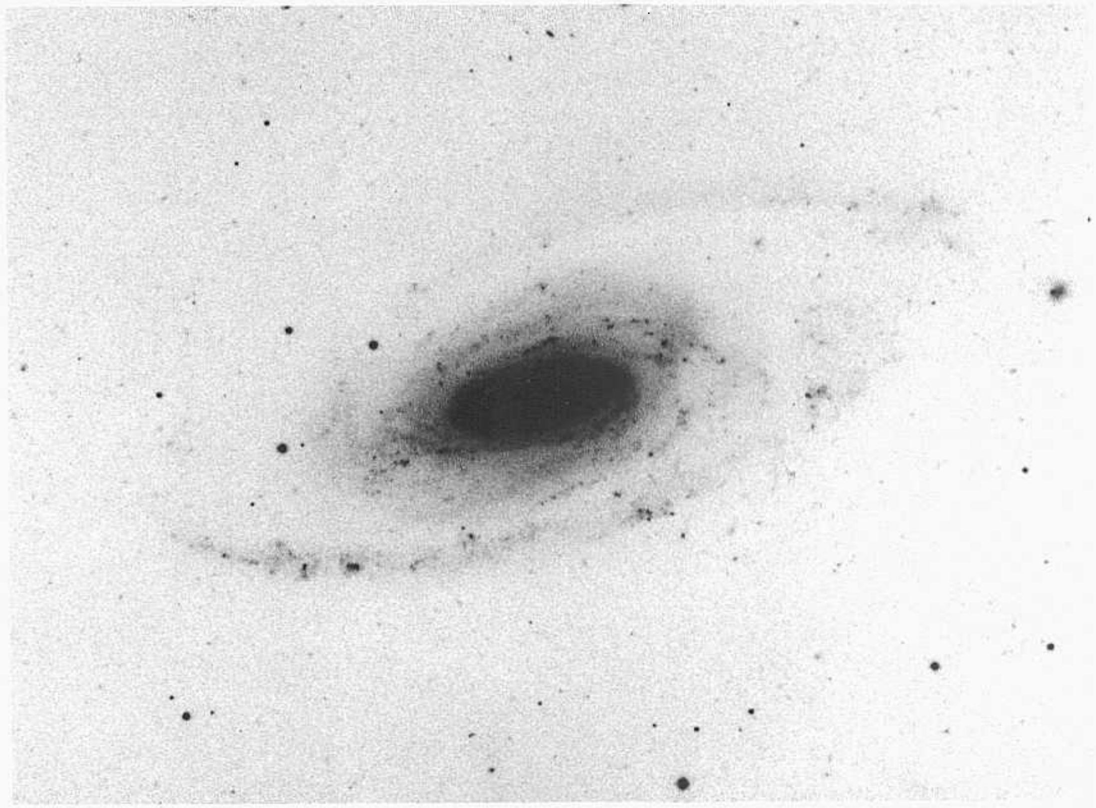
If seen more face on, NGC 7531 would resemble NGC 3031 **(M81;** panels 129, 332), but it is of slightly later type because the central bulge in NGC 7531 is smaller.



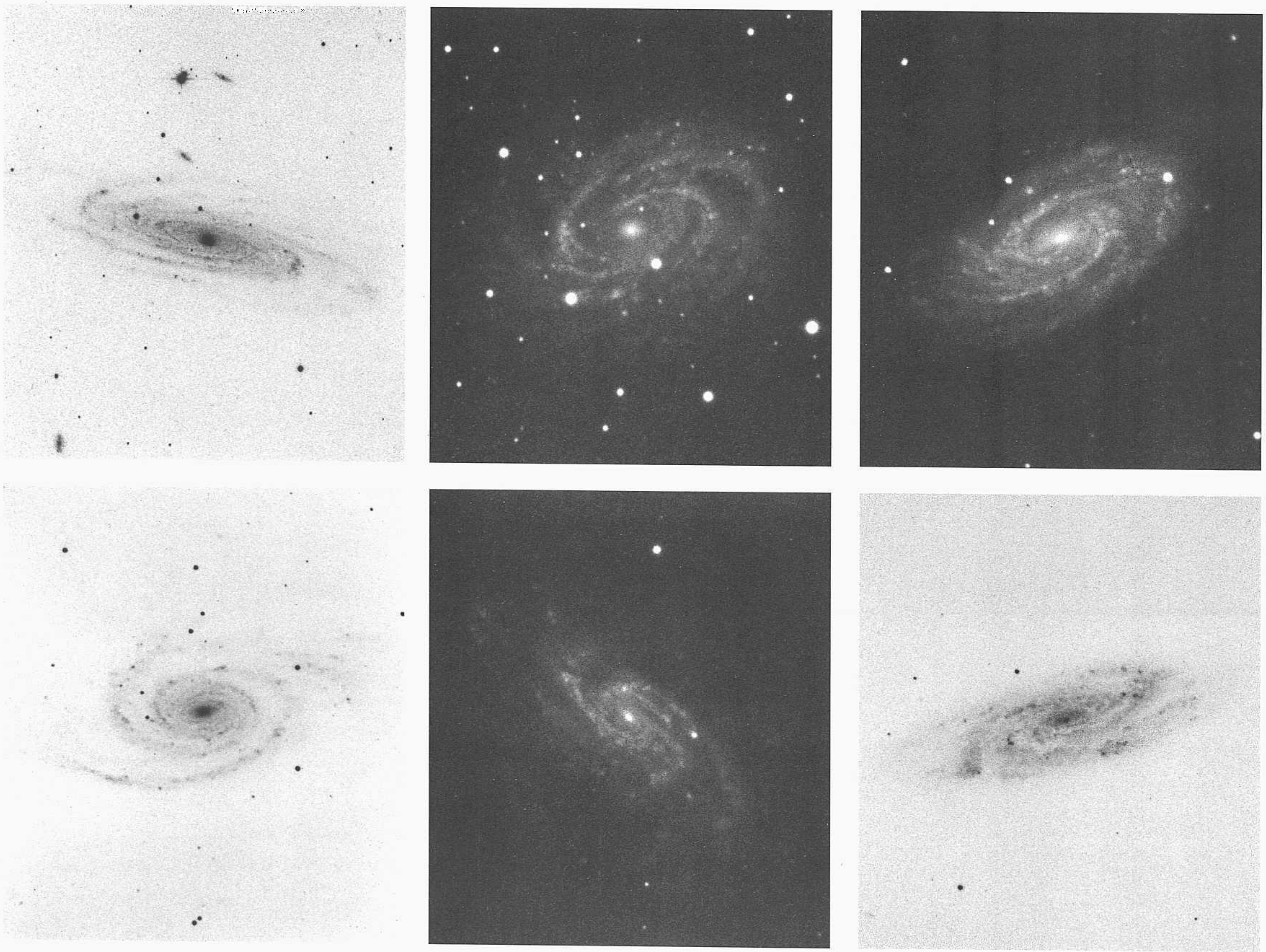
PANEL

7 75





PANEL
176



Most of the galaxies on this panel are classed as grand design types despite giving a first-glance impression of a multiple pattern. On second inspection, each of the six galaxies here has two principal arms, which can be traced for at least half a revolution (from their beginning in the central region) before they branch into well-defined fragments continuing outward. That the branched outer arms are progeny of the two inner grand design arms is definite. The ability here to identify **the** parenthood of the outer-arm fragments differs from the case in **a pure** MAS **pattern,** such as **that** of **NGC** 284 **1** (panels 142, S4, S12) and INCC. 488 (panels **I 15,** 1 1 6, S3, SI 2), **where** the arms fragment so complete- ly thai their parenthood close to the center cannot be determined,

NGC 3200 **Sb(r)I**
CD-810-S
Feb 25/26, 1979
103aO + GG385
45 niin

The spiral arms in NGC 3200 are very thin and well defined. The pattern is similar to that in NGC 3031 (panels 129, 332) except that the central bulge and smooth inner disk in NGC 3200 are smaller; the galaxy is later in the classification sequence.

The very early luminosity class is due to the great regularity of the spiral pattern. The red- shift of NGC 3200 is v_o = 3313 km s'". The absolute magnitude, based on the redshift dis- tance of 66 Mpc *(II* = 50), is M_B = -23.0, which is among the brightest galaxies in the Shapley-Ames Catalog (see Fig. 5 of the RSA).

NGC 4939 Sbc(rs)I
H-1812-H
May 3/4, 1937
Imp. Eel.
40 niin

The two principal outer arms in NGC 4939 are remarkably thin. They can each be traced inward in a nearly continuous way for about 1 1/4 revolutions, which is unusually large. The arms are very regular and are well formed, re- quiring, by definition, the very early luminosity class.

The redshift is v_o = 2903 km s^{-1}, giving a redshift distance of 58 Mpc. The apparent mag- nitude, corrected for absorption, is *Bp* = 11.0, which gives the bright absolute magnitude of M_B = -22.8, similar to that of NGC 3200 above.

The pitch angle of the arms is close to 0°: i.e., if NGC 4939 were viewed face on the spiral pattern would appear nearly circular, as in NGC 488 (panels 115, 116, S3, S12).

NGC 4603 Sbc(s)I-H Centaurus Cluster
CD-2168-S
March 27/28, 1982
103aO + GG385
45 min

Two principal arms can be traced in NGC 4603 starting as Luminous segments at the rim ol the inner disk. These can also be traced farther inward as dust lanes.

Branching occurs as the luminous arms are traced outward; the outer spiral pattern appears mildly multiple. Particularly interesting is the "third" principal outer arm, which begins as two branches connected to nothing in the inter- mediate disk on the left side of the major axis here, meeting as they wind outward into a single outer fragment.

The redshift is v_o = 2073 km s^{-1}. The galaxy is on the western edge of the rich Centaurus Cluster. It is listed as entry 120 in the master catalog of Dickens, Currie, and Lucey (1986).

NGC 3430 Sbc(rs)I-II
PH-7996-S
Feb 2/3, 1981
103aO
12 min

The spiral pattern in NGC 3430 is inter- mediate between the grand design and the MAS types. The arms are thin. The high-surface- brightness segments can each be well traced for at least half a revolution.

The redshift is u_o = 1555 km s^{-1}.

NGC 7171 **Sbc(r)I-H**
CD-1585-S/Br
Aug **11/12, 1980**
103aO + GG385
45 mill

The two principal arms of relatively high surface brightness begin at the rim of the inner disk in NGC 7 17 1. They can be traced for aboul half a revolution before disappearing. Multiple arm fragments ol lower surface brightness exist between the two principal arms.

The 1111 regions lire generally unresolved. The redshift of NGC 7 17 1 is v_0 = 27f>!S km s'".

NGC 7721 Sbc(s)II.2
PII-7691-S
Sep 26/27, 1979
103aO
10 min

NGC 772 1 is of later luminosity class than the other galaxies on this panel; the arms are thicker and less well defined. The pattern is of the grand design type.

The many bright 1111 regions in the prin- cipal arm are unresolved at about ihe 1 .5" level. The redshift of NGC 772 I is ,-,, = 2 191! km s'".

NGC 5194/5195 Sbc(s)I-II HA, pp. *26, 31*
PH-3922-S SBO| pec M51
March 30/31, 1962 panels **55,** 172
103aE + Ha **interference**
120 iiiin

The I lot interference filter image of NGC 5 1 94/5 1 95 on the facing page illustrates why the spiral pattern of tHis galaxy is of the grand design, despite the superficial appearance of multiple arms in the deep prints on panel] 72. The numerous MM regions outline the two principal arms, which can each be traced for nearly a whole revolution.

The most unusual feature of the pattern concerns the arm that begins near but not on the rim of the inner disk on the right-hand side of the image here (the opposite side of the major axis from NGC 5 195). This principal arm is deLached from the rim, in contrast to its opposite mate, which can be traced continuously inward until it meets the rim.

The largest HII regions have cores that resolve at the 10" level. This is consistent with the calibration of HII lineal" core sizes in luminosity class I-II late-type spirals (Sandage and Tam ma nn 1974a), putting M5 1 at a distance of 10 Mpc. as described earlier (panel 172).

NGC 3433 Sbc(r)1.3
CD-2109-S
March 19/20, 1982
103aO + GG385
45 min

The two principal arms in NGC 343 3 are of the grand design type. They have relatively high surface brightness compared with the outer arms that branch from them. The HII region knots are few, faint, and unresolved. The redshift of NGC 3433 is $v_{,,}$ = 2 5 66 km s̄ '.

NGC 3344 Sbc(rs)1.2
PH-7959-S
Nov 8/9, 1980
103aO
12 min

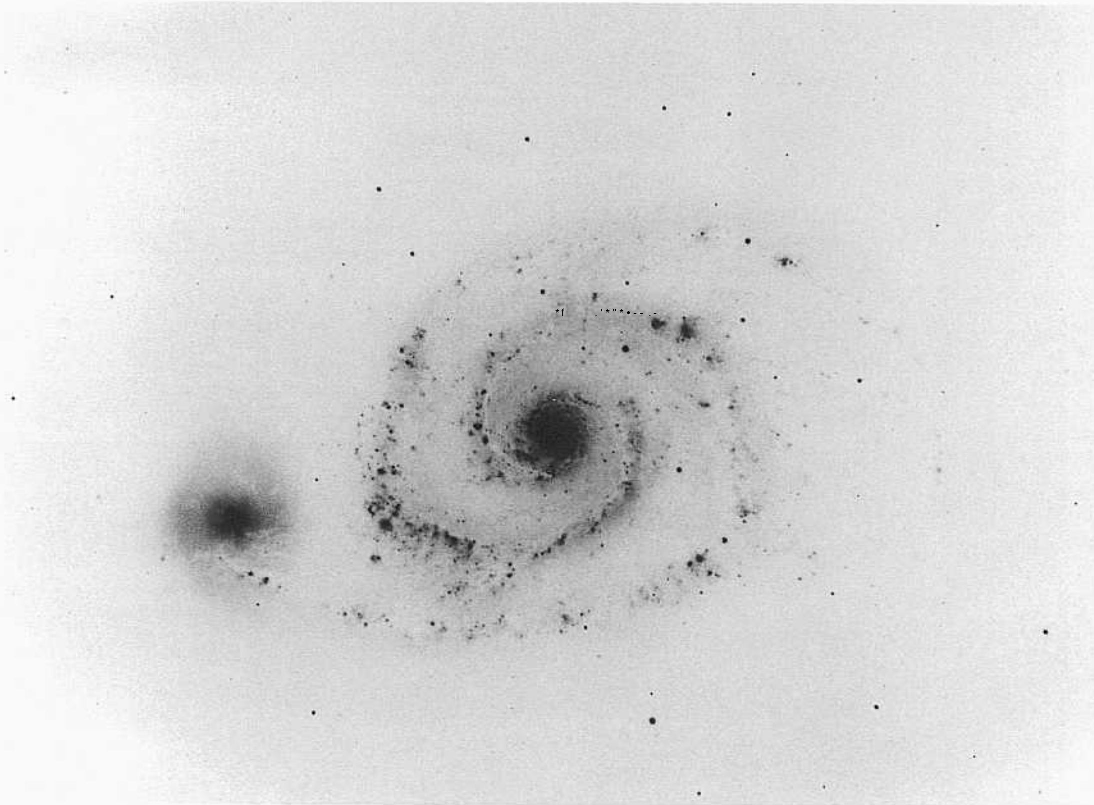
The two principal arms in NGC 3 344 from which other arms branch begin as an almost-complete inner ring which, however, as usual, is the overlapping of tightly wound opposite spirals connected by dust lanes to the central region.

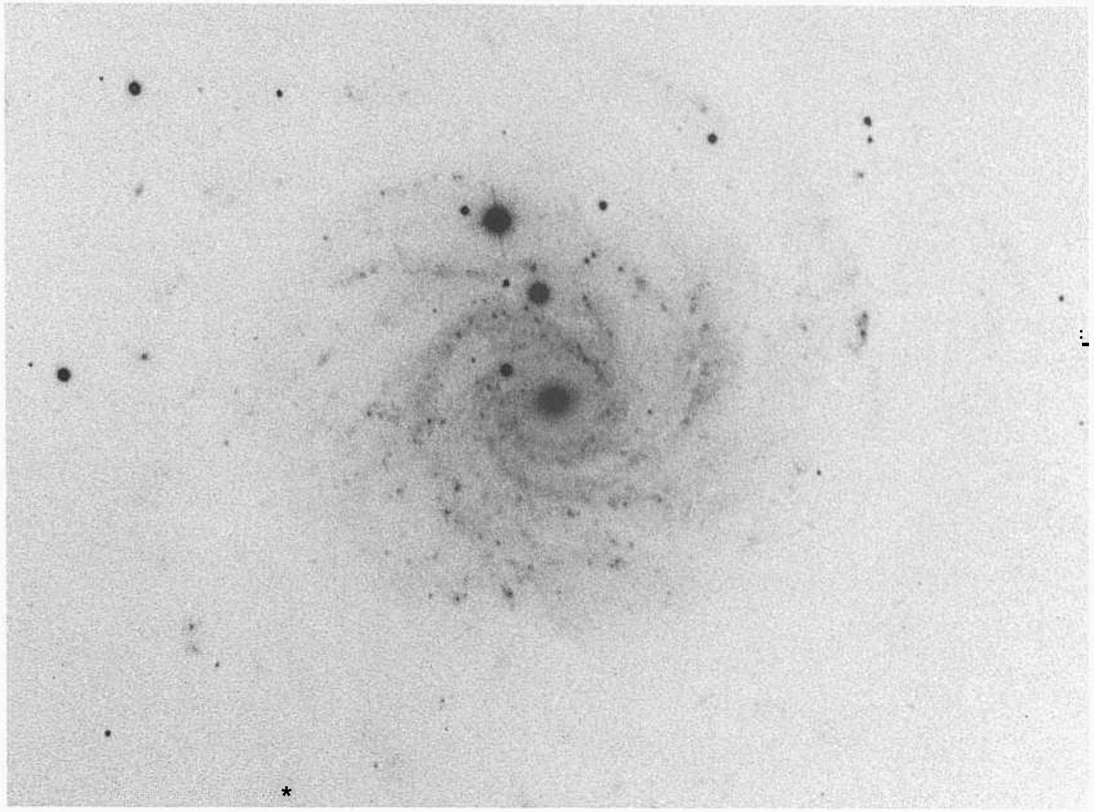
The redshift of NGC 3344 is small, v_o = 62 7 km s^{-1}, yet the HII regions do not resolve into large-core disks, as in M5 1, which has a smaller redshift of v_o = 541 km s^{-1}. The data are, however, consistent with the fainter absolute magnitude of NGC 3 344, M_B = -2 0.3, compared with Mg = -21.6 for M51, calibrated elsewhere (Sandage and Tammann 1974a).

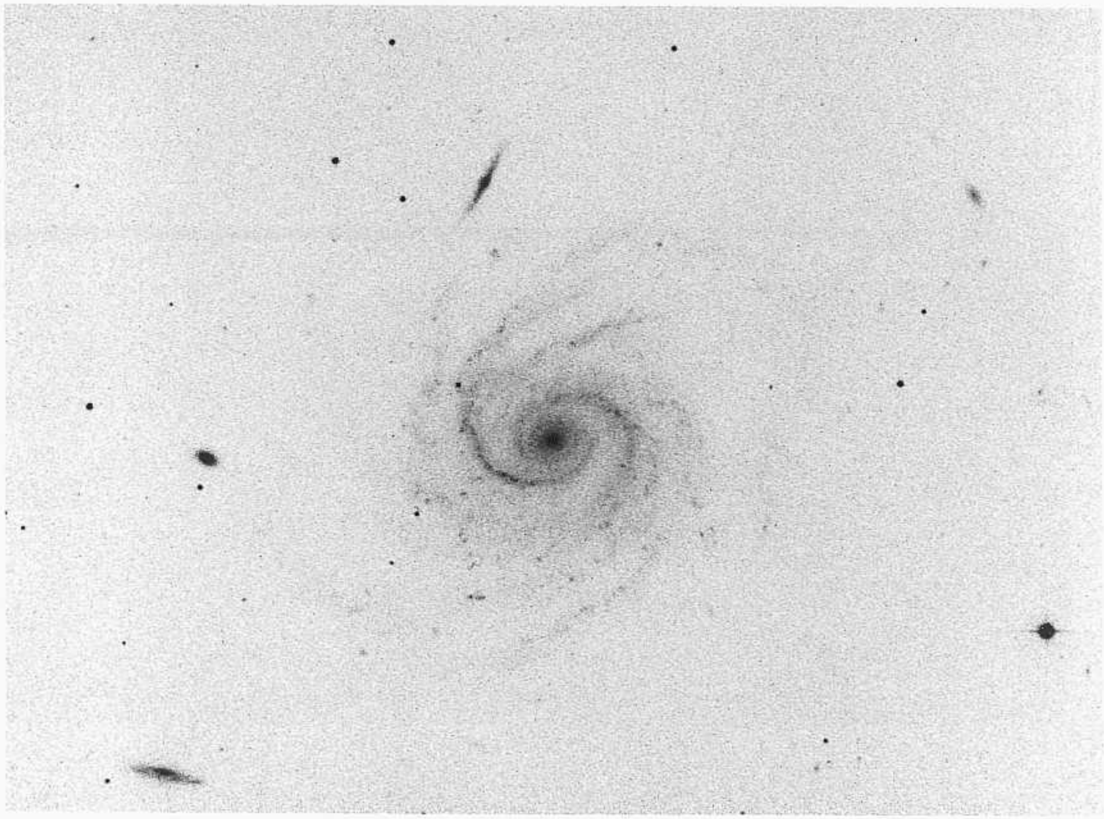
NGC 6780 Sbc(rs)I-II
CD-924-HB
May 3/4, 1979
103aO + GG385
45 min

NGC 6780 may be an outlying member of the NGC 6769 Group (Sandage 1975a), whose mean redshift is $<v_0>$ = 3 953 km s^{-1} : the redshift of NGC 6780 is v_0 = 3381 km s~'. The grand design spiral pattern of the two principal arms is similar to that of M5 1 at the upper left.

Note that both principal arms begin at detached positions relative to the central bulge, similar to the situation in barred spirals. But if a luminous bar is present in NGC 6780 it is weak to the point of invisibility here.

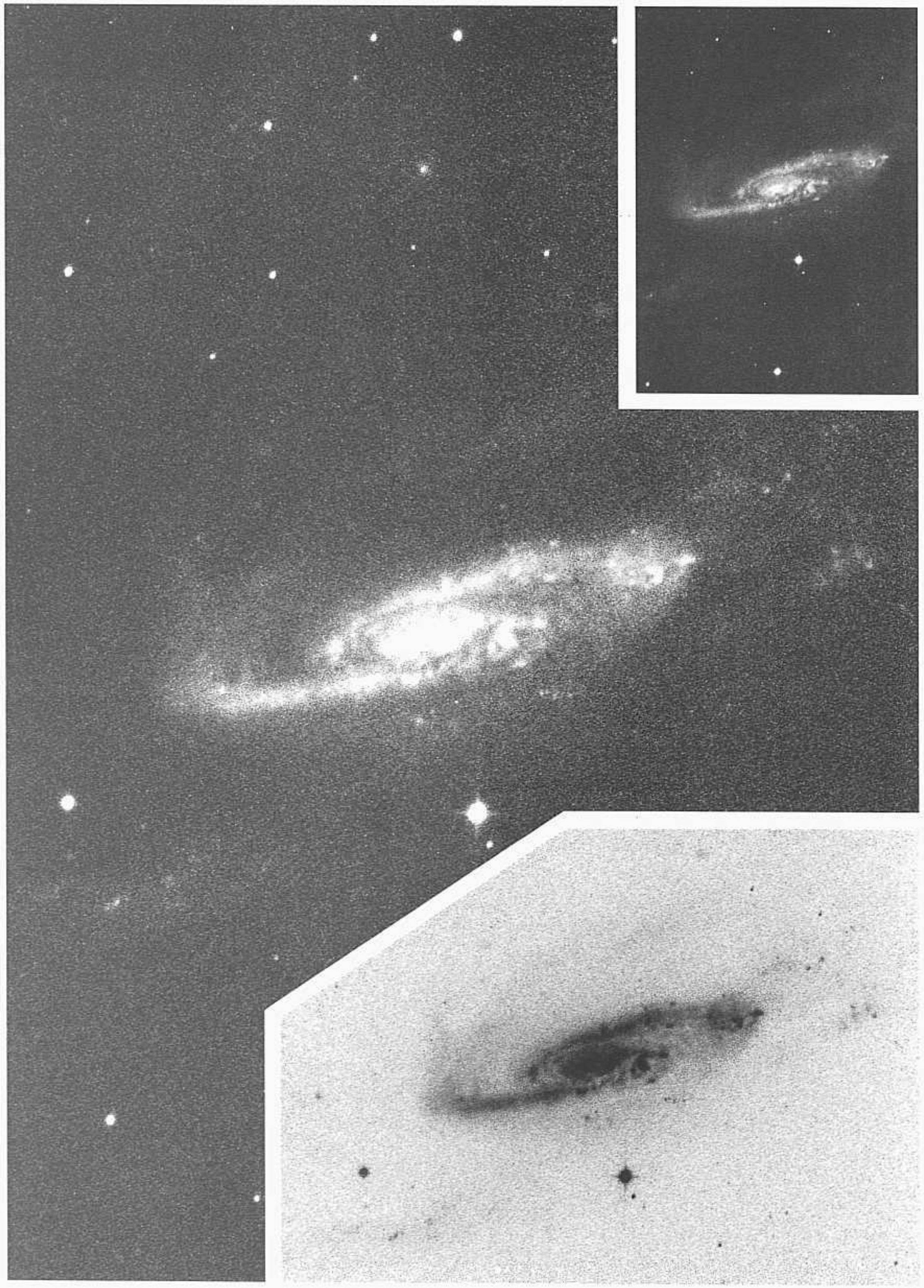


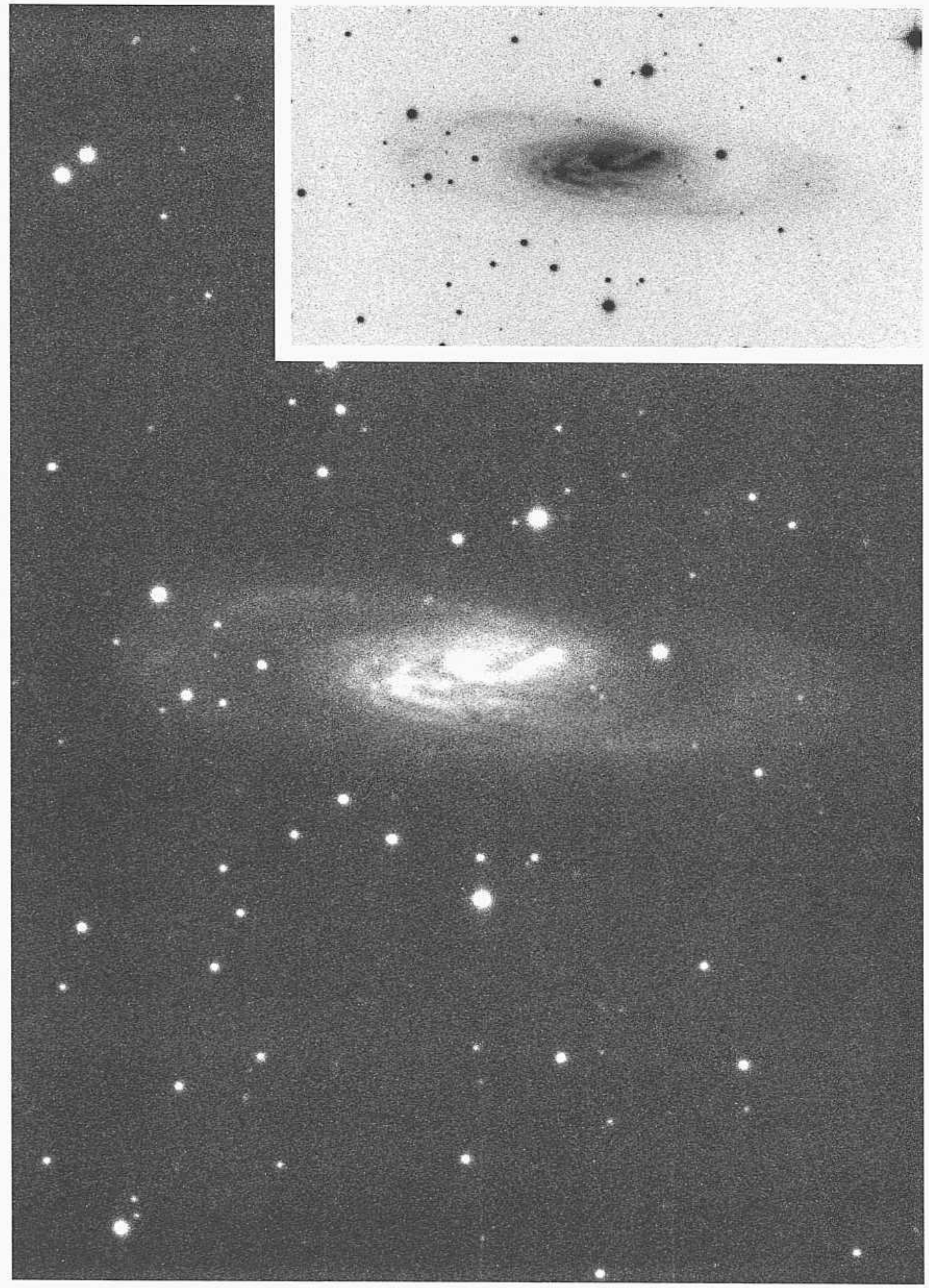




PANEL
177

PANEL
178





NGC 3981 **Sbe(s)I-II(tides?)**
CD-1672-S
Dec 31/Jan 1, 1980/1981
103aO
60 niin

The two **well-defined** principal arms of the grand design type in iNGC 398 1 have high surface brightness. They can lie traced for about Haifa **revolution** outward from their origin **near** the center until they **abruptly decrease in surface** brightness, become more open, and **exhibit** a smooth appearance. It is **the plume-like** appearance of the very **faint outer "arms"** that gives the notation (tides?) in **the** classification, although no companion is present. The designation simply describes the morphology not the cause, which probably is not interaction via an encounter but rather is endemic to the galaxy.

The heavy main print shows faint 1111 regions in the outer extensions of the inner arms and in a separate outer arm not connected with the two main inner arms. This third faint outer arm can be faintly seen as a straight segment along the major axis (at the top of the facing print) **which then** sweeps at a large **pitch** angle to the right in the orientation of **the** image here.

The redshift is v_n = 1554 km s^{-1}.

NGC **2369** **Sbc(s)l pec**
CIM36-S
Jan 31/Feb I, 1978
103aO + GG385
15 niin

NGC 2:if)<J is **similar to NGC 3981 al the left except** that the bright inner- arms arc not as well **defined** and **their outer extensions** as smooth arms have a **higher surface** brightness. The pal**tern is clearly of the grand** design.

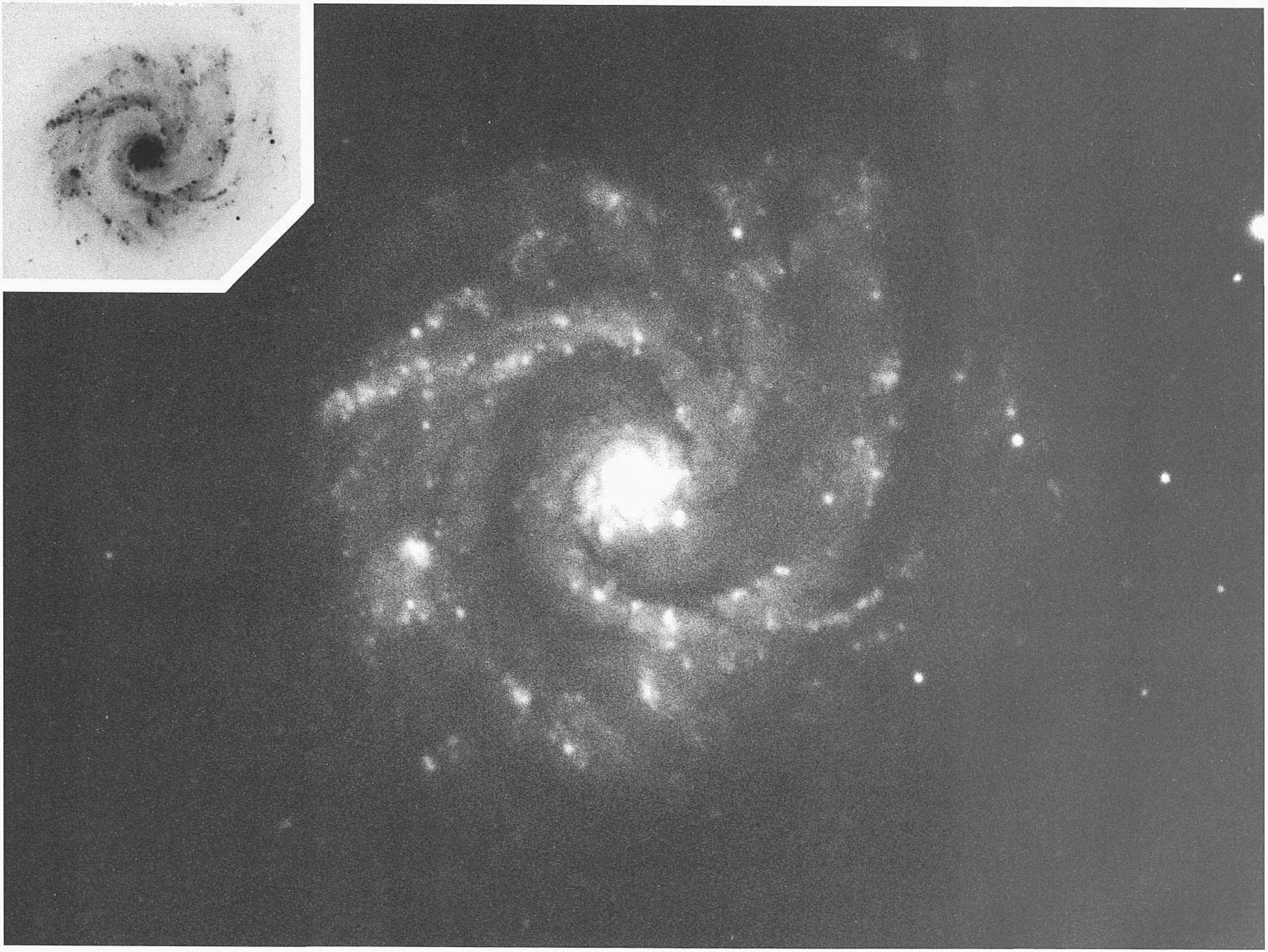
The **redshift of** NGC **2369 is** v_0 **= :!()! 6 km** s^{-1}.

NGC3631 **Sbc(s)II**
PH-8052-S
Feb4/5, 1981
103aO
12 min

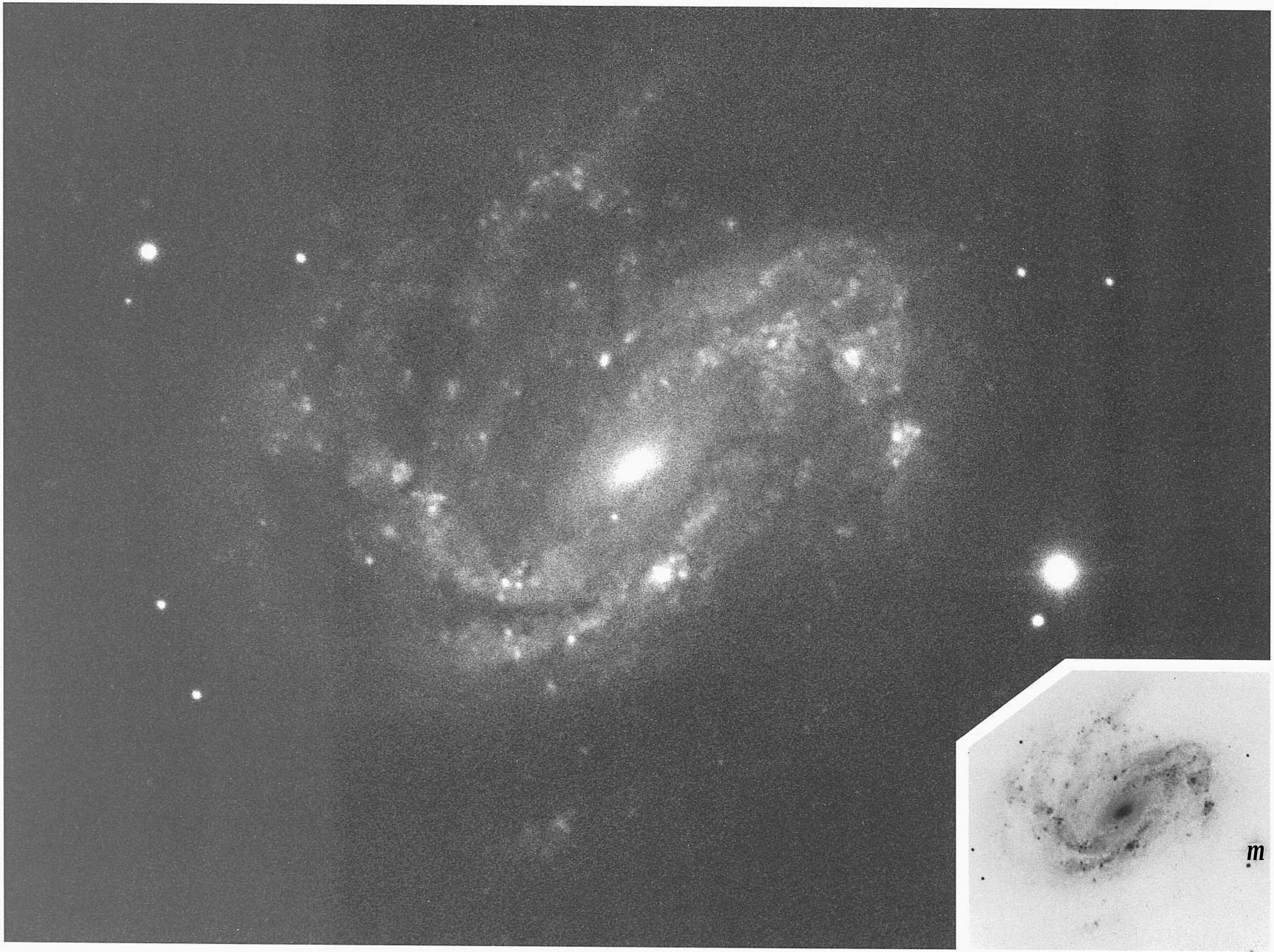
The grand design nature of the arms in **this** striking spiral is evident, as is the larger disorder (higher geometrical entropy) of the pattern compared with previous Sbe galaxies of earlier luminosity classes on the **preceding** eight panels. NGC 3631 is the **prototype** of this later SbcII luminosity class.

The two principal spiral arms begin near **the** center and become evident as luminous structures at the rim of the central, **high-surface-brightness** disk. Secondary arms of lower surface **brightness** branch outward from these two principal inner arms.

Bright **IIII** regions are present in all the arms: the rate of recent star formation is moderate-to-high. The largest **HII** regions coalesce at this angular resolution and have a combined core diameter at the 3" level. The redshift of NGC 3 631 is v_o= 12 38 km s~'.



PANEL
180



NGC 4051 | Sbc(r)Il | Racine wedge
PH-8056-S
Feb4/5, 1981
L03aO
12 niin

NGC 405] is one ol the original six emission-line galaxies used by Seyferl (1943) in his discussion of Moiml Wilson spec Ira anil dirccl plates of a class of galaxies known initially In llmnason. to Minkowski. and lo llulible to have star like (unresolved) nuclei and very broad emission lines in their spectra.

The beginning of the modern work on Seyfert galaxies and related objects, now called active galactic nuclei (AGN). was made in a seminal paper by Woltjer (1959). Seyfert galaxies and quasars are the most prominent examples of this class. Quasars are maxi-Seyferts.

Short-exposure plates of iNGC 405] and direct visual inspection at a large telescope show an intense slarlike (unresolved) nucleus which is a mini-quasar at the center[1] of the galaxy-

The outer spiral structure is nearly of the grand design type, having only several major arms rather than a series of fragments as in the MAS type.

The largest of the many HII regions in the several arms resolve (core plus halo) at about the 4" level. The redshift of NGC 405] is v_0 = 746 km s .

Secondary Racine wedge images are below and slightly to the left of the brightest stars in the frame and also of the center of NGC 405 1 . The Racine wedge image of this starlike center is seen here below and slightly to the left of the center of the central region. NGC 4051 clearly has an AGN (a mini-quasar) nucleus.

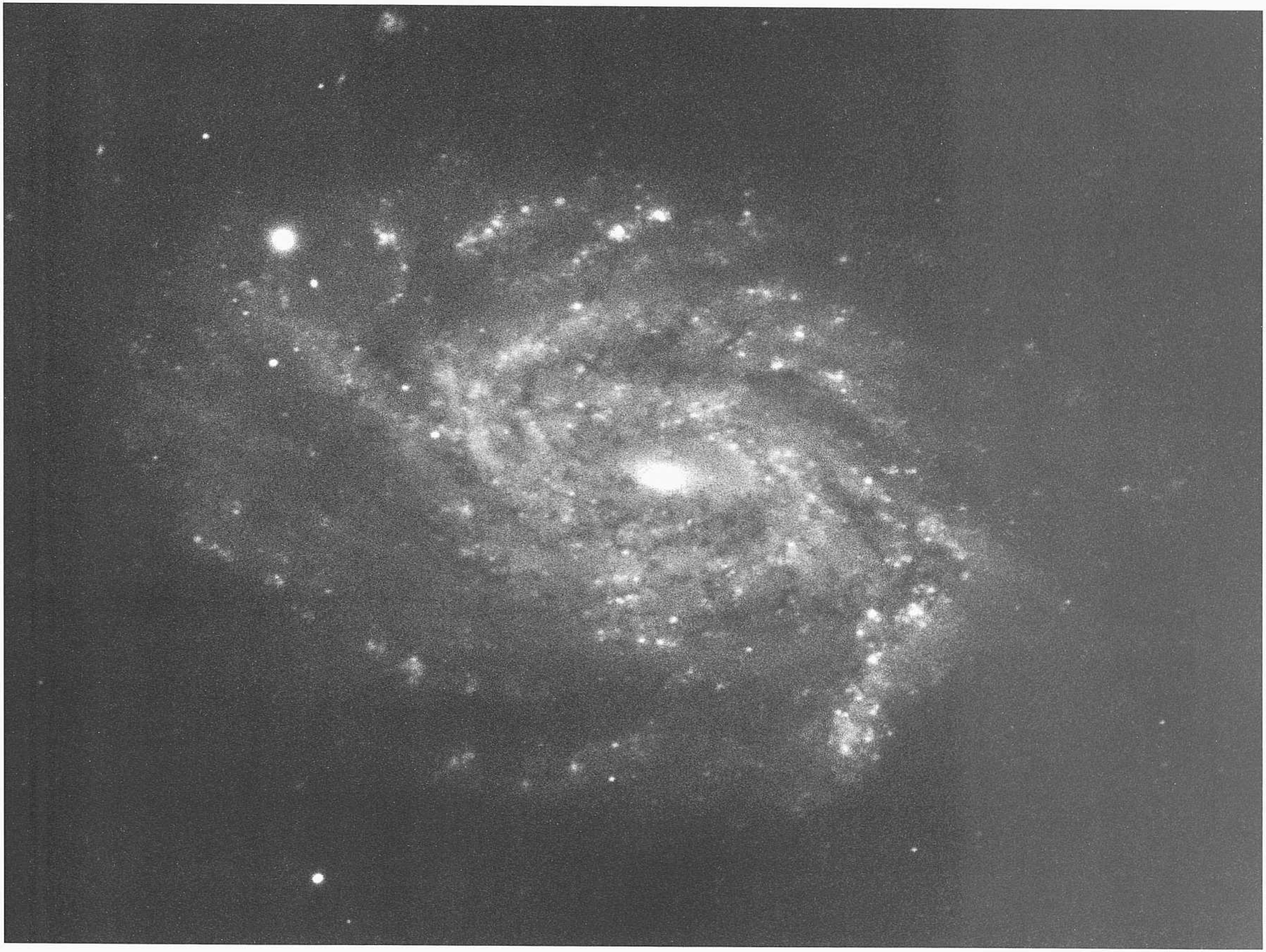
NGC 3726 **Sbc(rs)H** **triplet?**
PH-8024-S Racine wedge
Feb 3/4, 1981
103aO
12 min

NGC 3726, with a reclshift of v_o = 909 km s^{-1}. may **be** kinematically related to the much smaller **nearby** galaxies NGC 3769 **(SBcII: panel 311) with** v_0 = 791 km s̄ \ and NGC 3782 (SBcdIIh panel 328) **with** v_a = 785 km **s"¹.** The angular distances of these two galaxies from NGC 3726 are 68' and 69', respectively. With a mean **redshift** distance of 17 Mpc (H = 50), the projected linear separations of these nearby galaxies from NGC 3726 are 336 kpc and 341 kpc—about half the diameter of the Local Group.

The spiral pattern in NGC 3726 is more disordered than in the Sbc I and I—II galaxies of earlier luminosity class shown on preceding panels. The arms are thick, although each are well-enough defined to be traced as continuous segments for about half a revolution despite the branching from the main arms into outer fragments. The luminosity class is late II.

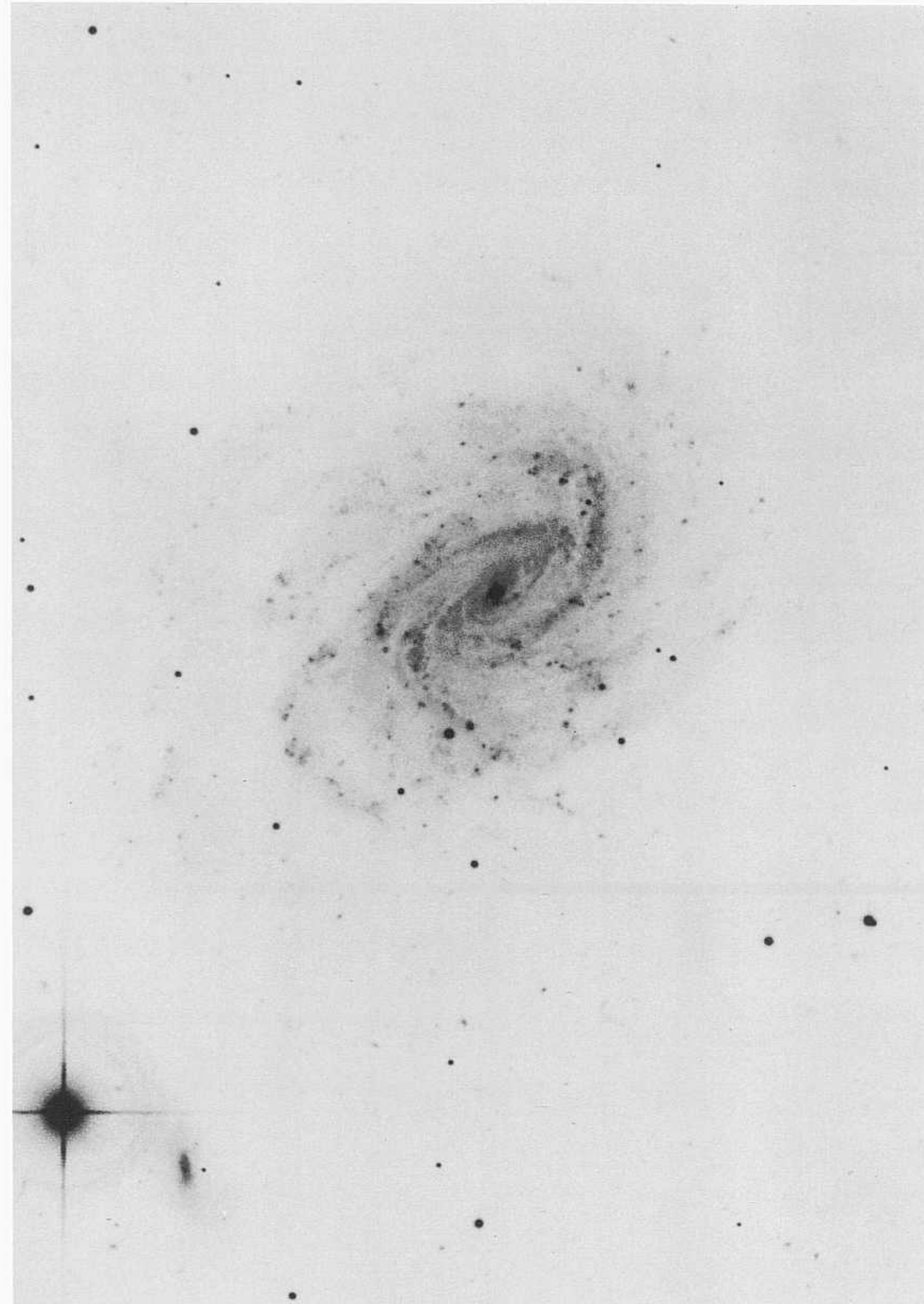
The largest of the numerous bright **HII** regions resolve into core plus halo diameters of about 4". At a redshift distance of 17 Mpc, this size corresponds to a linear diameter of 330 psc, consistent with the calibration of linear HII sizes as a function of luminosity class given elsewhere (Sandage and Tammann 1974a).

Secondary images from the Racine wedge are below and slightly to the right of the two **brightest** stars in the frame.



PANEL
181

PANEL
182



NGC **1187** **Sbc($_s$)Il**
CD-1548-S/Br
Aug 7/8, !»))!()
103aO + (;<;:i«s
15 min

The light print on the riglil shows **that I lit* inner-arm pattern is composed of three high-aur-face-brightness** grand design spirals. **Each begins near the small central nucleus, which itself** is of very hi^h surface brightness **and** which **has** a starlike irna^r at the center a I I lie 0 .8" resolution **of the** available plate material. The two principal arms of the* inner triad pattern ran IK* traced Ior about **three-quarters of** a **revolul** inn **outward before they** abruptly decrease in surface bright-ness; beyond **that** point, lower-surface-brightness arm fragments e.xist, shown best at I he left.

This pattern—**bright. well-defined** inner arms, abrupt surface-brightness change, anil **fragments beyond** the point **of change**—is **com-mon,** and has been seen earlier in ibis section. She examples are NGC 1566 (panel 1 7 1), NGC 5248 (panel I 74), NGC 7 1 7 1 . NGC 4603. and NGC **3430** (panel 1 76), NGC 3433 (panel 177). NGC 2369 and NGC **398] (panel** 178). and NGC 3 72 6 (panel 18 1).

The largest of the numerous 1111 regions everywhere in the arms resolve at the 2" level. The redshift of NGC 1 187 is u_{B} = 1424 km s~[1].

NGC 4995 Sbc(s)II pair
CD-1860-HB
April 6/7, 1981
103aO
75 rain

NGC 4995 at redshift v_o = 1 645 km s⁻' may form a kinematic pair with NGC 4981 (SBbcII; panel 2 10) at u_0 = 1492 km s^{-1} at an angular separation of 65'. At a mean redshift distance of 3 1 Mpc (*H* = 50) the projected linear separation of the pair is 5 86 kpc, similar to the separation of our Galaxy and M3 1 .

The luminous spiral pattern of NGC 4995 is intermediate between the grand design type and the MAS filamentary-arm type, although the grand design is more evident. Three high-surface-brightness principal arms define the pattern. The inter-arm regions are bright, providing a good background against which the spiral dust lanes are silhouetted throughout the underlying disk.

NGC 6984 Sbc(r)1.8
CD-1595-S/Br
Aug 12/13, 1980
103aO + GG385
45 inin

The two principal arms in NGC 6984 begin on the rim of an almost-complete internal ring which, as usual, is itself the near-overlapping of the tightly wound spirals near the center.

One of the two principal outer arms is thick near its beginning, although it is detached at this point from the inner near-ring much like one of the principal arms in M5 1 (panel 177).

The redshift of NGC 6984 is one of the larger in the RSA at v_0 = 443 5 km s~^{1}. Nevertheless, the two largest fill regions in the thick arm resolve at the 1" level, consistent with core plus halo diameters of 450 kpc in luminous galaxies (Sandage and Tammann 1974a).

NGC 3583 Sbc Racine wedge
PH-8075-S
Feb 5/6, 1981
103aO
12 min

The inner arms of very high surface brightness change abruptly in luminosity after only about a half revolution as they develop into the outer arm pattern. This characteristic is the same as has been discussed for other galaxies in this section (compare NGC 1187 on the preceding panel).

The redshift of NGC 35 83 is v_n = 2184 km s^{-1}.

NGC 3596 Sbc(r)II.2
CD-2101-S
March 18/19, 1982
103aO + GG385
52 **min**

Two principal arms emerge from the rim of the inner disk. Their spiral patterns can be well traced, each for half a revolution of unwind. After this point one of the principal arms breaks into a broad pattern that continues to wind outward, nearly overlapping the opposite inner arm after nearly a whole revolution.

The several bright HII regions are unresolved at the 1.5" level despite the small redshift, v_n= 10 72 km s"'.

NGC 2608 Sbc(s)II
PII-7990-S
Feb 2/3, 1981
103aO
12 min

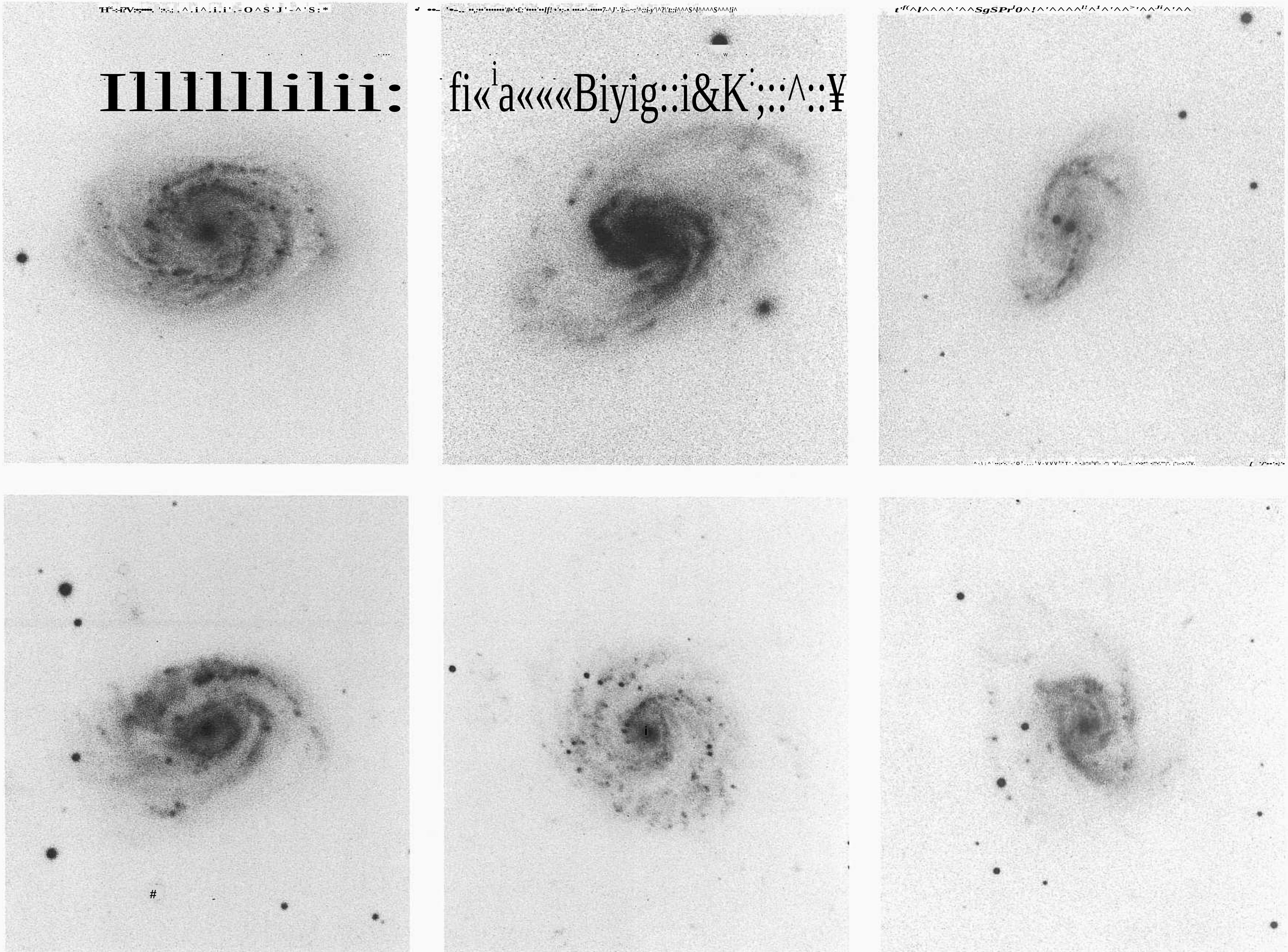
The arm pattern is clearly of the grand design type. Two principal arms that start at the center dominate the pattern.

The redshift is v_o = 2112 km s^{-1}.

NGC 3162 Sbc(s)1.8
H-572-S
Feb 5/6, 1956
103aO + GG13
20 min

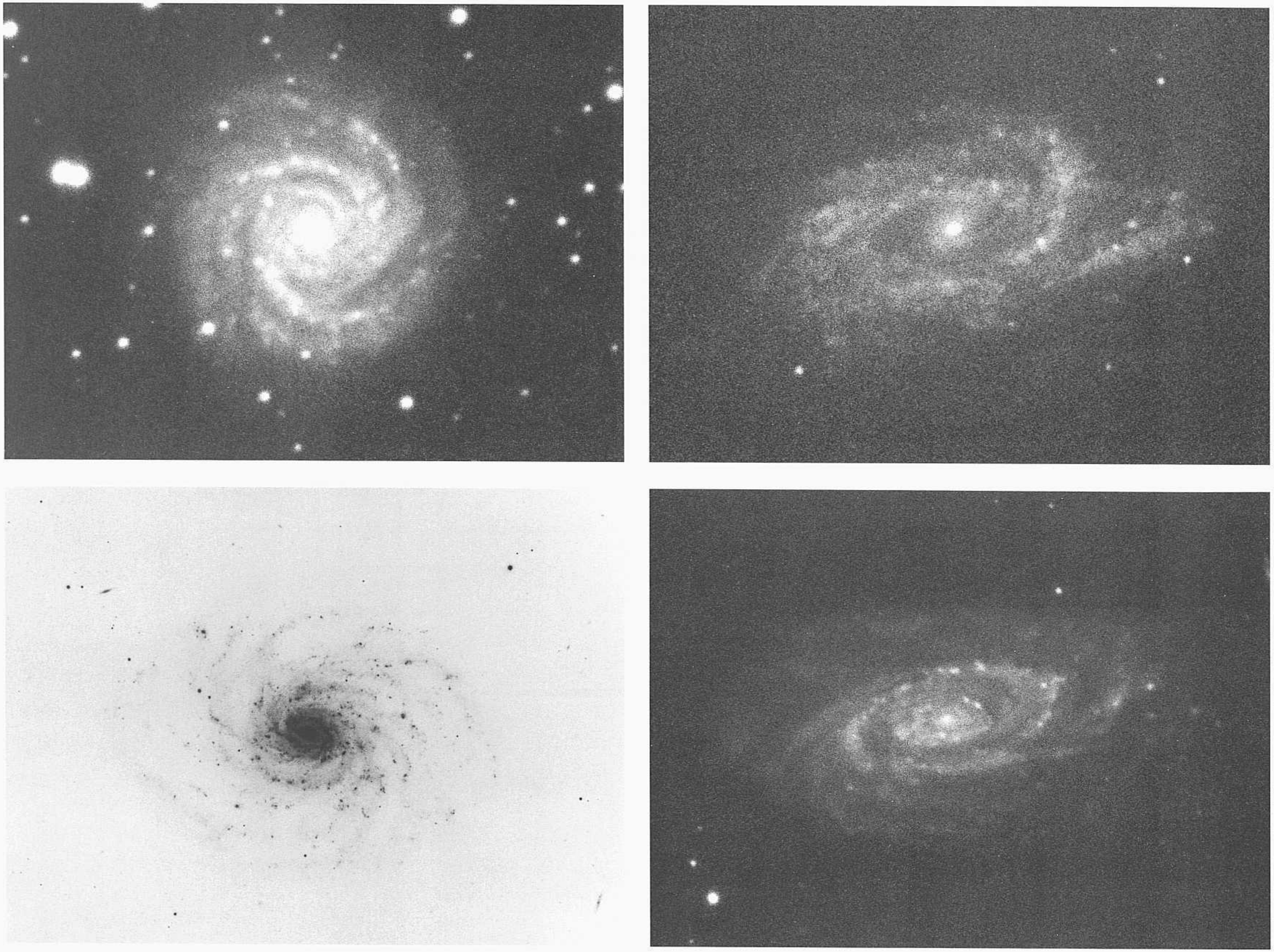
The inner arm pattern in NGC 3162 has a high surface brightness that abruptly decreases after slightly more than half a rotation, forming at that point the very faint outer arm pattern.

The redshift is v_n = 1223 km s"'.



PANEL 183

PANEL
184



Three of the (Our galaxies on this panel have mixed characteristics of both the grand design and the multiple-armed-spiral (MAS) types. They would define an intermediate position in the 12-step arm classification system of Elmegl'een and Elmegreen (1982, 1987) that spans the range from grand design, to filamentary, to chaotic. The arm systems in three of these galaxies are highly multiple, not of the classic morphology with two principal arms of a pure grand design pattern.

The arms in all four galaxies are highly regular. requiring an early luminosity classification.

NGC 6699 **Sbc(s)1.2**
CD-1540-S/Br
Aug 7/8, 1980
103aO + GG385
45 niin

Four principal arms can be traced in NGC 6699. found by counting the number of arm crossings in a cut across the major axis of the image. The numerous Mil regions in each arm are like heads on a string, similar to the two-arm pattern in M5 1 (panels 172, 177).

The redshift is v_0 = 3357 km s~^{1}.

NGC 3486 Sbc(r)1.2 panel S13
PH-8022-S
Feb 3/4, 1981
103aO
12 min

Many of the spiral fragments in NGC 3486 can be traced for only short distances before their surface brightness becomes so low that the outer features are lost. In these outer regions, the till region content that defines the path of the spiral substantially decreases.

The overall spiral pattern is very regular. The pattern starts at the rim of a high-surface-brightness inner ring. The nucleus is exceedingly bright, appearing Dearly starlike by visual inspection at a large telescope.

The several largest **III** I regions resolve at the 4" level for the core plus halo diameter. The redshift is low. $v_{,,}$ = 636 km s^{-1}.

NGC 4947 **Sbc(s)I-Il** pec
CD-915-III5
April 30/May I, 1979
103aO + GG385
-10 niin

The arm pattern in NGC 4947 is of the grand design type. Two principal arms exisl. beginning at the center as dust lanes and becoming luminous at the edge of the inner disk. The HH regions are numerous.

The redshift is r,, = 2222 km s"^{1}.

NGC 5351 **Sbc(rs)1.2**
PH-8096-S
Feb 6/7, 1981
103aO
12 min

The inner arms are of high surface brightness. The faint outer arms branch from them and form a multiple-arm pattern. The i-eilsliift of NGC 535 1 is i), = 3663 km s"'.

The six galaxies on this page, having very **regular** spiral patterns, consequently are assigned to the earliest luminosity classes I or **I-II.** All six are of the multiple-arm variety.

NGC **214** **Sbc(r)I-II**
PH-7819-S
Sep2/3, **1980**
103aO
12 mill

The **two** brightest arm fragments in NGC 2 1 4 start from the edge **of** a high-surface-brightness disk close **to the** center. Some of **the faint** outer multiple arms branch from these **two** main inner arms, hut others exist throughout the moderately high surface brightness intermediate disk, similar **to** the **earlier pattern** in NGC 2 841 (panels 142, S4, S12).

The IIII regions are unresolved at the 1″ level. The **redshift of** NGC **214 is »„ = 4757 km** s^{-1}.

NGC 6925 Sbc(r)I-II
CD-2020-Bedke/Gregory
Oct 26/27, 1981
103aO + **GG385**
15 min

The MAS **pattern in** NGC 6925 is similar to but later than the prototype multiple-armed pattern in NGC 488 (panels 1 1 ā, 1 1 6. S3 , SI 2) and in NGC 2841 (panels 142, S4, S12). Also, the luminous arms are somewhat better defined here **than** in NGC 2841.

The diameters of the IIII regions are smaller than 1". The redshift of NGC 6925 is u_o = 2780 km s^{-1}.

NGC 5324 **Sbc(r)1.3**
H-2388-H
Feb 21/22, 1947
103aO
30 **min**

The MAS spiral pattern in NGC 5324 is a later version of the Sab prototype NGC 488 and an earlier version of the prototype Scl MAS galaxy NGC 12 32 (panels 216, SI3). The redshift of NGC 5324 is v_{n} = 2853 km s"[1].

NGC 3963 **Sbe(r)1.2** **Racine wedge**
PH-8112-S
Feb 7/8, 1981
103aO
12 min

The plate used here for NGC 3963 was taken through clouds and gives a false impression of the true surface brightness of the galaxy; the sky was thick, decreasing the surface-brightness contrast between the galaxy and the night sky glow.

The plate was taken with a Racine wedge. The secondary images are faintly visible for (1) the brightest star in the field, superposed on one of the arms below and to the right of center, and (2) the nucleus, which is almost starlike upon visual inspection at the telescope, evidenced here also by the secondary image made by the wedge.

The spiral pattern is of the grand design rather than of the multiple-armed type. Only two principal arms exist; one, highly regular, can be traced for almost a whole revolution, while the other branches into **two** after half a revolution.

The redshift is v_{n} = 3295 km s^{-1}.

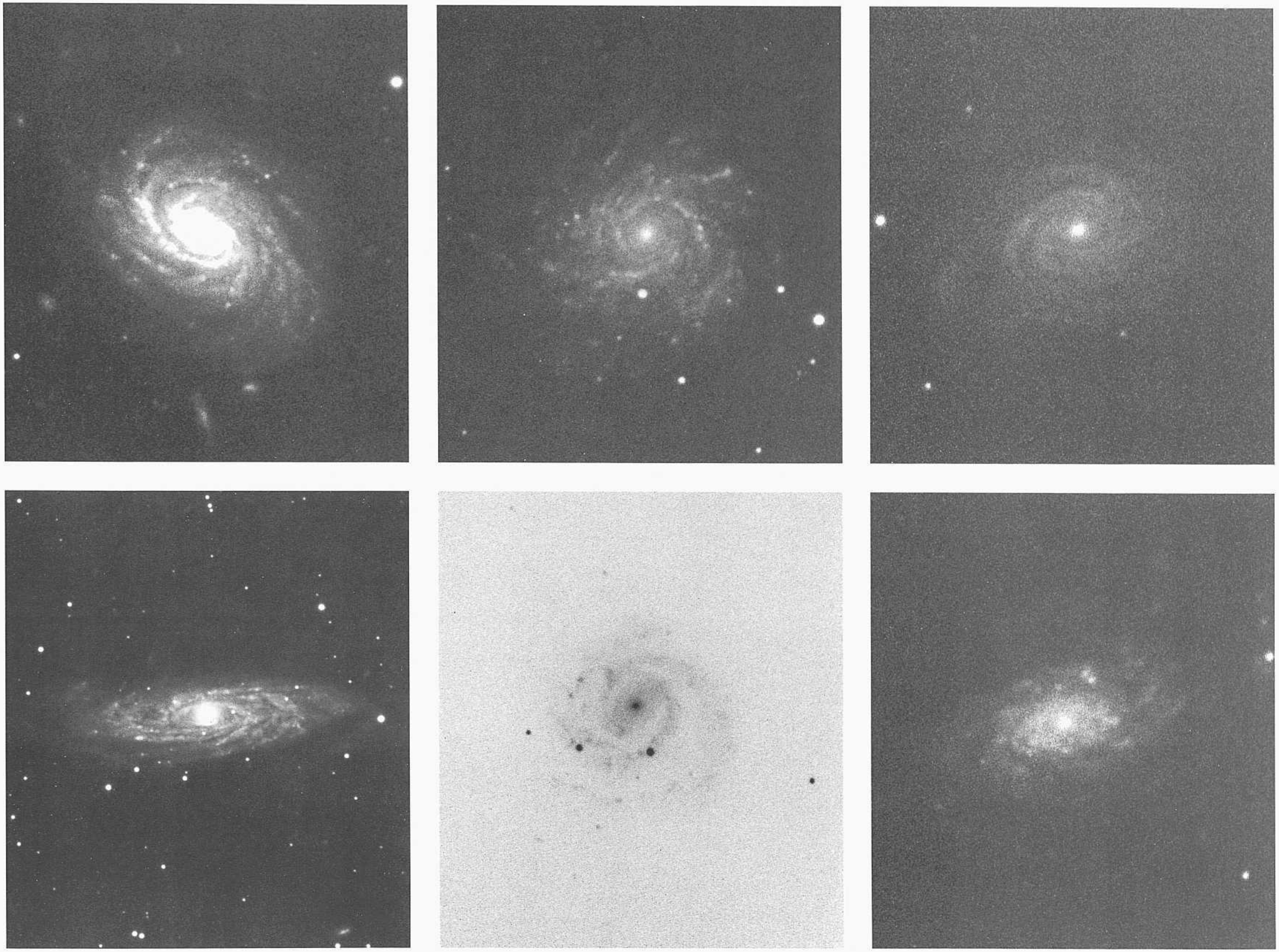
NGC 3720 Sbc(s) **pair**
CD-1426-S/Br
March 25/26, 1980
103aD + **GG495**
31 min

NGC 3720 forms a close pair with NGC 3719 (She) at an angular separation of 2.2'. The near equality of the redshifts, at u_o(3720) = 5804 km s"[1] and v_o (3719) = 5723 km s"', assures a physical association. At the mean redshift distance of 1] 5 Mpc (// = 50) the projected linear separation is small, at 74 kpc.

The nucleus is small and bright. The multiple arms are smooth at the resolution of the present plate material. The galaxy is clearly a spiral. The classification as EO by van den Bergh, based on 48-inch Schmidt paper prints, is inappropriate.

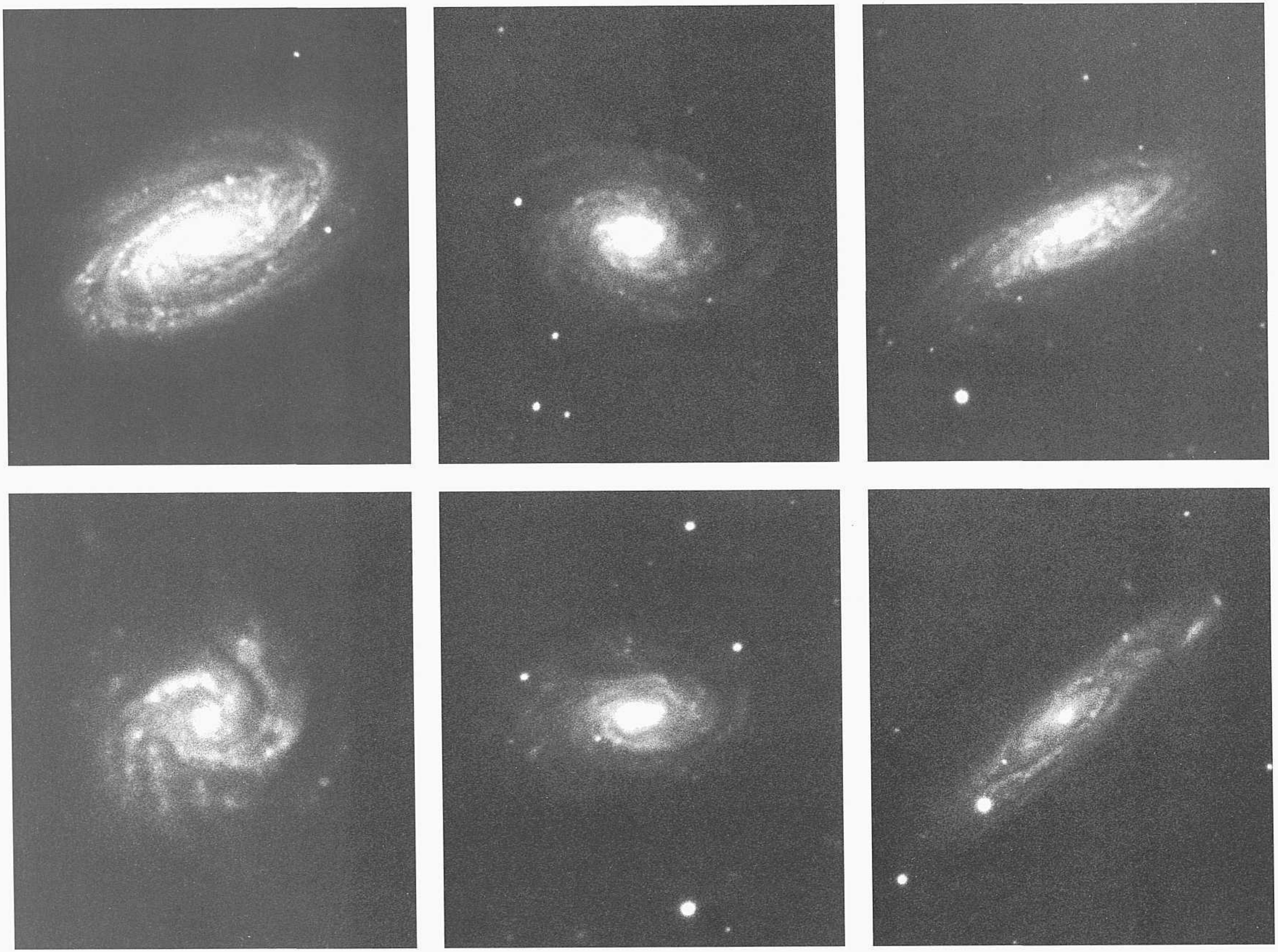
NGC 3259 **Sbc(r)I**
PH-8072-S
Feb 5/6, **1981**
103aO
12**min**

NGC 3259 is a multiple-armed spiral with a bright nucleus and a small **angular** diameter. Its redshift is v_{n} = 2005 km s"[1].



PANEL
185

PANEL
186



The six galaxies on this panel continue the illustration of Sbc forms having spiral patterns of the multiple-armed type. All arc of luminosity class [-II.

NGC 7392 Sbc(s)I-H HA, p. *20*
CD-1127-Br
Aug 20/21, 1979
103aO + GG385
4-5 niin

The main arms in NGC 7392 are narrow, and each can be traced as separate fragments for more than half a revolution outward. The largest HII region resolves at the 1.5" level; the others are unresolved. The redshift of NGC 7392 is v_o = 3035 km s^{-1}.

NGC 3506 Sbc(s)I-II
CD-1853-HB
April 4/5, 1981
103aO + GG385
45 min

Two principal high-surface-brightness arms begin near the bright center and wind outward for half a revolution, at which point they decrease in brightness. On one side, the arm fragments into four pieces of spiral arc with steeper pitch angles.

The HII regions are unresolved at the 1" level. The redshift is v_0 = 6348 km s^{-1}, which is one of the largest in the RSA (RSA, Fig. 2).

NGC 976 Sbc(r)I-II
PH-7548-S
Nov 6/7, 1978
103aO
12 min

The thin, regular, multiple arms begin on the rim of a bright internal ring which is largely burned out on this print. Very lew Mil regions exist in the arms. The few faint candidates are unresolved at the 1" level. The redshift of NGC 976 is large for RSA galaxies, at v_o = 4550 km s^{-1}.

NGC 2347 Sbc(r)I-II
PH-7897-S
Nov 6/7, 1980
103aO
12 min

NGC 2347 has the small angular diameter of 1.5' and a large redshift of v_0 = 4f>92 km s^{-1}. The spiral pattern is similar to that of NGC 976, above; the thin, easily traced arms begin on the rim of a bright internal ring.

IC 1788 Sbc(s)I-II
CD-1599-S/Br
Aug 12/13, 1980
103aO + GG385
-15 min

The arm pattern in l(! 1788 is similar lo (but later in tin* classification sequence than) how NGC 488 would appear if viewed nearly edge on. The redshifl of IC I 788 is r,, = 3306 km s '; the HII regions are unresolved.

NGC 1625 **Sbc(s)I-H** small group?
PII-7921-S
Nov 7/8, 1980
103aO
12 min

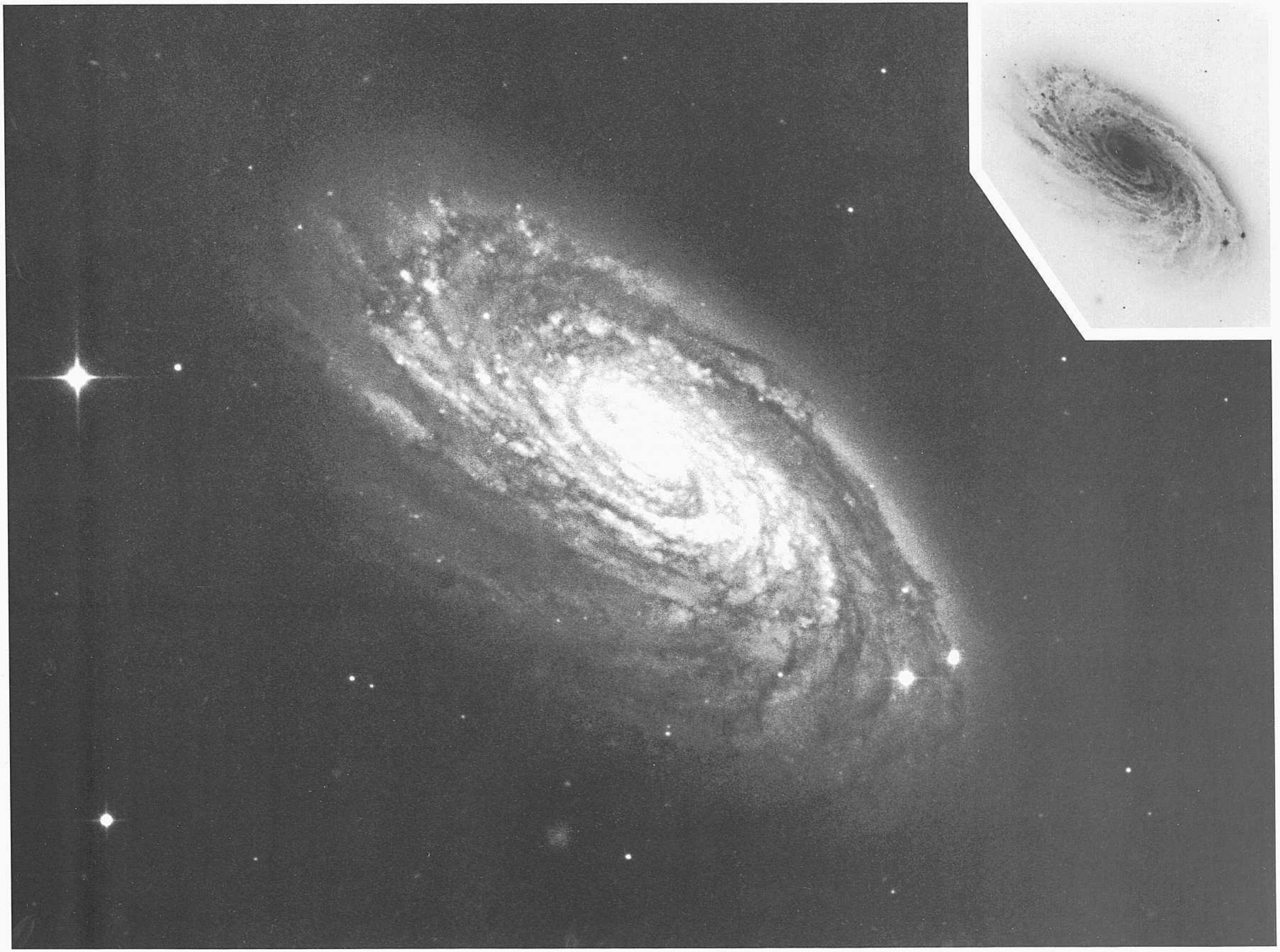
NGC 1625 may form a physical group with NGC 1622 (Sa with exquisite narrow arms) and NGC 16 18 (SBa?) at separations of 10.2' and 17.6'. respectively, but both are of unknown redshift. If the redshifts are the same as that of NGC 1625, v_o = 3033 km s"', their projected lineal- separations from NGC 1625 are 180 kpc and 3 10 kpc. respectively.

NGC 1501 **Sbc(s)II** **VCC 1401**
CD-756-S **M88**
Feb 4/5, 1979
103aO + Wr2c
50 niin

NGC 45 01 **is** a **very-large-angular-diameter** ***(D25*** = 7') **spiral,** located 2° north of the **center** of Virgo **subcluster** A associated with NGC 4486. The galaxy is one of the largest spirals in the Virgo Cluster region. It is similar in angular size to the other large Virgo Cluster member **spirals,** such as NGC 4192 (panel 135) and NGC 4216 (panel 149) of type Sb. and NGC 4321 (panel 213). NGC 4535 (panel 297). NGC 4303 (panel 2 13). NGC 4254 (panel 224). NGC 4536 (panel 174). and NGC 4654 (panel 302), of type Sc. Images of these largest of the Virgo Cluster spirals are **printed** to a common angular scale in an atlas of Virgo Cluster galaxies given elsewhere (Sandage. **Binggeli,** and Tamuiann 1985a).

The many, well-organized dust lanes, silhouetted against the **bright** background disk, are prominent in the multiple-armed spiral pattern of NGC 4501. The spiral **morphology** here is a later version of that of NGC 488 (panels 115, 116, S3, S12) if viewed at this inclination.

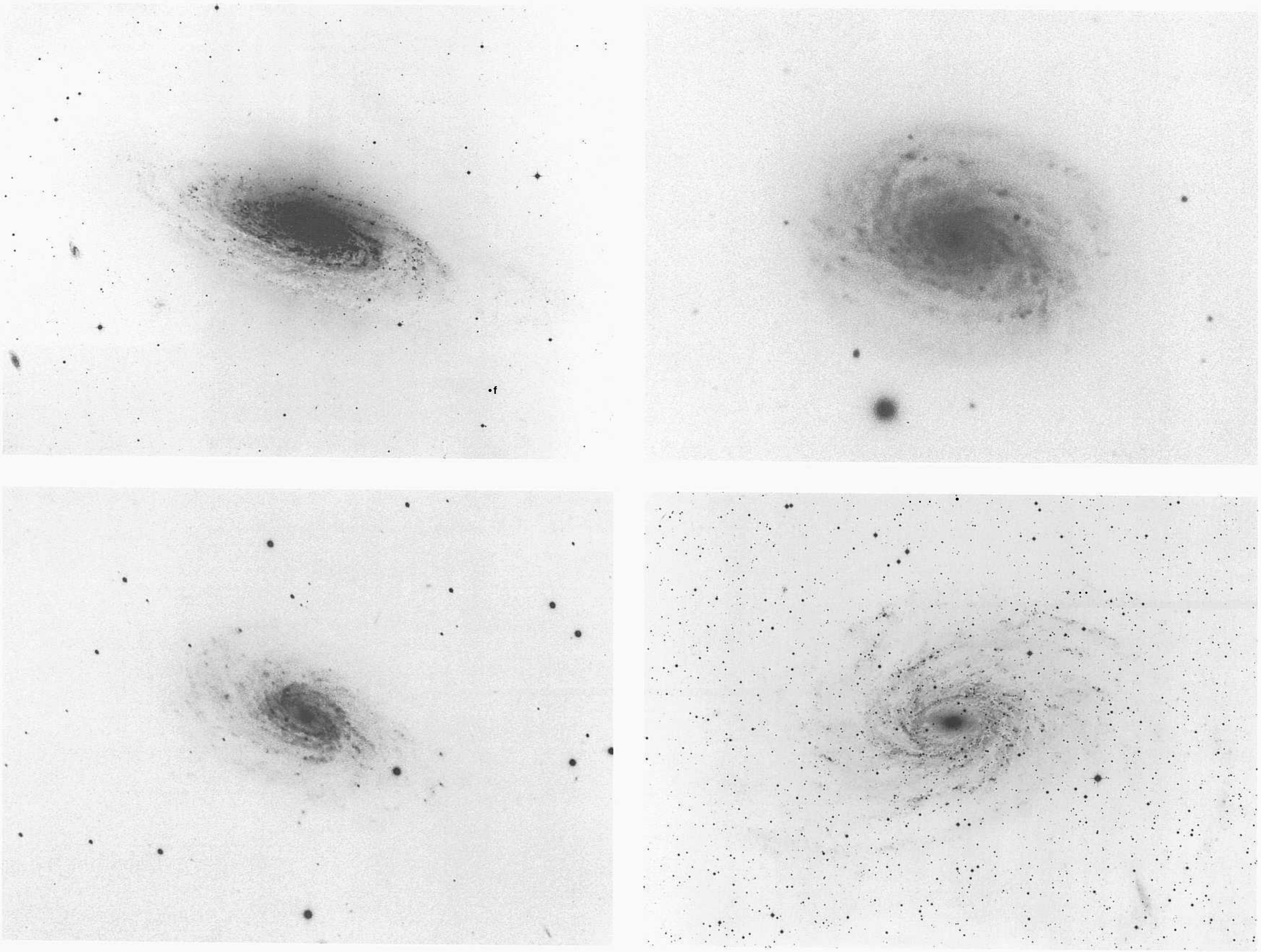
The largest of the several HII regions may resolve at about the 2" level, corresponding to a linear diameter of about 200 psc, adopting a distance of 21.8 Mpc (m - *M* = 31.7) for the Virgo Cluster. However, it is not established beyond doubt that NGC 45 01 is, in fact, a member of the cluster. Its redshift is high, v_0 = 2161 km s^{-1}. which is near the upper limit for the arbitrary redshift range for Virgo Cluster inclusion. And further, the galaxy is away from the main concentration of member galaxies. However. NGC 4548 (SBbl-II), which has nearly the same angular size and which is close to NGC 4501 in the sky, has v_o = 366 km s^{-1}, assuring its membership in the cluster and improving the circumstantial case **for membership** of NGC •150 **1.**



PANEL
187

PANEL

188



The four galaxies on lliis pane] arc good prototype examples of the Sbc morphology, having extreme filamentary spiral patterns at the intermediate luminosity class 11 or even as late as II-III. Three of the four galaxies have very low redshifts and, as a consequence, have well-resolved stellar contents.

NGC 3521 Sbc(s)II HA, p. *15*
CD-1748-S
Jan 12/13, 1981
103aO + GG385
45 iniii

The central 1' (diameter) region of' NGC 3521 is a high-surface-brightness disk having spiral dust lanes but no luminous arms. Luminous arm fragments begin at the edge of this inner disk. They are interspersed with associated dust lanes and define the outer MAS pattern, which is of the NGC 2841-NGC 488 type.

The moderately short exposure print in the Hubble Atlas, made from an original Mount Wilson 100-inch plate, shows the bright central disk and a hint of a luminosity distribution above the plane, centered on this central region. In the Hubble Atlas print this appears as an overlay of luminosity in silhouette against the far side of the disk. In the print here from a deeper Las Campanas plate, this "cylinder" of light perpendicular to the plane, concentric with the center, is more evident. It can be traced in height until it appears even beyond the image of the disk on the far side, showing that the distribution is, in fact, perpendicular to the plane.

The disk is resolved into individual stars. The largest HII regions have core-plus-halo diameters of 4", which, with a redshift distance of 12 .5 Mpc based on the redshift of v_o = 627 km s^{-1}, is a linear diameter of 240 psc, consistent with the calibration elsewhere (Sandage and Tammann 1974a).

NGC 2268 Sbc(s)II
PH-7550-S
Nov 5/6, 1978
103aO
12 min

The spiral pattern consists of an inner set of very-high-surface-brightness arms (partly burned out here) and an outer set of multiple-fragment arms of lower surface brightness. The redshift of NGC 2268 is v_0 = 2458 km s"'. No resolution occurs of tin[1] HII regions or of individual stars.

NGC 4-800 Sb(rs)ll-lll HA, p. 76
PII-8032-S
Feb 3/4, 1981
103aO
12 min

NGC '1800 is classed Sb here, in the RSA, and in the Hubble Atlas. It is shown in the She section here hi illustrate that the differences between Sb and Sbc classes are subtle and arbitrary; nevertheless it is clear from this print and the one in the Hubble Atlas that NGC 4800 is slightly earlier than NGC 352 1 at the left. It has a larger and brighter central region, and its arms are less well resolved into stars and 1111 regions.

The redshift of NGC 4800 is u_0 = 808 km s^{-1}.

NGC 6744 Sbe(r)II/SBl>c(r)II
CD-1473-S/Br
May 10/11, 1980
103aO + GG385
45 min

This very large (the angular diameter measured from the outermost arms is I 8'). nearby spiral is at low galactic latitude (|< = -26°). making foreground field contamination by Galactic stars apparent and the identification of any particular individual resolved star's in the arms uncertain.

But the resolved HII regions are more easily identified. The largest of these have core-plus-halo diameters of about 6". At the redshift distance of 13 Mpc. based on the redshifl of v_D = 663 km s^{-1}. this corresponds to a linear diameter of 385 psc. consistent with a calibration given elsewhere (Sandage and Tammann 1974a).

The arm pattern is clearly multiple. The outermost arm, out of the frame of this print. overlaps the spindle Iml\ galaxy at the lower-right corner. This companion is highly resolved. Its separation from NGC 6 744 is 10.1' northwest (the orientation of the print here is north at the right, west at the bottom), corresponding to a small projected linear separation of 3 9 kpc.

NGC 470 Sbc(s)II.8 Karachentsev 31
PH-273-Mi panel 84
Nov 7/8, 1956
103aO
20 niin

NGC 470 forms a close physical pair with NGC 474 (RSO/a. panel 84) at a separation of 313". The redshifts are K$_O$(470) = 2643 km s^{-}' and i;$_0$(474) = 2596 km s^{-1} . At the mean redshift distance of 52 Mpc *(H* = 50) the projected linear separation is small, at 80 kpc—roughly equal to the distance of the Magellanic Clouds from the Galaxy. The sharp rims in NGC 474 may be the aftermath of a merger with yet a third galaxy, or may be due to some type of interaction with NGC 470.

However, no evidence exists of distortion in the morphological form of the companion NGC 470, shown here. The spiral pattern is regular. It has broad, tightly wound arms that nearly overlap each other after each unwinds by 180°. The pattern is that of the grand design: the arms are thick with a moderate amount of disorder, giving the late luminosity class. Many HI I regions exist in the arms, but none have diameters larger than 1 .5"'. The mystery is how NGC 470 here can have so regular a spiral pattern if the peculiar features of NGC 4 74 on panel 84 are due to a tidal encounter between the pair.

NGC 4094 Sbc(s)II
CD-244-S
Feb 14/15, 1978
103aO + GG385
45 min

NGC 4094 has multiple arms that are relatively thin but which can only be traced as fragments. The largest HII regions resolve at about the 2" level. The redshift of NGC 4094 is v_0 = 1184 km s"^{1}.

NGC 6221 Sbc(s)II-III pair
CD-1582-S/Br
Aug 11/12, 1980
103aO
45 niin

NGC 6221 forms an apparent physical pair with NGC 6215 (Sc; panel 251), based on the redshifts of v_o = 13 55 km s~' and v_o = 12 70 km s~^{J} , respectively. The angular separation of 2 5' gives a projected linear separation of 190 kpc at the mean redshift distance of 26 Mpc *(H* = 50). The galactic latitude of the pair is small, at —9°.

The morphology of NGC 6221 is semi-chaotic, perhaps due to an encounter. Two symmetric heavy dust lanes start from the nucleus and thread through the middle of the opposite thick arms which begin at the center. These lanes are similar to the two straight dust lanes in prototype SBb galaxies, such as NGC 1300 (panels 154, S8). Aside from this, the pattern is not strongly barred.

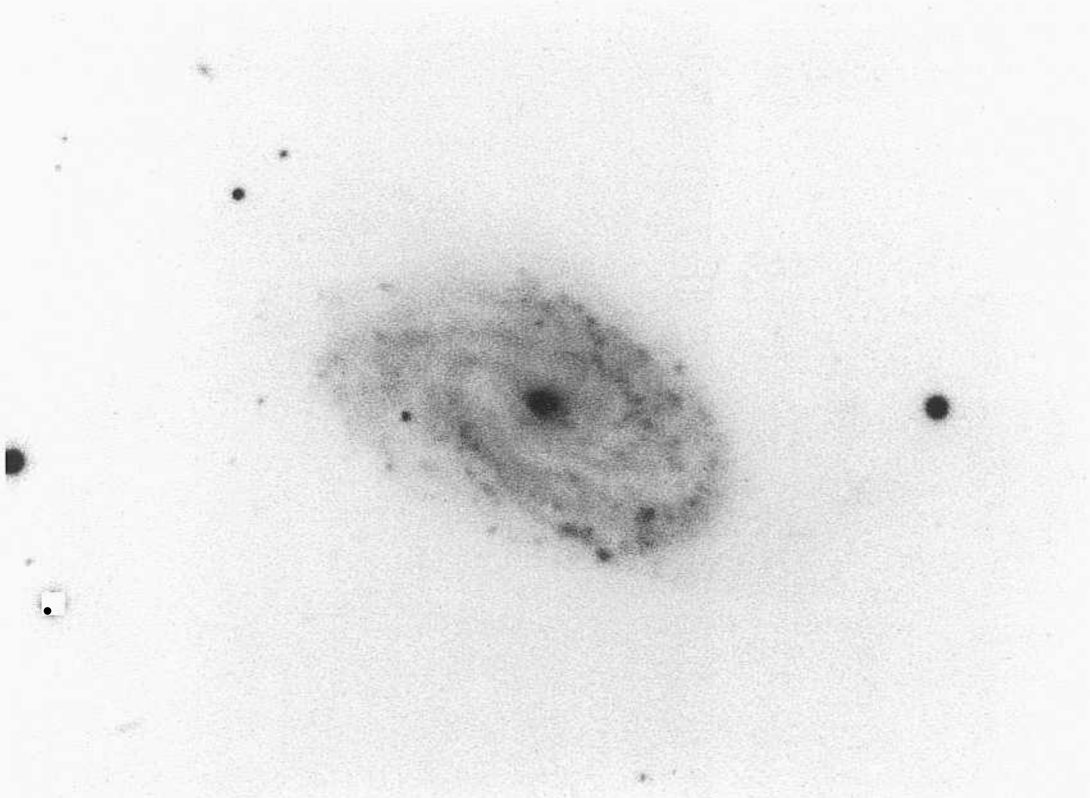
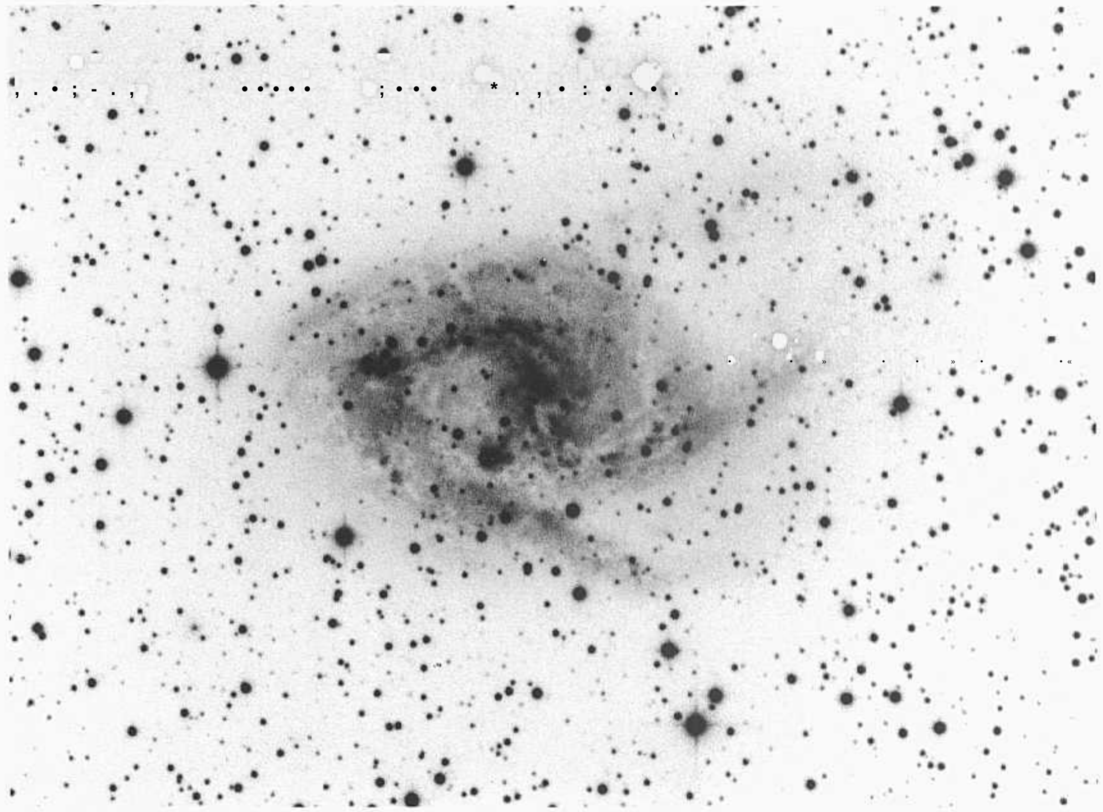
NGC 3646 Sbc(r)IIpec Karachentsev 281
H-2219-H
Jan 6/7, 1946
103aO
60 niin

The morphology of NGC 3646 is peculiar, as if the result of an encounter. The outer spiral pattern cannot be traced even as to the sense of direction, but the inner spiral pattern is regular.

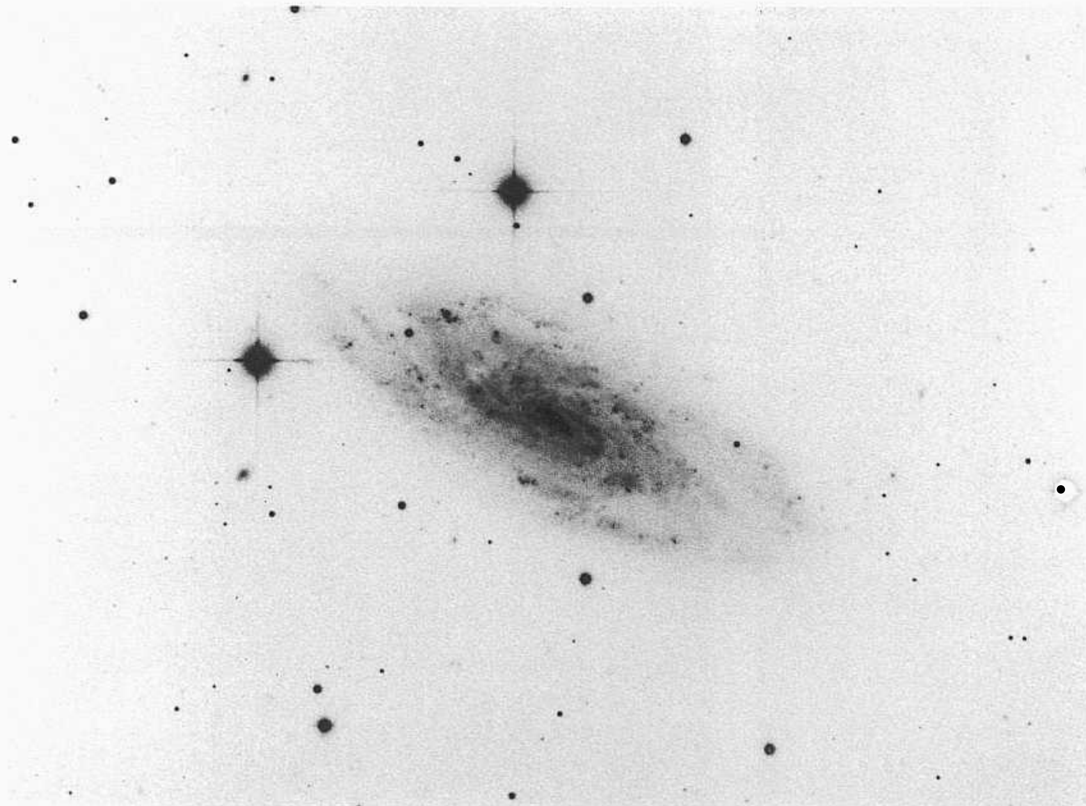
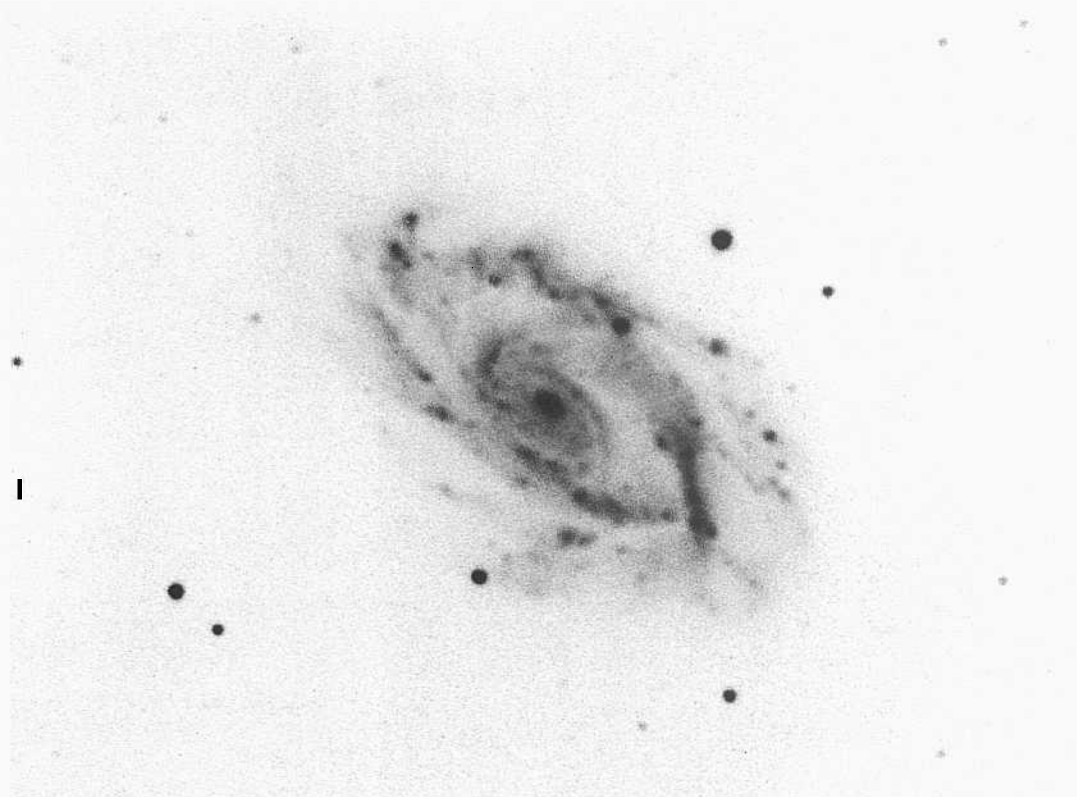
NGC 3646 forms a physical pair with NGC 3 649 (SBa: not in the RSA) at an angular separation of 8'. The redshifts from the catalog of Karachentsev (1987) are i7$_o$(3646) = 4227 km s"^{1} and i)$_o$(3649) = 4322 km s~'. At the mean redshift distance of 85 Mpc (H = 50), the projected linear separation is 200 kpc. However, there is no indication of morphological distortion in the spiral pattern of NGC 3 649. The peculiar outer ring structure in NGC 3646 here cannot be attributed to interaction with NGC 3 649.

NGC 3 649 is much smaller in angular diameter than NGC 3646 . The diameters are 80" for NGC 3 649 and 2 60" for the outer ring of NGC 3 646. Note that the inner part of NGC 3646 resembles a normal Sbc spiral of the same size as NGC 3649. The linear diameter of this inner part is 33 kpc—a normal value for most RSA spirals. However, the outer ring of NGC 3 646 has a linear diameter of 1 07 kpc, which is abnormally large.

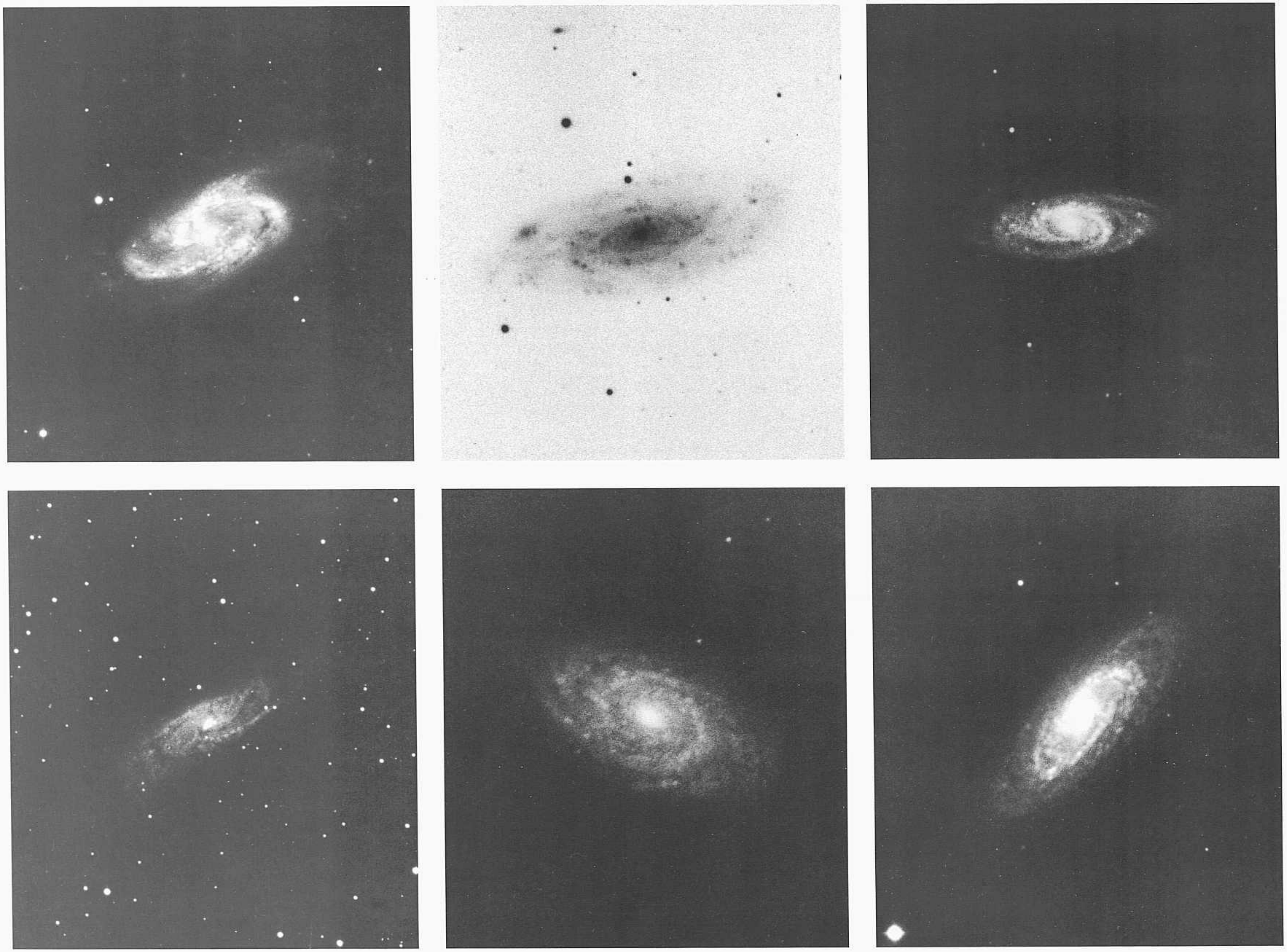
The fact that the inner image of NGC 3 646 has a normal morphology and is of normal size suggests that the ring is a result of a dynamical process such as the dropping of one galaxy through another, as postulated by Theys and Spiegel (1976, 1977) and by Lynda and Toomre (1976) in other ring galaxies. The abnormal velocity field and an early comment on the large linear diameter of the ring are given by Burbidge, Burbidge, and Prendergast (1961).

PANEL
189

PANEL
190



The six **galaxies on** this panel arc of **intermediate-to-late** luminosity class **II or II-III.** Most have **filamentary** arm structure, although each has two dominant principal **arms inside** the filamentary fragments **that** are **in** the **outer** arm **pattern.**

NGC 150 Sl)c(s)H pec
CD-1588-S
Aug 11/12, 1980
103aO + GG385
45 min

The spiral pattern in NGC 150 is of the grand design type although there are three high-surface-brightness arms rather than only two in the reflection symmetry of grand design patterns. Two bright inner arms start from the center. After half a revolution one of these (called here the first) nearly overlaps the second which, however, can only be traced for less than half a revolution; consequently it does not overlap the first. The third arm crosses the first (out of the fundamental plane?) after the first has made only a quarter revolution outward. The third then decreases in surface brightness and continues outward as a very-low-luminosity arm which can be traced for another half revolution. A prominent dust lane threads the middle of the first arm. Such a three-armed pattern is unusual but not unknown.

The redshift is v_0 = 1620 km s^{-1}.

NGC 4219 Sbc(s)II-III
CD-1877-HB
April 11/12, 1981
103aD + GG495
45 niin

NGC 4219 has a small central bulge (nucleus). Two main, moderately ill-defined luminous arms with associated dust lanes begin at the center and can be traced as bright fragments of a grand design pattern for about half a revolution. The disk inside the edges of these arms has moderately high surface brightness from the center outward (i.e., the inter-arm region is filled with disk light).

The redshift is v_0 = 1684 km s~'.

NGC 7162 **Sbc(rs)Il** **pair**
CD-1584-S/Br
Aug 11/12, 1980
103aO + GG385
45 inin

The spiral pattern in iNGC 7 1 62 is multi-armed in thick fragments that begin at the center.

NGC 7162 forms a physical pair with NGC 7166 (SO: panel 34) at an angular separation of 11'. The redshifts are u_0(7162) = 2169 km s~' and u_0(7166) = 2376 km s~'. At the mean red-shift distance of 45 Mpc *(II* = 50) the projected linear separation is 145 kpc.

NGC 5376 Sbc(s)II
PH-7644-S
April 27/28, 1979
103aO
12 min

The disk of NGC 5376 is filled with moderately thin arm fragments and associated dust lanes.

The redshift is v_0 = 22 10 km s^{-1}.

IC 1783 **Sbc(rs)Il**
CD-542-S
Oct 1/2, 1978
103aO + GG385
45 min

Two principal bright inner arms form an almost complete inner ring. Lower-surfacc-brightness, outer (fossil?) arms are relatively thin and well defined.

The redshifl is v_0 = H2 72 km s"'.

NGC 1353 Sbc(r)II
CD-I 183-Br
Aug 23/24, 1979
103aO + GG385
4'5 min

The spiral pattern of NGC 1353 is nearly identical with those in NCC 7 162, NGC 5376, and IC 1783 on this panel. Two bright, tightly wound inner arms have the grand design pattern. Fainter outer arms, with many fragments, spread throughout the outer disk, giving the appearance that the disk is filled with arm segments similar to in NGC 2841. Hut NGC 1353 is later in the classification sequence.

The redshift is v_0 = 152 1 km s"' .

NGC 5055 Sbc(s)II-III HA, p. *15*
S-59-Ritchey panel S5
March 9/10, 1910
Seed 23 (blue)
300 min

NGC 5055 insert
H-93-Duncan
May **14/15,** 1926
E33
180 **min**

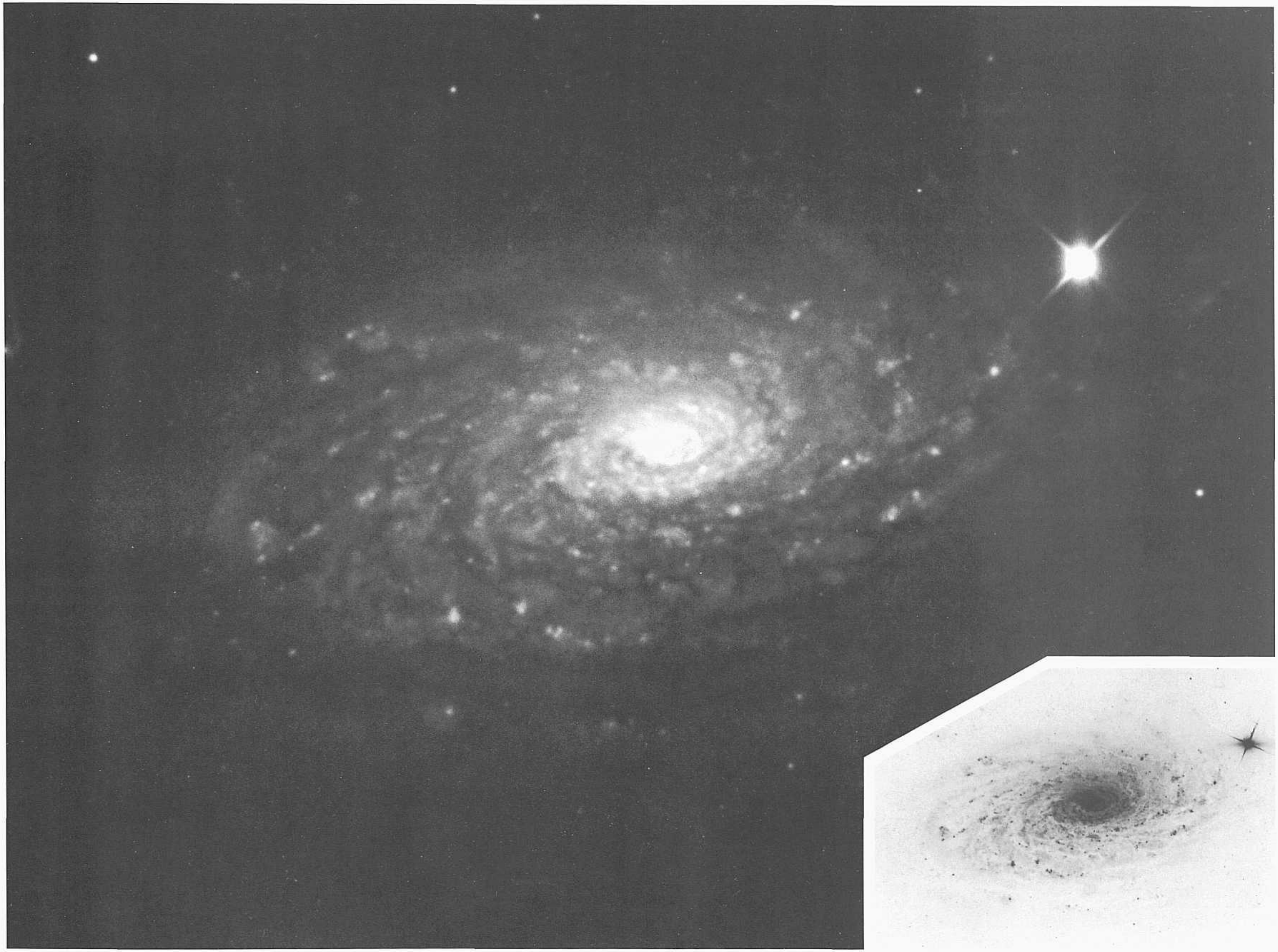
The original plate used here as the main print was taken by Ritchey in 1910 with the newly completed Mount Wilson 60-inch reflector, which many astronomers believe was the most productive telescope of all time. The insert negative print is made from the plate used for the reproduction in the Hubble Atlas, taken by John Duncan **with** the Mount Wilson 1 00-inch reflector in 1926.

The quality of the images shows the superior nature of both the 60-inch and the 100-inch telescope optics in their ability to resolve to the seeing limit of the Mount Wilson site (better than 0.4" under the best conditions).

The spiral pattern of NGC 5055 is similar to those in four of the six galaxies on the preceding panel. The inner region has very-high-surface-brightness arms which thread throughout the disk. These filamentary arms can be traced as fragments almost to the center of the galaxy.

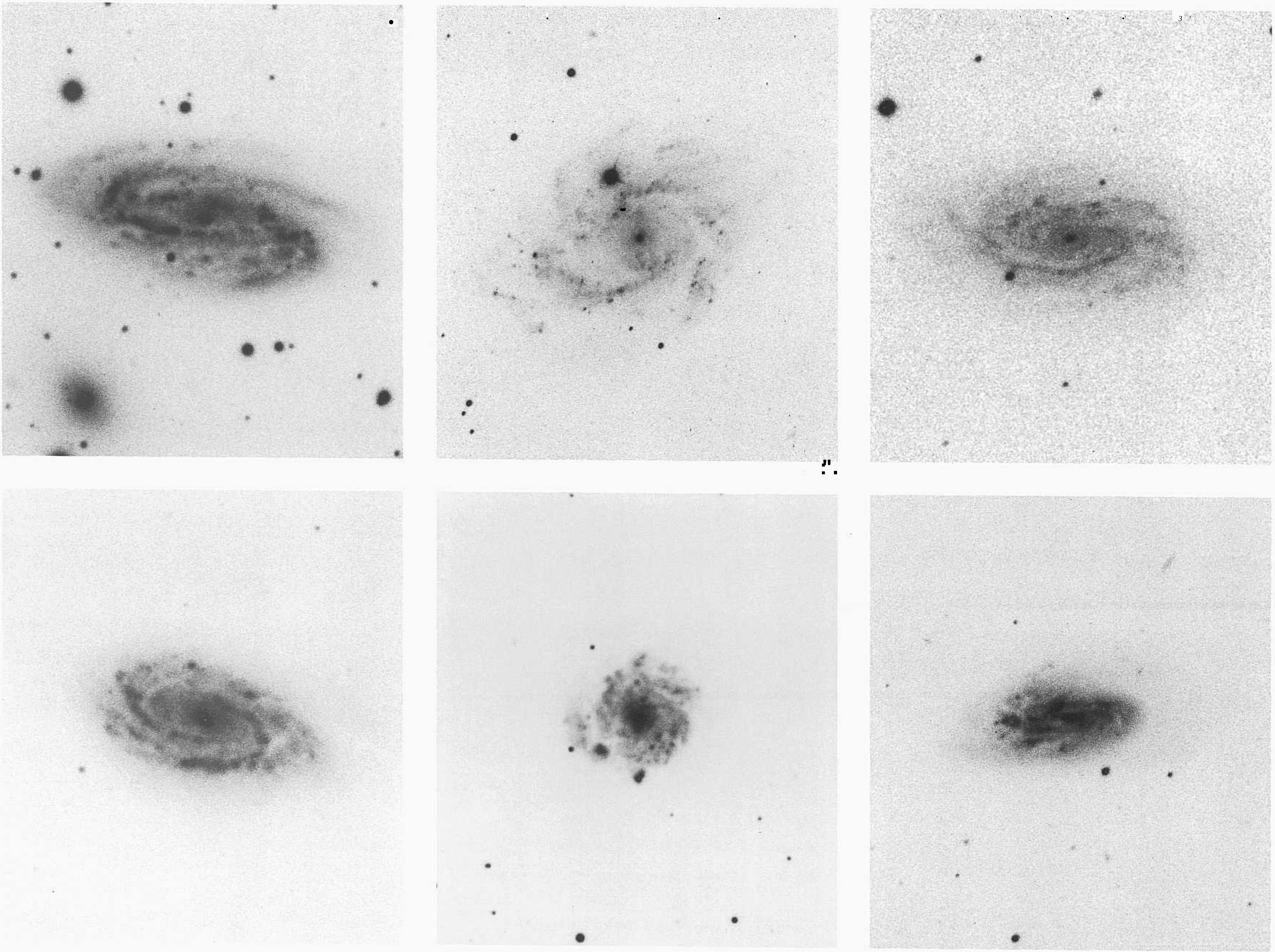
The surface brightness of the multiple-armed pattern decreases abruptly at radius 5 0" (2.7 kpc) from the center. The outer, lower-surface-brightness multiple arm fragments, together with their associated dust lanes, wind outward and cover the extended disk, similar to the pattern in the earlier Sb prototype NGC 2 841 (panels 142. S4. S12).

Many small, generally unresolved IIII regions exist, the largest of which are less than I .5" in diameter. The redshift of **NGC** 5 0 55 is small at $v_o = 550$ km s^{-1}.



PANEL
191

PANEL
192



NGC 6754 **Sbc(s)IMII** **pair**
CD-528-S/Br
Sep30/Oct **1, 1978**
103aO + GG385
45 **niin**

NGC 6754 forms an apparent **pair** with an anonymous SBO galaxy of unknown **redshift** at an angular separation of I.]/.

The spiral pattern is not multiple, as in NGC 5055 on the preceding panel, nor is it as regular as in grand design spirals of earlier luminosity classes. One principal bright arm is easily traced, but the other, which begins on the far side of the center, is more difficult to follow; it breaks into fragments as it comes to the near side on the outside of the first **principal** arm. The asymmetry of the luminosity distribution of the dust silhouetted against the disk identifies the near and far sides.

No individual **HII** regions are easily identified. The redshift is v_0 = 3207 km s"'.

NGC 5313 Sbc(s)II
PH-8094-S
Feb6/7, 1981
103aO
12 niin

NGC 5313 forms an apparent pair with NGC 5311 (Sa, very early), of similar angular diameter but of unknown redshift at a separation of 9.4'. If the redshift of NGC 5311 is similar to that of NGC 5313, v_o = 2588 km s~\ the projected linear separation of the pair would be 140 kpc.

The spiral pattern of NGC 5313 is of the grand design type. The luminosity class is **II.** There are only two principal arms, both of high surface brightness and tight piteli angles so that they nearly overlap in their outer regions after each has unwound by about half a revolution. A prominent dust lane exists on one side of the spiral pattern, silhouetted against the background disk.

Visual inspection at the telescope shows the disk to be of very high surface brightness. There is an unresolved **(starlike)** nucleus.

NGC 864 **Sbc(r)n-III/SBbe(r)II-III**
H-1438-H
Nov 21/22, 1932
Imp. Eel.
45 **niin**

The central oval forms **a** weak **bar. The** two **principal** arms spring **from the** ends **of the** bar's major axis. Fainter outer arm **fragments** exist.

The two largest of **the** many 1111 regions resolve **at** about the *2"* level; the others are unresolved. The redshift **of NGC** 864 is v_0 = 1707 km s"[1].

NGC 278 **Sbc(s)11.2**
PH-12-S
Sep 25/26, 1951
103aO
5 miii

The surface brightness **of** the multiple-armed spiral pattern in NGC 278 is exceedingly high, although not as high as those of the two principal inner arms **of** the **Seyfert** galaxy NGC 1068 (Sb: panel 138), which are among the brightest arms in the RSA. Multiple exposures at short-exposure times also show a very bright nucleus in NGC 278, which, however, is still **diffuse** at the 2" level rather than unresolved (starlike) as in many Seyfert galaxies. The print here is from a short-exposure, early 200-inch **Palomar** plate, underexposed **to** show the **multiple-armed** pattern that begins at the center.

The redshift of NGC 278 is u_o = **932** kms"'. The two diffuse knots may be HII complexes; the largest has an angular **diameter of** about 5", corresponding to a linear **diameter** of 450 psc.

Faint luminosity exists outside **the** etlge **of** the bright disk. A spiral **pattern** exists in dust that is silhouetted against the **envelope** luminosity.

NGC **4682** **Sbc(rs)II**
CD-1883-HB
April 11/12, 1981
L03aO
60 min

The principal **arms** in [NGC 4682 **are narrow** and **are well** traced **for almost** u whole **revolution** from **their beginning near Lhe center.** They branch and **have** a **fainter** surface **brightness** in **the** outer regions.

The redshift is v_0 - 2099 km s⁻'.

NGC 3547 **Sbr(s)II-lII pec**
CD-1852-HB
April 4/5, 1981
103aO + GG385
45 **min**

Spiral **structure** is present **as** segments rather **than** in **a regular** pattern. The surface brightness of the arms and the underlying disk is high. **The** redshift is v_o = 14(11 km **s**$^{-1}$.

NGC 1808 Sbc pec
CD-706-S
Jan 30/31, 1979
I03aO + GG385
45 min

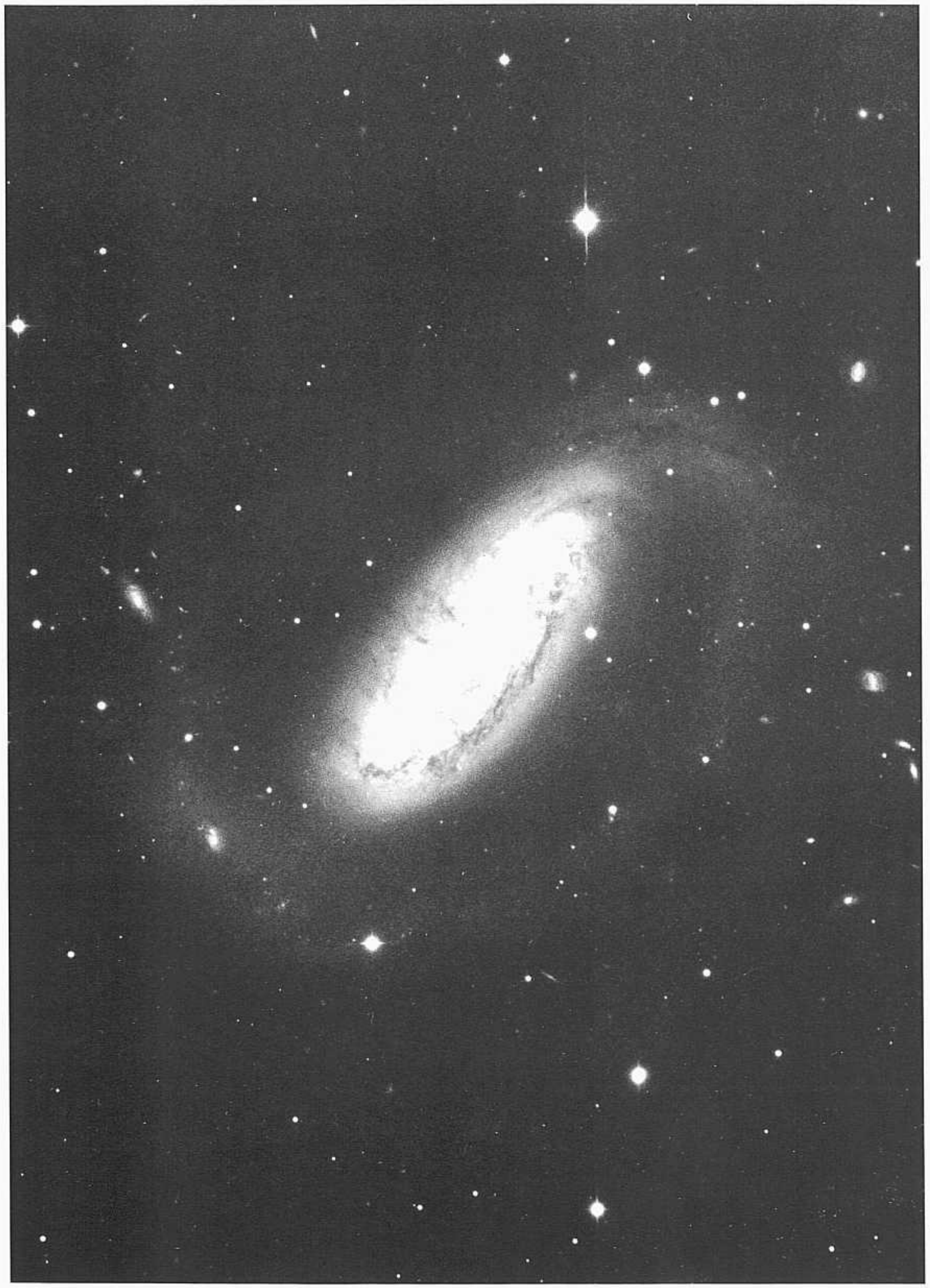
The central region of NGC 1808 **provides what** appears **to** he direct evidence of a galactic fountain **composed** of narrow dust lanes **perpendicular to the plane. The** shallow print on the right shows a series of dust lanes cutting across **the** far **edge of** the **disk, perpendicular** to the **major** axis. A short-exposure Mount Wilson 1 00-inch plate (not shown here) shows the far side of the disk to he heavily **obscured** within a 15° cone centered on the minor axis. The optical depth of the dust in the cone is ahout unity.

The cone originates in the plane at the center of the galaxy **where** at least six **very-high-surface-brightness (unresolved)** knots exist, evidently connected with the origin of the fountain. Weaker dust lanes, also perpendicular to the plane, are silhouetted along about half the length of the far-side image of the disk.

Heavy dust lanes in the disk are evident in silhouette on the near side, most easily seen in the thin right-hand print.

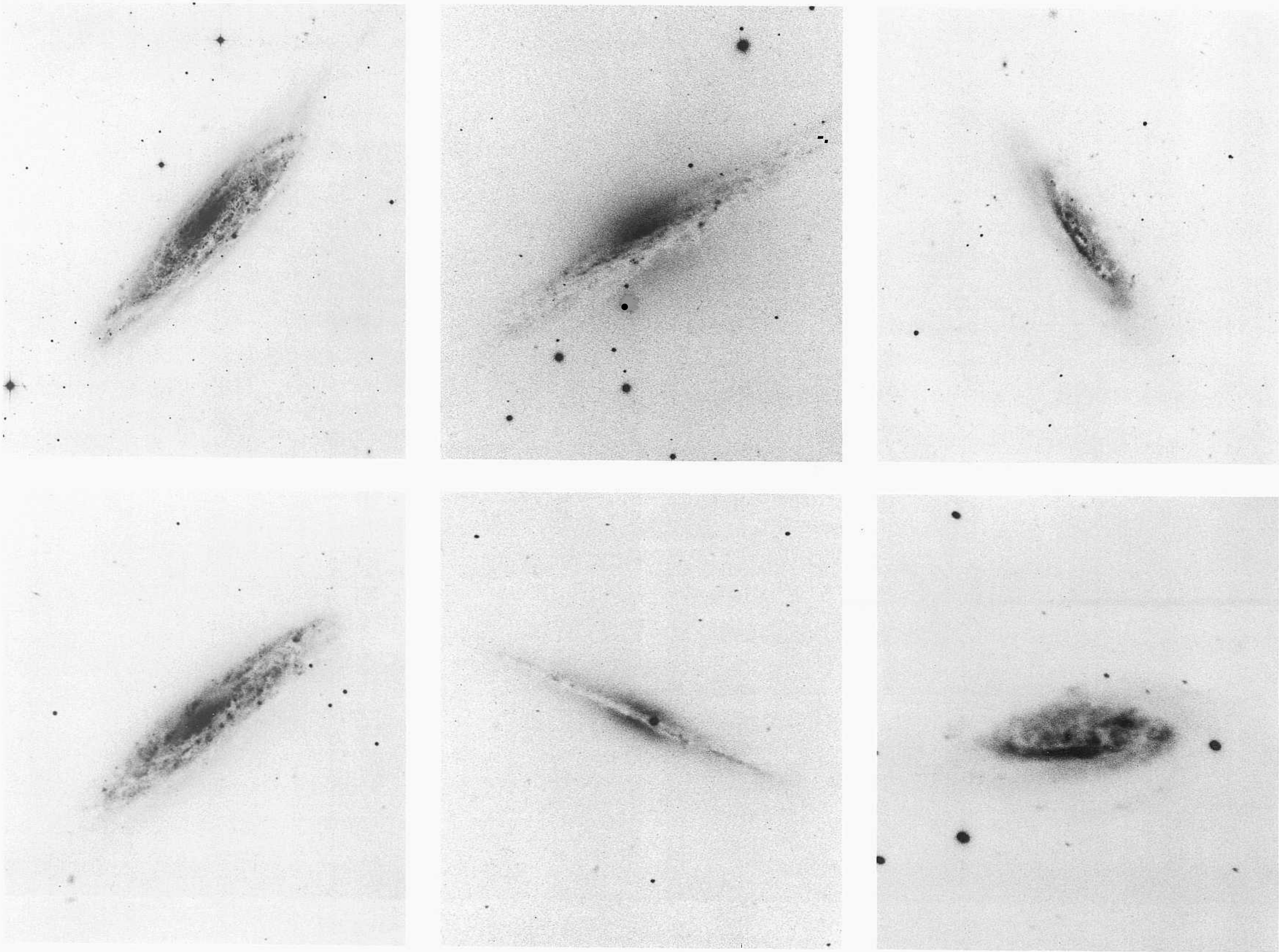
Two oppositely symmetrical, very-low-surface-brightness outer arms emerge from opposite ends of the major axis. Each can be traced for half a revolution before they overlap to form what at first glance would appear as a complete outer ring.

No Hll-region candidates are obvious. The redshift of NGC 1 808 is low. v_o = 820 km s"[1].



PANEL
193

PANEL
194



Galaxies on this and the following panel arc seen nearly edge on. Their classification as She is. of course, uncertain because the spiral .structure is al best difficult to trace. The classification criteria used here are (1) the size of the central bulge (smaller than in SI) types shown on panels 149—154 and larger than in Sc's) and (2) good dust lanes and. where visible, a moderate rate of recent star formation, as judged by the number of Hll-region candidates and other signs of recent star formation.

NGC **134** **Sbc(s)(II-III)**
CD-448-Rose
Aug 10/11, 1978
103aO + Wr2c
90 niin

The innermost part of the disk is smooth over the first 50" **(diameter)** region. The multiple dust lanes that outline the arm fragments then begin at the rim of the disk.

Dust-lane asymmetry between the near and far sides is **particularly** strong in this galaxy. As the sense of the opening of the spiral pattern is also unambiguous in the image here, NGC 134 is another excellent ease for determining the sense of the rotation relative to the opening of the spiral arms (Hubble 1943; de Vaueouleurs 1958).

The redshift is v_0 = 1594 **km** s^{-1}.

NGC 4666 **SbcII.3** **triplet**
CD-1411-S/Br
March 23/24, 1980
103aO
75 min

NGC 4666 is in the busy area of the southern extension of the Virgo Cluster, at RA = 12' 42"', Dee = —00° 11'. It forms an apparent pair with NGC 4668 **(SBc;** panel 313), at a separation of 7.8'. The redshifts are u_o(4668) = 1530 km s"" and w_o(4666) = 1474 km s"'. NGC 4632 (Sc: panel 288), with a redshift of v_o = 1557 km s"', is 46' distant from NGC 4666. At a mean redshift distance of 30 Mpc for the apparent triplet, the **projected** linear separations of NGC 4668 and NGC 4632 from NGC 4666 are 68 kpc and 400 kpc, respectively.

NGC **1055** **Sbc(s)II**
PH-7700-S
Sep 26/27, 1979
103aO
12 min

The direction of opening of the spiral arms (clockwise going from the inside outward) and the identification of the near side is unambiguous **in this** galaxy. Note that the light from the moderate-sized central bulge can be seen above and below the near side of the disk.

The redshift is v_o = 1098 km s"1.

NGC 4013 Sbc:
H-1997-H
May 25/26, 1938
Agfa **Blue**
60 niin

The size of the bulge is the only classification criterion for NGC 40 1 3 ; the galaxy is nearly edge on.

NGC **4522** SWSb: **VCC 1516**
CD-1352-S/ISr **panel 291**
March 15/16. 1980
103aO
75 niin

NGC 4522 **here and NGC 4433,** below, have almost **identical morphologies outside** the ridge-line of the **classification** system. **(They are** not down the middle **»I' the morphological box hut exhibit a classification dispersion** perpendicular to that **ridge-line.) A single, high-surface-brightness arm fragment** is visible on one side of **the major** axis. LI a symmetrical arm exists on the other side it is hidden by dust. But the pattern of extreme asymmetry may indeed be in fact, not merely in appearance.

The **redshift of** NGC 4522 is v_0 = 2 1 86 km s^{-1}. The galaxy is listed as a **cluster** member in the Virgo Cluster Catalog **(BinggeK, Sandage,** and **Tammann** 1985).

NGC 4433 **SbcIll** **pair**
PH-1171-S **HA,** p. *23*
Dec **14/15,** 1955
103aO
30min

NGC 4433 forms a **physical pair** with NGC 4428 (Se; **panel** 2 65), with angular separation of 7.2'. The n-dshifts are v_o*(4-42H)* = 282H km s"' and u_o(4433) = 277 I km s"'. Al a mean **redshift** distance of 56 Mpc, the projected linear **separation is I 1 7 kpc.**

The morphology of NGC 4433 is similar In that of NGC 4522, above.

IC 750 **S(b)** Karachentsev **313**
CD-1544-S/Br
Aug 7/8, 1980
103aO + GG385
4-5 niiii

IC 750 forms a close pair with IC 749 (SBc; panel 306) at a separation of 3.3'. The **redshifts** are closely the same, $u_o(749) = 827$ km s~[1] and $u_o(750) = 742$ km s"V At the mean redshift distance of 16 Mpc, the projected linear separation is small, at **15 kpc.**

The **morphology** of **IC** 750 is similar to that **of** both NGC 4522 and NGC 4433 on the preceding panel. The surface brightness of the central parts of IC 750 is very high, but the resolution into individual HII regions is not nearly as great as it is in the companion. The normal morphology of IC 749 shows no evidence of tidal perturbation, but, like the morphology of NGC 4522 **and** NGC 4433. **the** form of IC 750 is outside the ridge-line of the classification sequence (i.e.. it is **outside** the middle line through the morphological box).

NGC **2764** Amorphous or Sb pec panel **145**
PH-7602-S
April 3/4, 1979
IllaJ + GG385
30 min

NGC 2764 has been discussed on panel 145, in the Sb section. It is shown here to contrast the sizes of the central bulge in Sb, Sbc, and Sc galaxies.

The redshift of NGC **2764** is v_{n_c} = **2636 km** s^{-1}.

NGC **7090** **Amorphous or** SBc:(on edge)
CD-1544-S/Br
Aug 7/8, 1980
103aO +GG385
45 min

NGC 7090 is a large-angular-diameter, late-type galaxy, seen nearly on edge. The main body, shown well in the heavily printed image at the top middle, is 6' in diameter. At the redshift distance of 15 Mpc from the redshift of v_0 = 754 km s~[1]. the corresponding linear diameter is large, at 26 kpc.

The central bulge is small or nonexistent. There is no visible halo or bulge above the plane. The asymmetry of the luminosity distribution in the disk is the reason for the barred subtype. Based on these criteria, the (uncertain) classification here is SBc.

NGC 6835 Amorphous?
CD-911-HB
April 29/30, 1979
103aO + GG385
40 imin

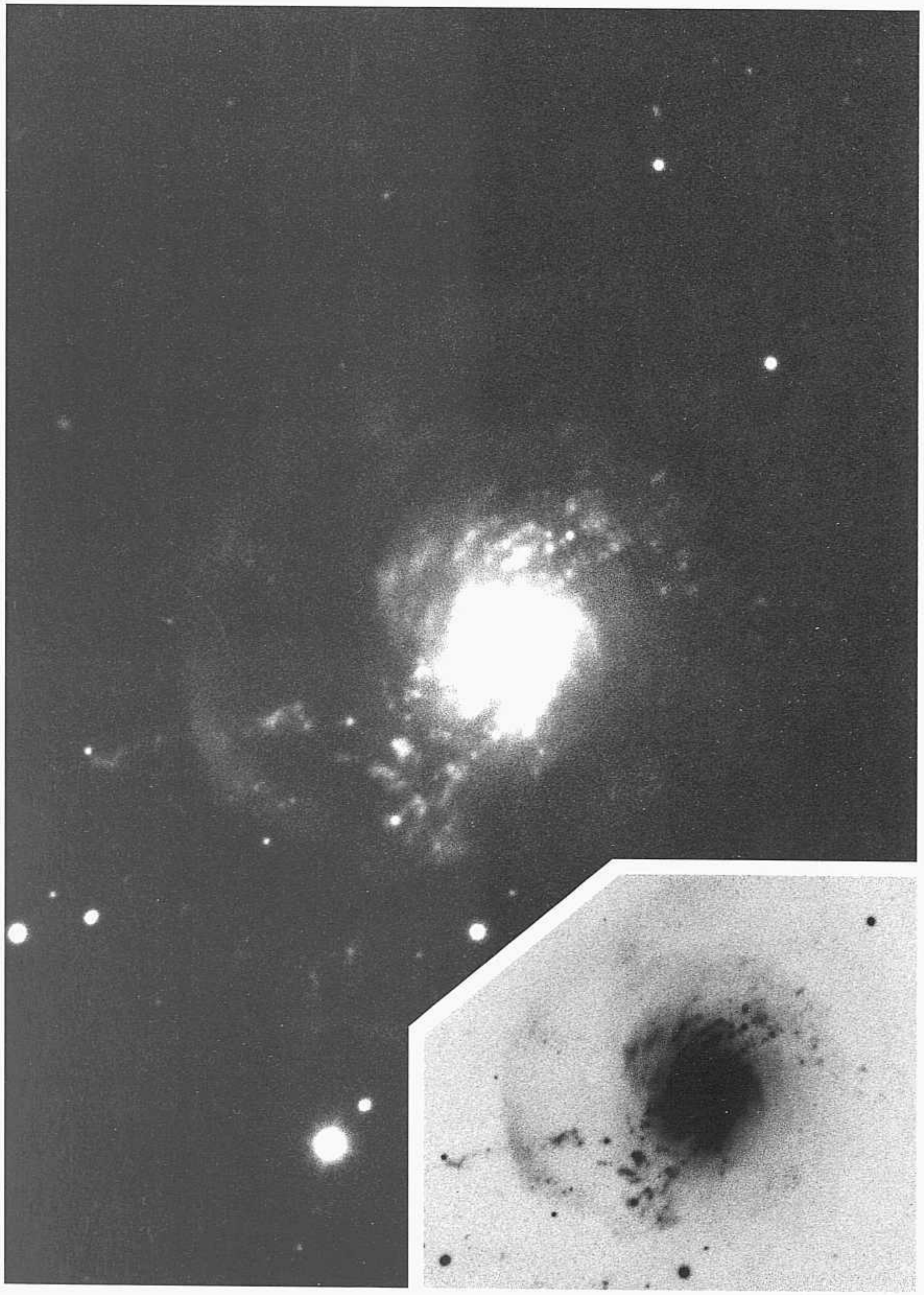
The classification of NGC 6835 is uncertain. From the asymmetry in the pattern seen in the short-exposure image at the top right, one guesses the presence of spiral structure, similar to the case in the very early galaxies NGC 4425 (SBO or SBa; panels 57, 60) or NGC 4429 (SO/Sa; panels 60, S2) if that galaxy could be viewed more edge on. On the other hand, the asymmetry in NGC 6835 may simply be due to dust patches.

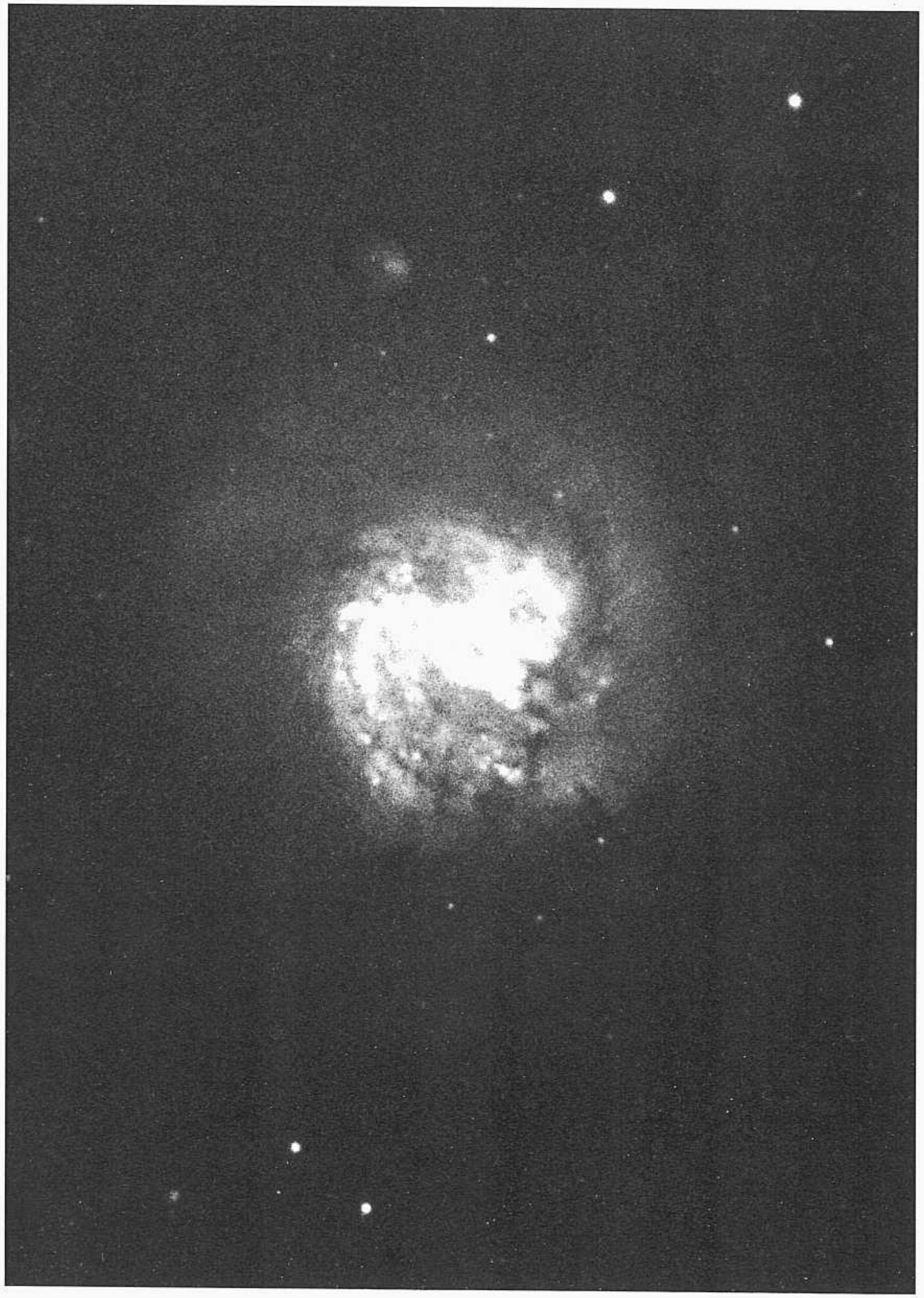
No resolution into components of the stellar content is seen. The heavy print at the upper right shows high-surface-brightness luminosity **of** the face; hence the Amorphous? classification is suggested.

The redshift is v_a - **17**11 km s"[1].

PANEL
195

PANEL
196





NGC **3310** **Sbe(r)(merger)** **Racine wedge**
PH-7982-S
Feb 1/2, 1981
103aO
12 niin

NGC 3310 is unusual **because** of the smooth outer **plume** thai **surrounds half the** image. l(is similar to plumes in NGC 7252 (panel 340). NGC 4038/4039 (panel 280). **and** others mentioned earlier in this seetion. **Interpretation** of these plumes and of the polar rings as merger events, by **Toomre** and Toomre (1972), **Toomre** (1977), **Schweizer** (1980, 1982, 1983. 1986). **Quinn** (1984), Schweizer, Whitmore. and Rubin (1983), Schweizer and Seitzer (1988), and others, may apply here as well.

That the feature may be a merger rather than a **tidal** plume **due to** encounter is suggested by two circumstances. (1) NGC 3310 is isolated; there are no candidates in the nearby field for tidal companions. (2) Very short **exposures** on **a** plate taken with the Mount Wilson 60-inch **reflector** show *two nuclei* buried in the high-surface-brightness image, separated by 2". Each nucleus is sharp, and each is surrounded by galaxy material belonging separately to each.

The chaotic nature of the spiral fragments, with their many knots and their high rate of current star formation, may have been induced by the event.

The redshift of NGC **3310** is v_0 = **1073 km** s^{-1}.

NGC **5713** **Sbc(a) pee** **group**
CD-1391-S/Br
March 21/22, 1980
l03aO
75 mill

[NGC **5713 is the center of a** group **of late-type** spirals **that** includes NGC **569** 1 **[S(B)b pec;** panel 168. v_o" 1768 **km** s"[1]], **NGC 5705** (Slid. **not** in **the** RSA: v_0 = 1660 km s"[1]). **NGG 5713 here** (v_o **=** 1777 **km a⁻'}, and NGC 5719 (Sab?, not** in **the KSA;** v_0 = 1628 **km** s⁻'). **The** mean **redshift** distance **of** the **group** is **34** Mpc. **The** angular and **the projected** linear separations of **the** galaxies from **NGC** 57 L3 **are** 34.9' and **345 kpc for** NGC. **569** 1. 25.8' and **255 kpc for** NGC 5705. and 1 1.4' and 1 13 **kpc for** NGC 57 19. The group defined by these **four members** is evidently smaller than the Local **Group.**

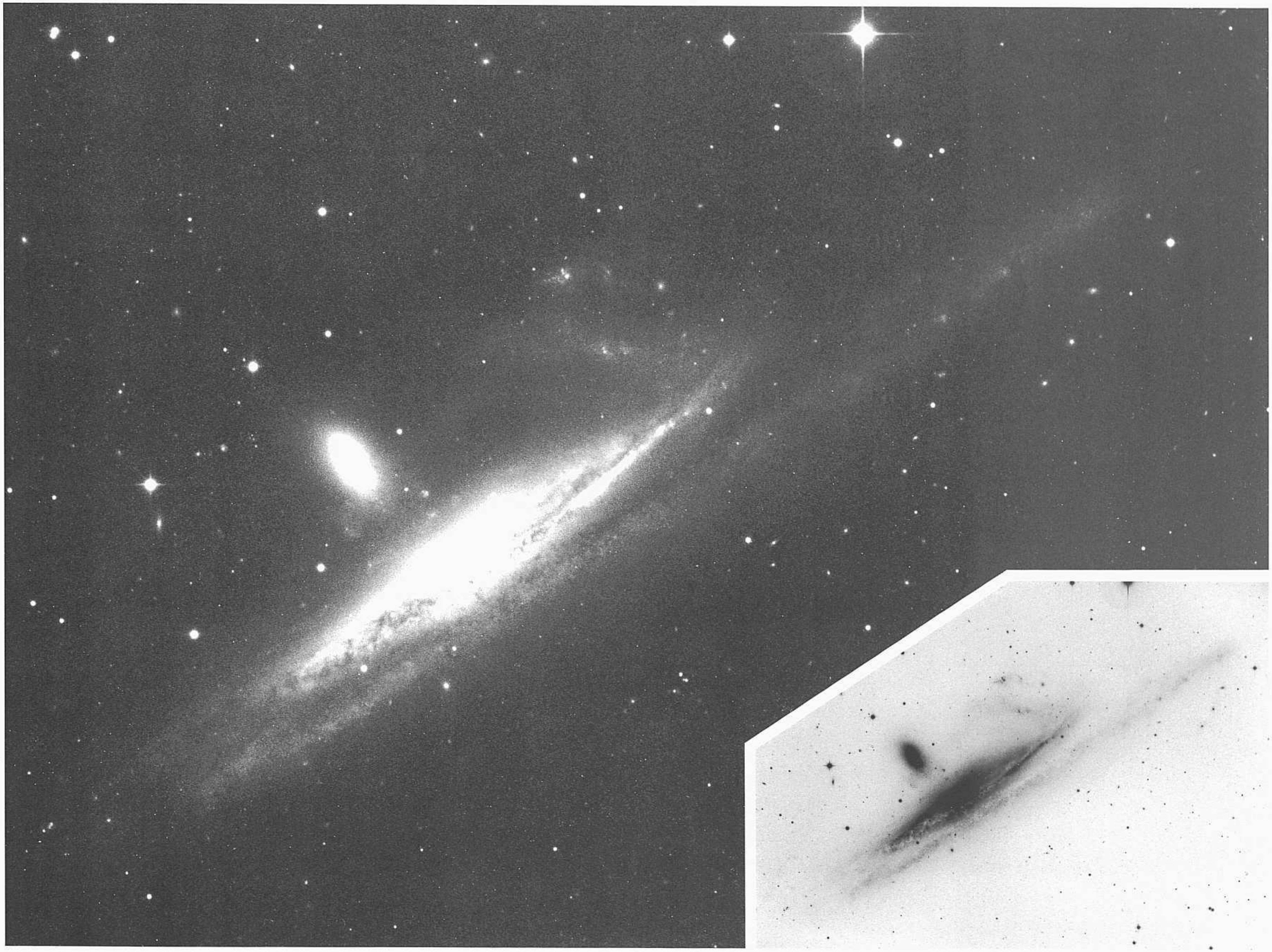
The inner arms **of** NGC S7 13 **are chaotic** and are of the MAS type rather than **the** grand design. They are **of** high surface brightness **for half** a revolution from the center, beyond **which** a single smooth, low-surface-brightness arm continues in a spiral pattern **outward.** Star formation is evident in the inner arm fragments, **as judged** from **the** knots **that** are **HH-region** candidates.

NGC 1531/1532 Amorphous group
CD-2025-Bedke/Gregory Sbc(s)(tides?)
Oct 27/28, 1981 panel 337
103aD + **GG495**
120 min

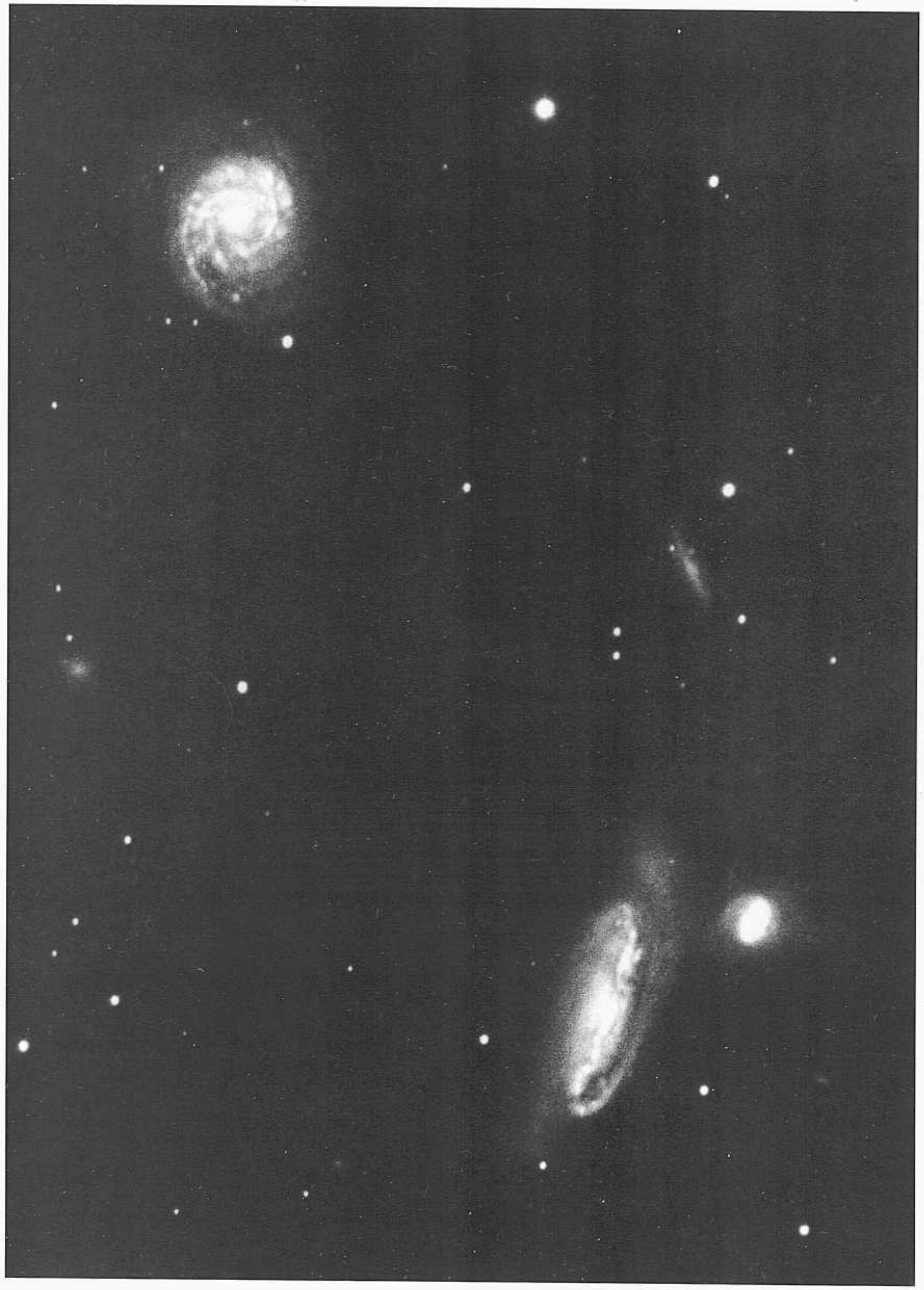
The unusual plumes in NGC 1 5 32 suggest a tidal **distortion** due to an encounter. The evident candidate responsible for the **perturbation** is the amorphous companion NGC 1531. whose morphology is **of the** same class as M82. The two galaxies form a physical pair: the redshifts are u_o**(1531)** = 1053 km s'" and u_o(1532) = 1105 km s^{-1}.

Three **dwarf** candidate companions form a wider physical group centered on the bright pair. The most interesting of the **companions** is at RA **(1950)** = 4^{h} 10^{m} 56^{s}, Dec (1950) = -33° 07' 36". It **appears** as a dwarf **S0(8),N** on a yellow plate but as an Im with **condensations** on a blue plate, similar to the transitional (im-dE.N) case of NGC 4286 (panel 20) (Sandage and Hoffman 1991). The low ratio of the hydrogen mass to total mass also suggests that the dwarf is in transition between Im and dE.N dwarf types (Sandage and **Fomalont** 1993).

The other two dwarf candidate companions are a **high-surface-brightness** SBO (M = —19) at **RA (1950)** = **$4^{h}10^{m}$ 39^{s},** Dec (1950) = -32° 56' 33", and a prototype faint dEO ,N nucleated dwarf elliptical at RA (1950) = 4^{h} 09^{m} 32^{s}, Dec (1950) = -32° **59'** 09".



PANEL
198



NGC 5426/5427 Sbc(rs)1.2 **pair**
CD-909-HB Sbe(s)l
April 29/30, 1979
103aO + GG385
40 miu

Both NGC 5426 and 1NGC 5427 have normal She **morphologies. They evidently form** a physical pair; the **redshifts are** u_0 = **2455** km s~[1] and v_o = 2565 km s[-1]. respectively. The **angular** separation of 2.'.\' corresponds lo a projected linear **separation** of 34 **kpc** at the mean **redshifl** distance of 50 Mpc (// = 50).

The only evidence for a **close tidal encounter are** the **two thin straight strands of** the **multiple** outer arms of NGC 5426 **that overlap the outer** thin **spiral** arms of NGC 542 7, where the **spiral** pattern is of the **grand design. Otherwise,** each galaxy has beautifully **formed arms** that are so regular that each is assigned the **earliest** luminosity class because of the **small geometrical** entropy. Evidently, close **encounters** at some **phase** in their action have **had nearly** negligible **perturbative** effects on the visible morphology.

NGC 7769/7770/777 I Sbc(s)(ticlea?) panel 8 1
PH-7545-S Sa pec Karnchenlsev 592
Nov 6/7, 1978 SBab pec
L03aO
12 min

'The triplet **evidently** forms a **physical** group: **the redshifts (Maytill,** in **11** it mason. **Mayall,** ami **Sandage L956) tire** u_o = 4565 km **s**[-]', v_o = **4554** km **s**[-]', and v_0 - **4492** km s[-] **' for NGC** 7769 (She), **NGC** 7770 (Sa **pec),** and **NGC** 777 **1 (SBab** pee), **respectively. At** the mean redshift **distance of 9 I** Mpc **the angular separations of NGC** 777 **1** from **NGC** 77ü[4]) **of** 3 15" mid **from NGC** 7770 of 60" **correspond** lo **the** small **projected** linear **separations** of' ').'! kpc and 26 kpc, respectively.

The morphologies of **NGC** 7770 **and** *N('A* 777 1 suggest tidal **interactions** dm- to n close encounter. Roth have smooth luminous **outer** regions, **which** are **either** well-defined (tidal?) outer arms as in NG(! 777 I . or compose an **outer** envelope that has a **broken symmetry,** as **in NGC** 7770.

The SBbc Classification Section

NGC **1365** **SBbc(s)I** **FCC 121**
CD-1668-S panel **S8**
Dec 31/Jan 1, 1980/1981
103a0
75 min

NGC 1 365 is nominally classed as a **member** of the Fornax Cluster on the basis of its position and its **redshift. It** is 1 .2° southwest of **the center of the** cluster defined by NGC 1399. The core radius **of the** cluster is 0.7° (Ferguson 1989): hence NGC 1**365** is 1 .7 core **radii** from **the** cluster center. The redshift velocity of NGC 1365 is v_0 = 1562 km s^{-1}, which is close to the mean cluster redshift of $<v_o>$ = 13 66 km s~^{1}. The velocity dispersion of the cluster is 32 5 km s~^{1}.

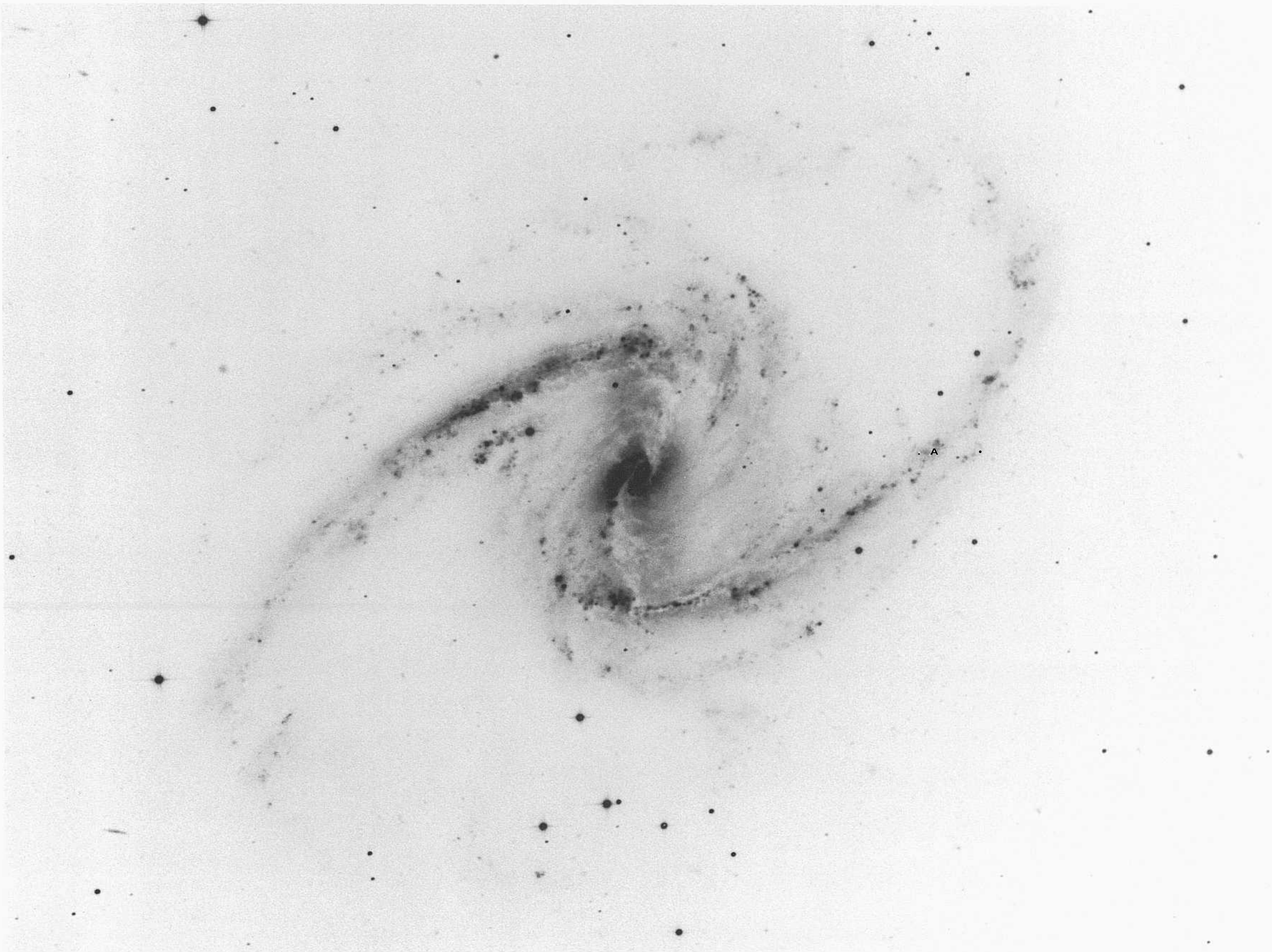
Despite the close agreement of the **position** and redshift **of** NGC 1365 to the Fornax **Cluster** values, the cluster membership **of** NGC 1365 is often **questioned** because its angular size, D_{95} = 9.8'. is so large. Yet **this** angular size is comparable to the D_{95} angular diameters of the largest spirals in the Virgo Cluster, which is at nearly the same distance. The four largest Virgo spirals and their angular diameters and redshifts v_0 are NGC 4192 (9.5'. -251 km s"^{1}), NGC 4536 (7.4'. 1646 km s"^{1}), NGC 4321 (6.9% 1464 km s"'). and NGC 4501 (6.9% 2161 km s"'). The negative redshift of NGC 4192 and other large spirals in the Virgo Cluster region assures Virgo Cluster membership; negative redshifts occur in the RSA **(excluding** galaxies in the Local Group) only in the 6° radius centered on the **Virgo** Cluster (Sandage and Tammann 1976a), attributable to the large velocity dispersion in the Virgo Cluster.

The **morphological** type **of** NGC 1365 is later than NGC 1300 (SBb: panels 154, S8), which **is** the prototype of the **(s)-subtype** barred **spirals; the bar** in NGC 1365 is less straight **and** less smooth, and the arms which spring from the ends of **the** bur are more open. Hence, the type is intermediate between SBb and SBc.

The straight dust lanes are **on** opposite sides of **the** bar. Again (as in the SBb types) these **lanes** are **on tin*** *leading* **edges** of the bar relative to the **direction** of rotation. The positions **of** maximum star **formation** in the thin arms begin at the ends of the bar. The largest **Mil** regions resolve into disks at about the 2" level.

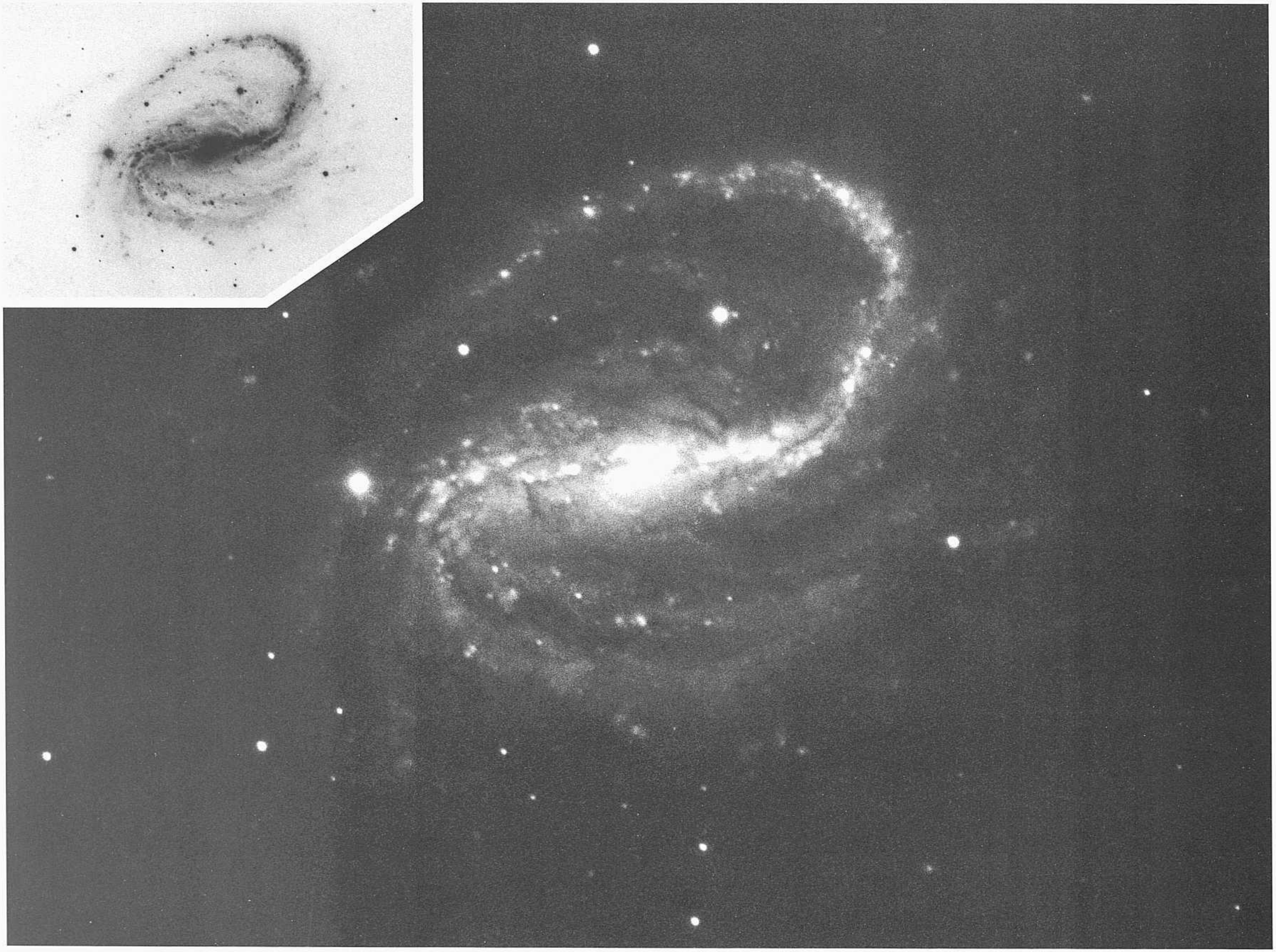
The circulation pattern of the well-ordered but intricate velocity **field** in the vicinity of the bar appears to be well traced **by** the delicate wisps of dust lanes that begin at the two strong shock positions. Note that these delicate lanes are along *the following* edges of the bar and that they are nearly perpendicular to the resulting two nearly **straight** dust shock lanes in the bar.

The luminosity class of NGC 1365 is in the highest bin, at I, because of the regularity and thinness of the arms.



PANEL
199

PANEL
200



NCC 7479 **SBbc(s)I-II** **panel S»**
PH-152-H
Ocl 14/15, 1952
L03aO
30min

The arms in [NCC T1T[1]) art- less **regular Lhan** in NCC **1365, They** arc **branched** into **secondary low-surface-brightness Iragmen**ls on the inside **of the Lwo** main **grand design principal** arms **thai spring from the ends of the bar.**

The **lwo characteristic** nearly **straight** (hint lanes in the **bar continue into the two high-surface-brightness** parts DI the **principal arms. Tin*** lane in what is taken **to be the** near **side (From the** asymmetry **of the luminosity pattern by the** usual **argument; Hubble L943) is well silhouetted and** is **in the middle of that** arm. **The largest** Mil **region** in **the** opposite arm **resolves** at **the angular** diameter (core plus halo) **of** *2"*. which is **large** (5 **1** 0 psc: compare **Sandage** and **Tammann** 1974u) **at the** distance **corresponding to the observed redshift of** v_0 = 2630 km **s**$^{-1}$.

NGC 1097 RSBbe(s)I-II HA, p. *46*
H-2025-B
Oct 21/22, 1938
Agfa Blue
90 niin

The reproduction here is from the same original Mount Wilson 100-inch plate that was used for the print in the Hubble Atlas. In the meantime the plate has suffered surface scratches that may not have been completely removed in tile reproduction here.

The central region in NGC 109 7 is an oval rather than a well-defined bar as in NGC 1300 (SBb; panels 154. S8). Nevertheless, the two straight dust lanes characteristic *oi* SBb spirals are present, presumably resulting from the shocks caused, as usual, by the response of the gas to the rotation of the oval gravitational field.

A tightly wound high-surface-brightness spiral pattern exists in the nucleus, similar to but not as well defined as in NGC 43 14 (SBa: Hubble Atlas, p. *44:* panels 95, 106 here). The complex structure is shown by Sersic in *Observatory* (1958) and in the insert print here.

The outer arms are of low surface brightness. The star-formation rate is low. The HII regions do not resolve at the *2"* level. The redshift of NGC 1097 is v_o = 1284 km i^{-1}.

NGC 7678 SBbc(s)I-II
PH-6547-S
July 25/26, 1973
098 + RG2
60 nun

This distant SBbc spiral of the NGC 1300 type, with redshift v_0 = 3756 km $s\sim^{1}$, has massive star formation in one of its principal grand design arms. Note the two dust patches near the ends of the central oval, which is the bar. These patches occur near the beginning of the (s)-type arms.

NGC 4123 SBbc(rs)I.8 Karachentsev 322
CD-1847-HB panel S8
April 3/4, 1981
103aO
75 min

NGC 4123 forms an apparent pair with NGC 4116 (SBc: panel 306) at an angular separation of 14'. The redshifts are $i?_o$(4116) = 1 140 km $s^{"1}$ and u_o(4123) = 1157 kms"'. The projected linear separation is 93 kpc using a mean redshift distance of 23 Mpc *(H* = 50). Note that this separation is small, similar to the distance of the Small Magellanic Cloud from the Galaxy.

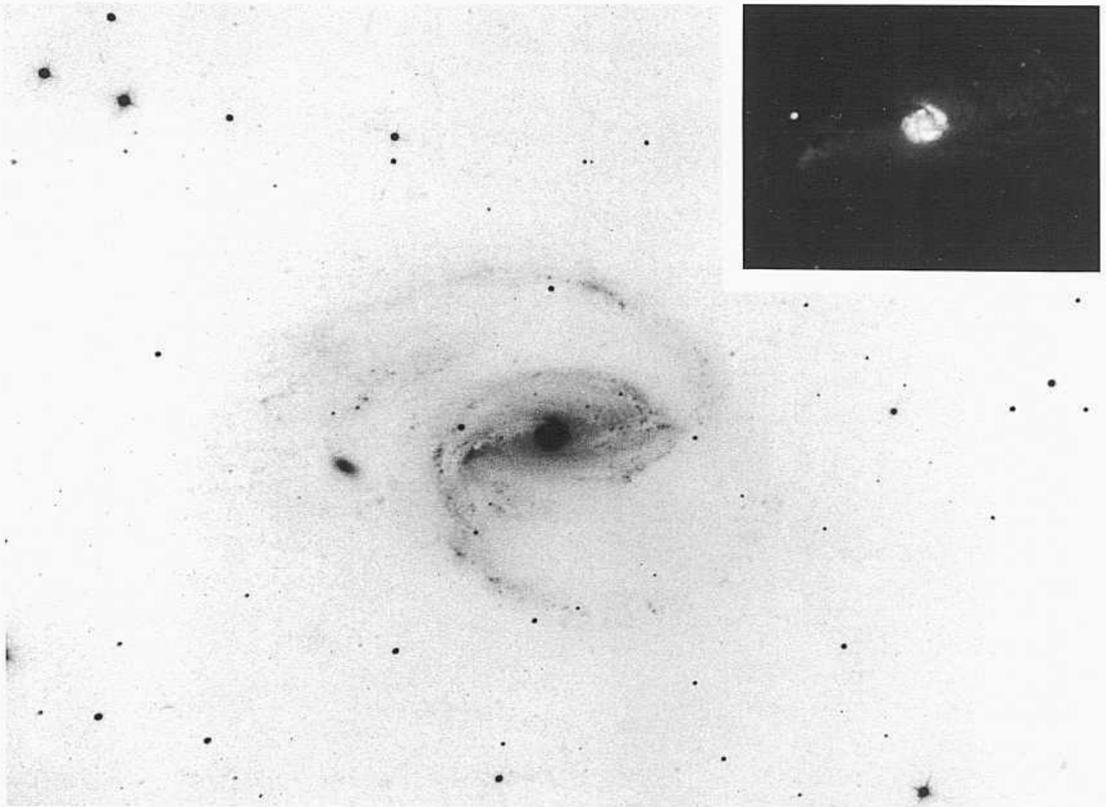
Despite the closeness of the pair there is no evident distortion of the morphology of NGC 4123. The bar is moderately well formed. The characteristic nearly straight dust lanes on the leading edges of the bar are present. Star formation is profuse at the ends of the bar.

The two principal arms are of the grand design type, but a second set of arms, also of high surface brightness, exist. Each starts symmetrically near the start of the principal arms at the strict ends of the bar. The pattern is unusual, leading to four principal arms, three of which are moderately well defined. Because of the outer set of arms that do not start from the ends of the bar, the arm subtype is (rs), although the pattern is unusual.

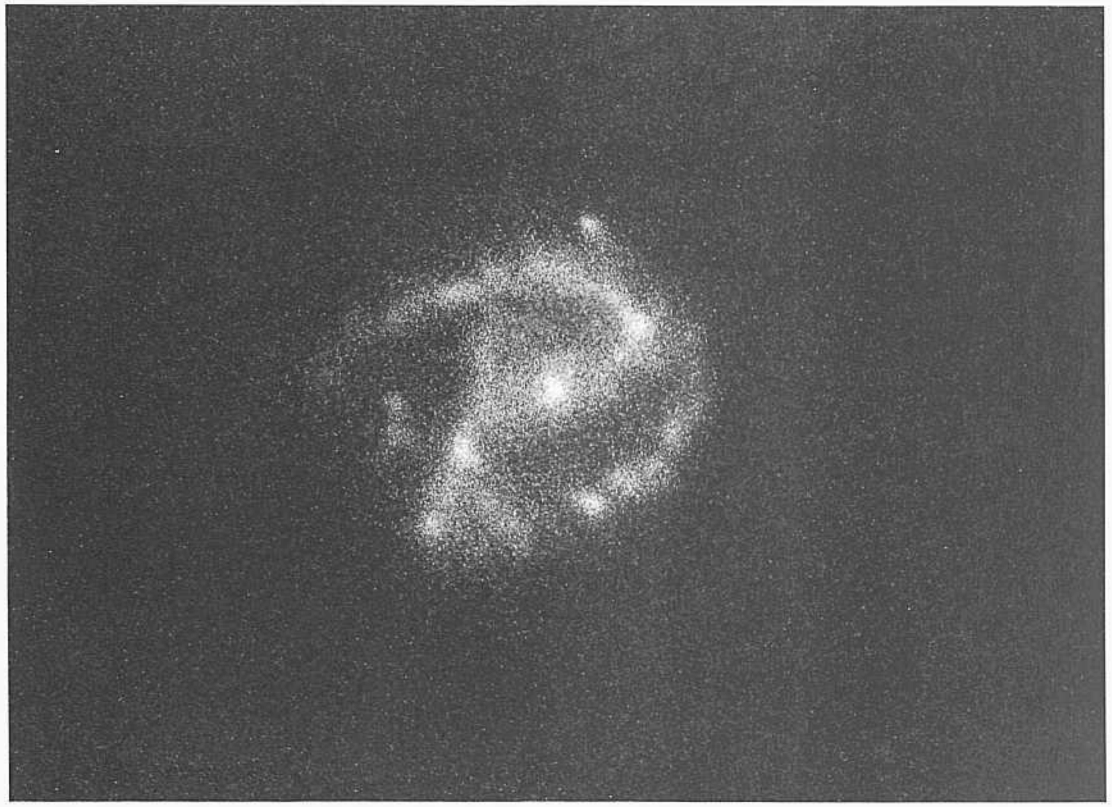
NGC 4412 SBbc(s)I-II pec VCC 921
H-1947-H
Feb 23/24, 1938
E40
50 min

NGC 4412 is listed as a Virgo Cluster member in the Virgo Cluster Catalog. A negative print, enlarged to a common scale with other Virgo Cluster galaxies, is shown in paper IV of the Virgo Cluster series (Sandage, Binggeli, and Tammann 1985a).

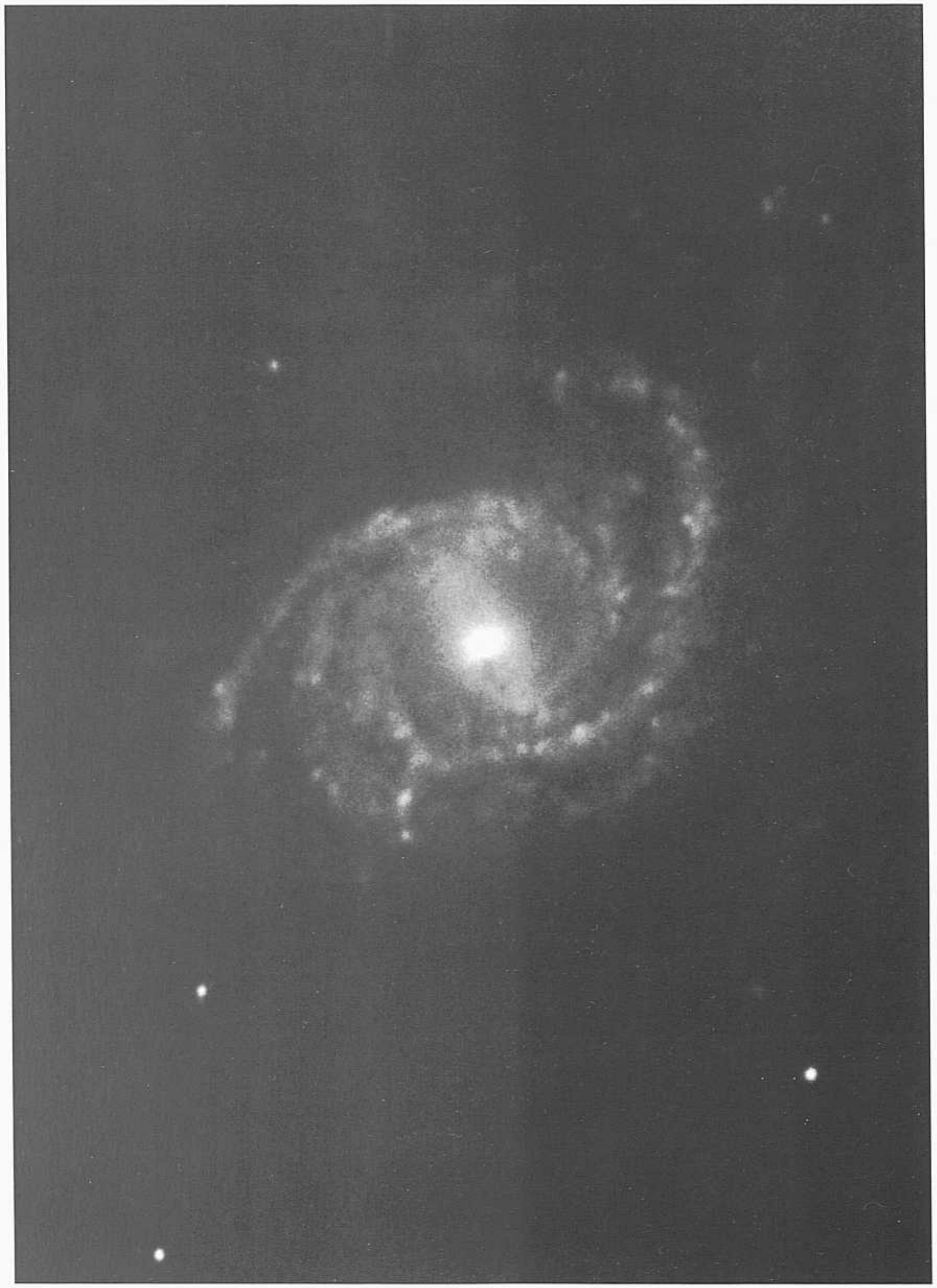
The two principal arms springing from the ends of a bar are of very high surface brightness.



PANEL
201



PANEL
202



NGC 5350 SBbc(rs)I-II group
PH-7624-S panel 29
April 27/28, 1979
103aO
8 **niin**

NGC 5350 forms a physical pair **with** NGC 5353 **(S0/E7;** panel 29) **with** a **separation of** 5.5'. The **redshifts** are $u_o(5350) = 2305$ **km** i^{-1} and $u_o(5353) = 2224$ km i^{-1}. At **a** mean **redshift** distance of 45 Mpc (H = 50) **the** projected **linear** separation is small **at** 72 kpc. **The** pair is in **a** group **with** NGC 5354, 5355, 5358. **and perhaps** 5371, several of which have been shown earlier on panel 29. INGC 5371 (Sh) is shown on panel 126.

The arm **pattern** in NGC 5350 is intermediate between that of the grand design and MAS types. Two main arms start at the ends of the bar but are so tightly wound that they form an inner near-ring after each has unwound by half a revolution. Fragmentary secondary arms exist on one side of the pattern more strongly than on the other.

NGC 3145 SBbc(ra)l HA, p. *21*
CD-790-S panel S9
Feb 23/24, 1979
103aO + GG385
•15 iuiu

The **description in the Hubble** Alias is:

> *The thin multiple units of this galaxy are **complex. The** brightest arms in the northwest **quadrant appear to approach** the nucleus at right angles (tangent rather **than spiraling** inward). There is a single **faint** arm in the .southwest **quadrant which crosses** one of the regular anus nearly at right angles. This **is** a very rare feature **of galaxies** and is particularly well shown here. A **few** dust lanes ran be seen near the crossover point.*

The above language describes **how the** arms approach **the** nucleus **at right angles instead** of spiraling **inward. It** is. **of** course, **an explanation** of how arms in *barred* spirals start. iNGC 3 145 is obviously a **barred** spiral not recognized in the Hubble Atlas because of **the combination of an** unfavorable inclination angle and **the** position **of the line** of nodes.

The arms are **thin** and are very **well** defined, requiring typing as luminosity class I. The redshift of NGC 3145 is $v_0 = 3416$ **km** s^{-1}.

The three galaxies on this panel have arms that are intermediate between those of the pure grand design and the MAS types. Also, in all three the arms begin at the edge of either a complete or an almost-complete inner ring.

NGC 7755 SBbc(r)/Sbc(r)I-II
CD-1165-Br
Aug 22/23, 1979
103aO + GG385
45 min

The possible bar in NGC 7755 is betrayed. if it exists, by the two thin, nearly straight dust lanes connecting the center with the almost-complete ring composed of the inner spiral arms. These two dust lanes are. as in all more-pronounced barred SBb and SBbc galaxies, on the leading etlge of the bar. which here is the central oval.

The numerous HII regions are unresolved at the 1" level. The redshift of NGC 7755 is v_o = 2969 km s^{-1}.

A compact EO , possibly M32-like, candidate companion exists at an angular separation of 100". well visible on this print.

NGC 2545 SBbc(r)I-II
PH-7899-S
Nov 6/7, 1980
103aO
12 min

The inner ring in NGC 2545 is of very high surface brightness and appears to be nearly complete. A short-exposure plate shows that the surface brightness varies around the ring. The feature is related to the two positions on the ring where the faint bar terminates.

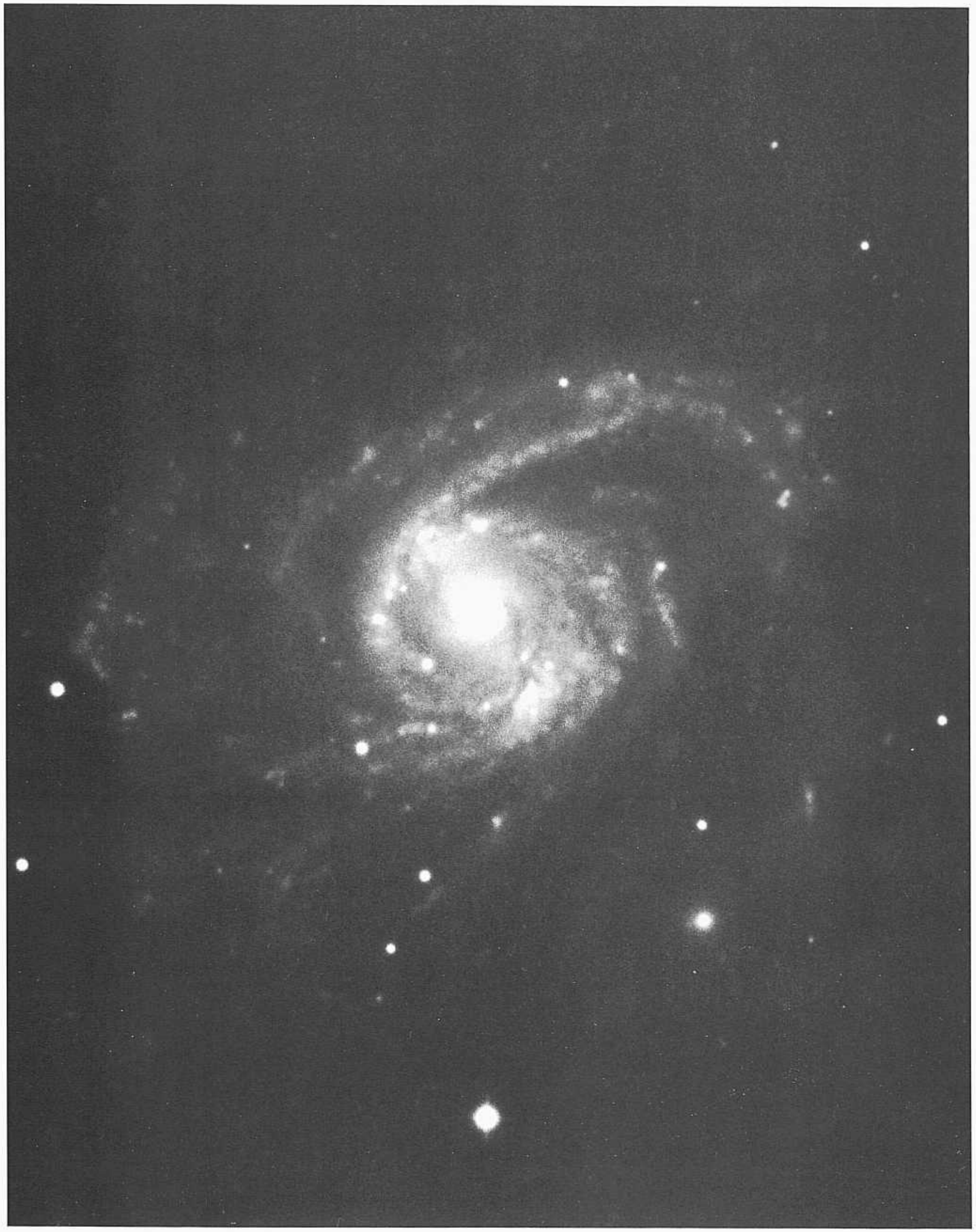
As in other barred SBb and SBbc types, the maximum star-formation rate occurs near the ends of the bar, continuing for about a quarter revolution along the arms. It is this feature that causes the surface-brightness variation around the seeming ring. But, as usual, the form is made by two overlapping, tightly wrapped separate arms. The morphology is similar to that of NGC 3081 (SBa: panels 99, 107), NGC 3185 (SBa; panel 99), NGC 1326 (SBa: panel 100), and NGC 6902 (Sa; panel 69). The most extreme example of a near-perfect ring is NGC 7742 (Sa: panel 66).

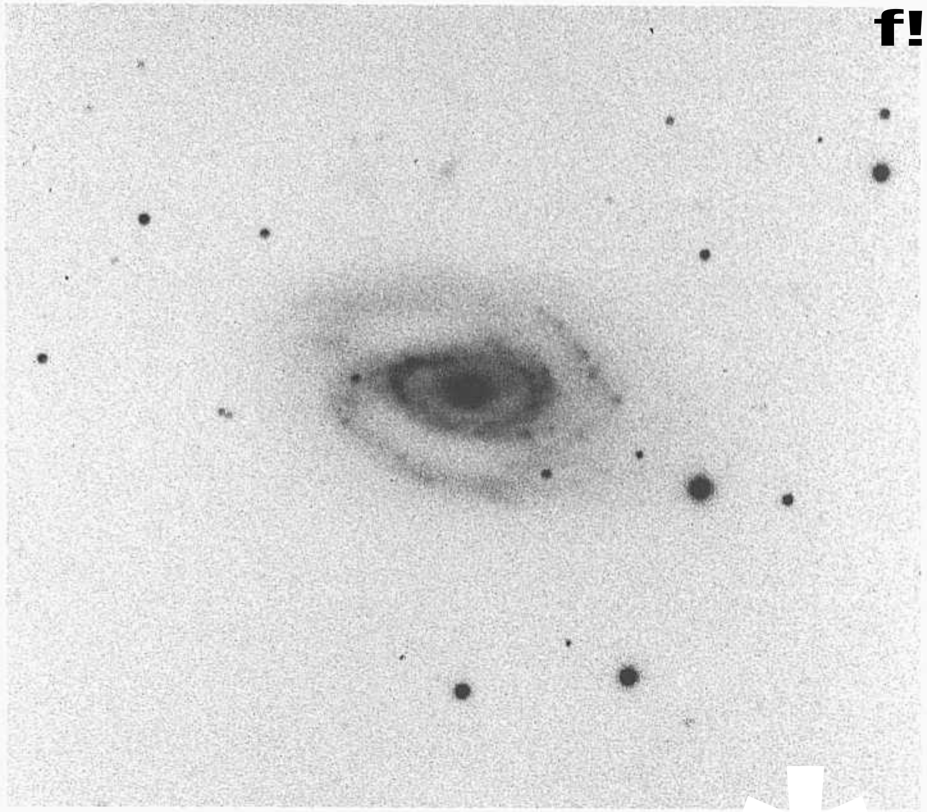
The redshift of NGC 2545 is v_a = 3312 km s^{-1}.

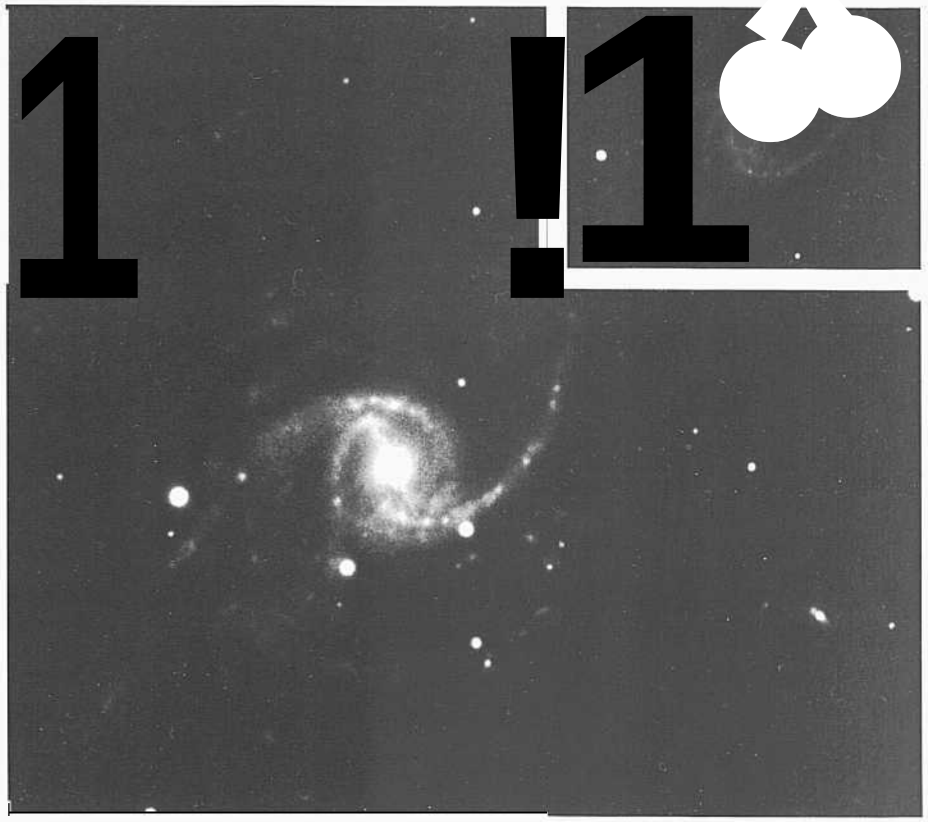
NGC 5905 SBbc(rs)I
PH-7741-S
June 11/12, 1980
103aO
12 min

The thin arms in NGC 5905 spring from the ends of the well-defined bar and are so tightly wound as to nearly overlap after each unwinds by half a revolution. Each becomes a thin outer arm of high surface brightness that can be traced for another half revolution outward, beyond which they continue but at much lower surface brightness. Fragmentary secondary arms exist over the outer face.

The redshift is $v_{,,}$ = 3544 Um s"'. The numerous HII regions are unresolved at the I" level.

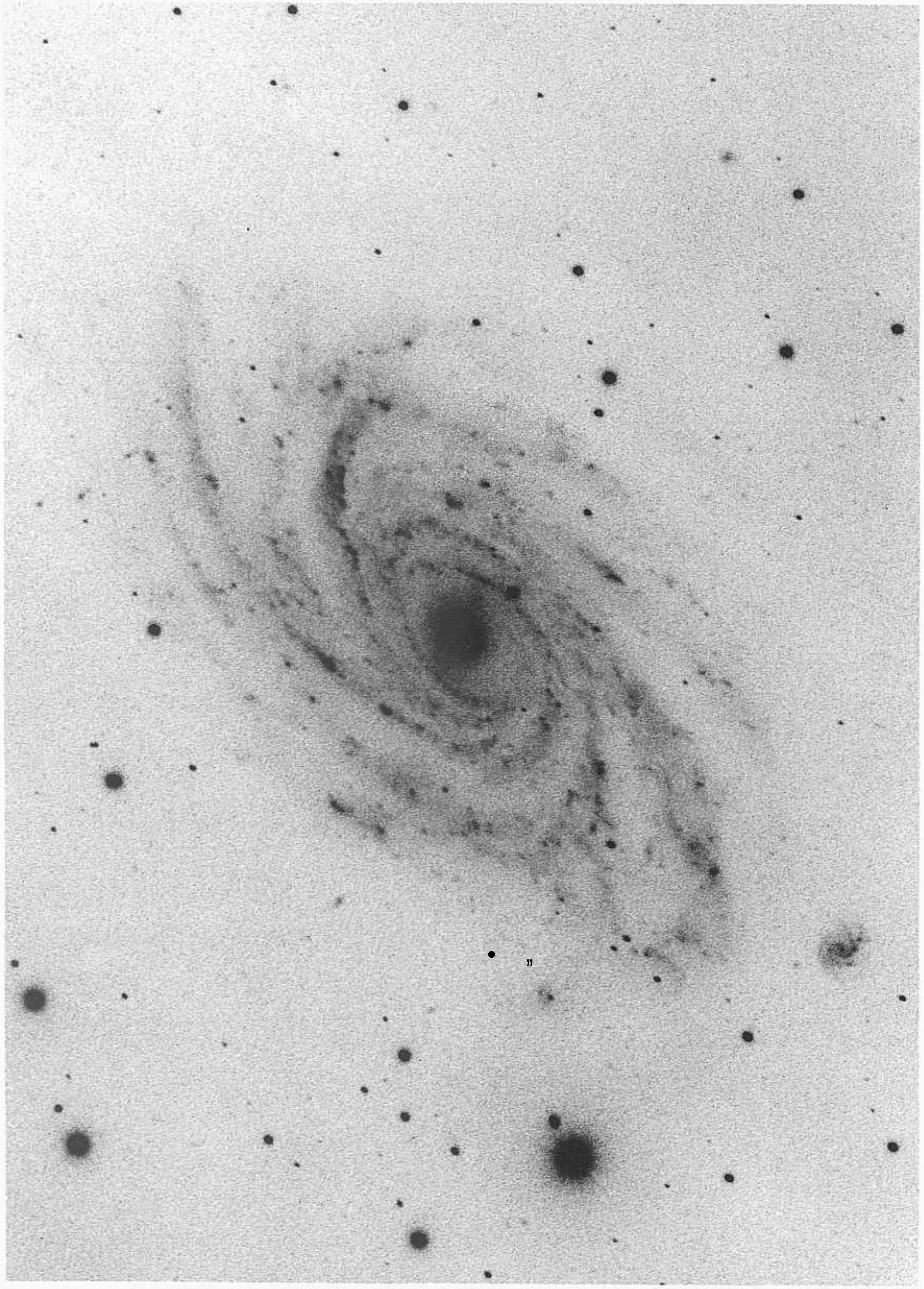


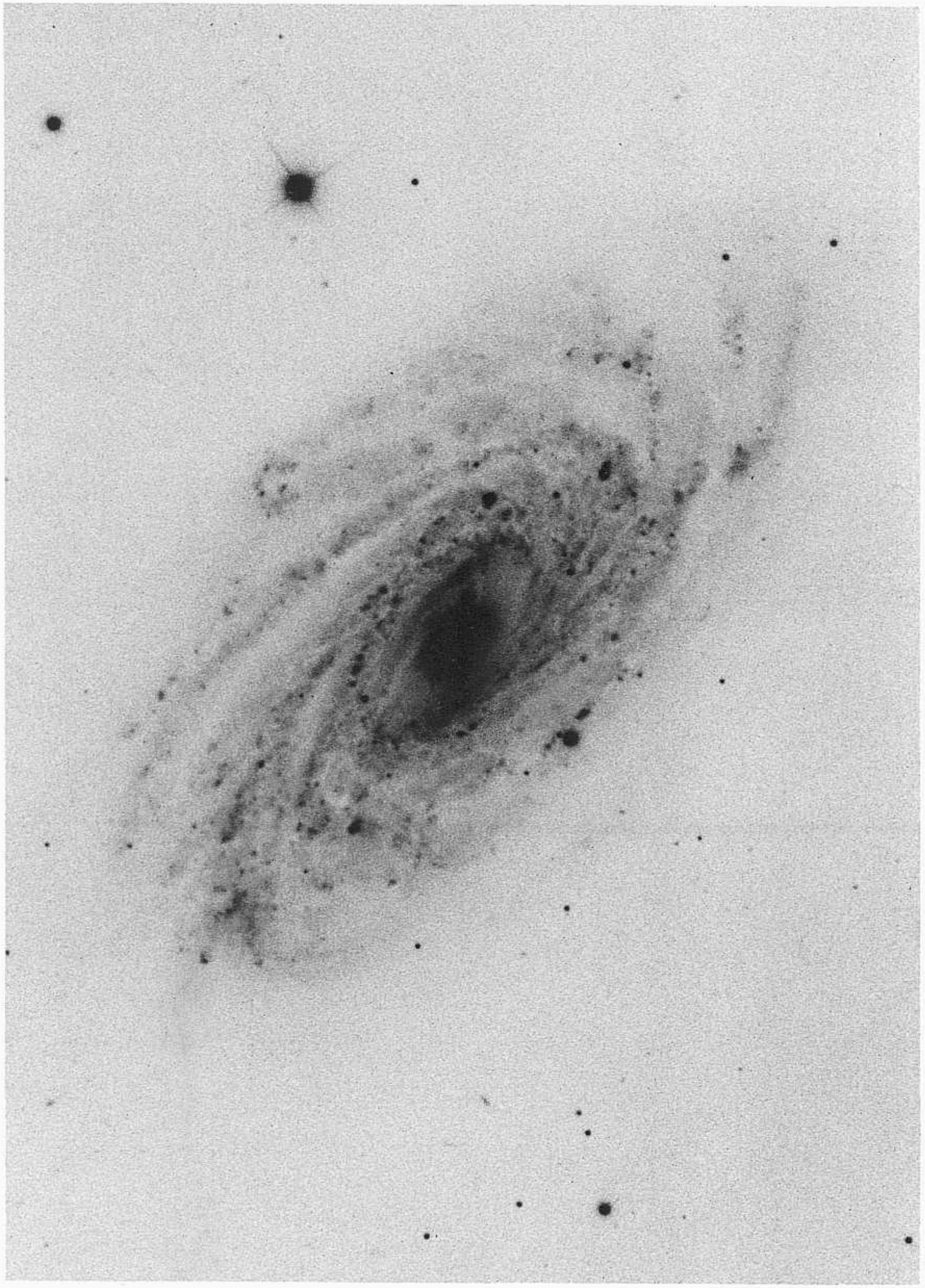




I'AN EL
203

PANEL
204





The two galaxies on this panel are ol' luminosity class I or I-II because the arms are well formed with minimum chaos. Both galaxies are of the filamentary-arm type (MAS), and the arms in l>oth begin on the rim of an inner smooth disk al the radius where the bar terminates in the disk.

NGC 2336 **SI5l>c(r)I** **panel S13**
PH-7703-S
Feb **11/12,** 1980
103aO
12 ruin

At least eight major arm fragments can be identified in NGC 2 336. which is the prototype SBbc galaxy of the MAS type at early luminosity class.

The numerous **Mil** regions in NGC 2336 are not resolved at the 1" level. The redshilt is v_0 = 2424 km s~'.

NGC 3953 **SBbc(r)MI**
PH-7639-S
April 28/29, 1979
103aO
12 mill

The multiple arms in NGC 3953 are thicker than in NGC 2336: they cover more of the disk and have a greater geometrical entropy; hence the luminosity class is later than in NCC 233 6.

The central region of NGC 3953 is more of an oval than a bar. The two characteristic thin (shock-induced) dust lanes may he present in the central disk.

The largest **Mil** regions (core plus halo) resolve at about the 3" level. The redshifl of NGC 3953 is .„ = 1036 km s"'.

The four galaxies on this panel continue the examples of the intermediate arm type between the grand design and the filamentary (MAS) spiral patterns. As on the preceding panel, the galaxies here are of the earliest luminosity class. Three of the four galaxies are of the (r) subtype; one is of the (s) subtype.

NGC 3124 SBbc(r)I
CD-1665-S
Dec 30/31, 1980
103aO + GG385
40 min

The spiral pattern in NGC 3124 is highly regular. Each of the two principal inner arms begins slightly downstream from an end of the well-defined bar. Each of the tightly wound arms nearly overlaps the other after half a revolution. Subsequently, they spiral outward and branch into the outer fragments, which remain at high surface brightness for another half a revolution.

The H11 regions are unresolved at the 1″ level. The redshift is $v_0 = 3307$ km s^{-1}.

NGC 2223 SBbc(r)I.3
CD-146-S
Feb 3/4, 1978
103aO + GG385
45 min

The multiple arms in NGC 2223 are thicker and slightly less well defined than in NGC 3124, above, but the spiral pattern is similar. The redshift of NGC 2223 is v,, = 2529 km a"1. The 1111 regions air unresolved.

NGC 3054 SBbe(s)I
CD-708-S
Jan 30/31, 1979
103aO + GG385
45 niin

The arm pattern in NGC 3054 is primarily of the grand design type but with branched fragments in the outer regions. A feature to be noted are the two thin, very-well-formed dust lanes down the middle of the two principal arms in their first half-turn from the place of origin on the inner disk. The central region is a diffuse bar or an oval.

The arms are symmetrical and well formed, requiring the luminosity class I.

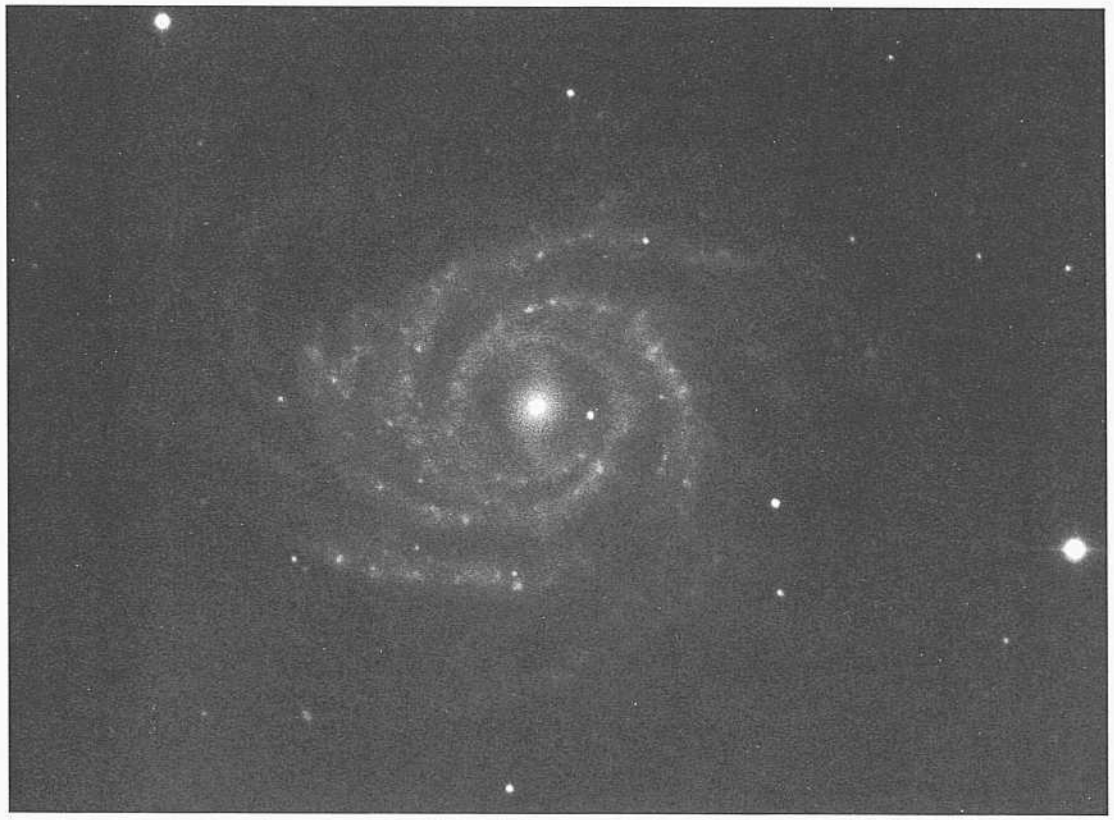
The HII regions are unresolved. The redshift of NGC 3054 is $v_a = 1923$ km s"1.

NGC 4891 SBbe(r)I-II group
CD-1468-S/Br
May 10/11, 1980
103aO + GG385
45 min

NGC 489 1 forms an apparent loose physical group with NGC 4899 (Sc: panel 232) at a separation of 30'. and with NGC 4902 (SBb; panel 162) at a separation of 64'. The v_o redshifts are 24 1 8 km s̄ ', 2437 km s̄ ', and 2426 km s~' for NGC 4891 , 4899. and 4902, respectively. At the mean redshift distance of 48 Mpc (*H* = 50) the projected linear separations from NGC 4891 are 420 kpc for NGC 4899 and 895 kpc for NGC 4902. Hence the size of this group is similar to that of the Local Group.

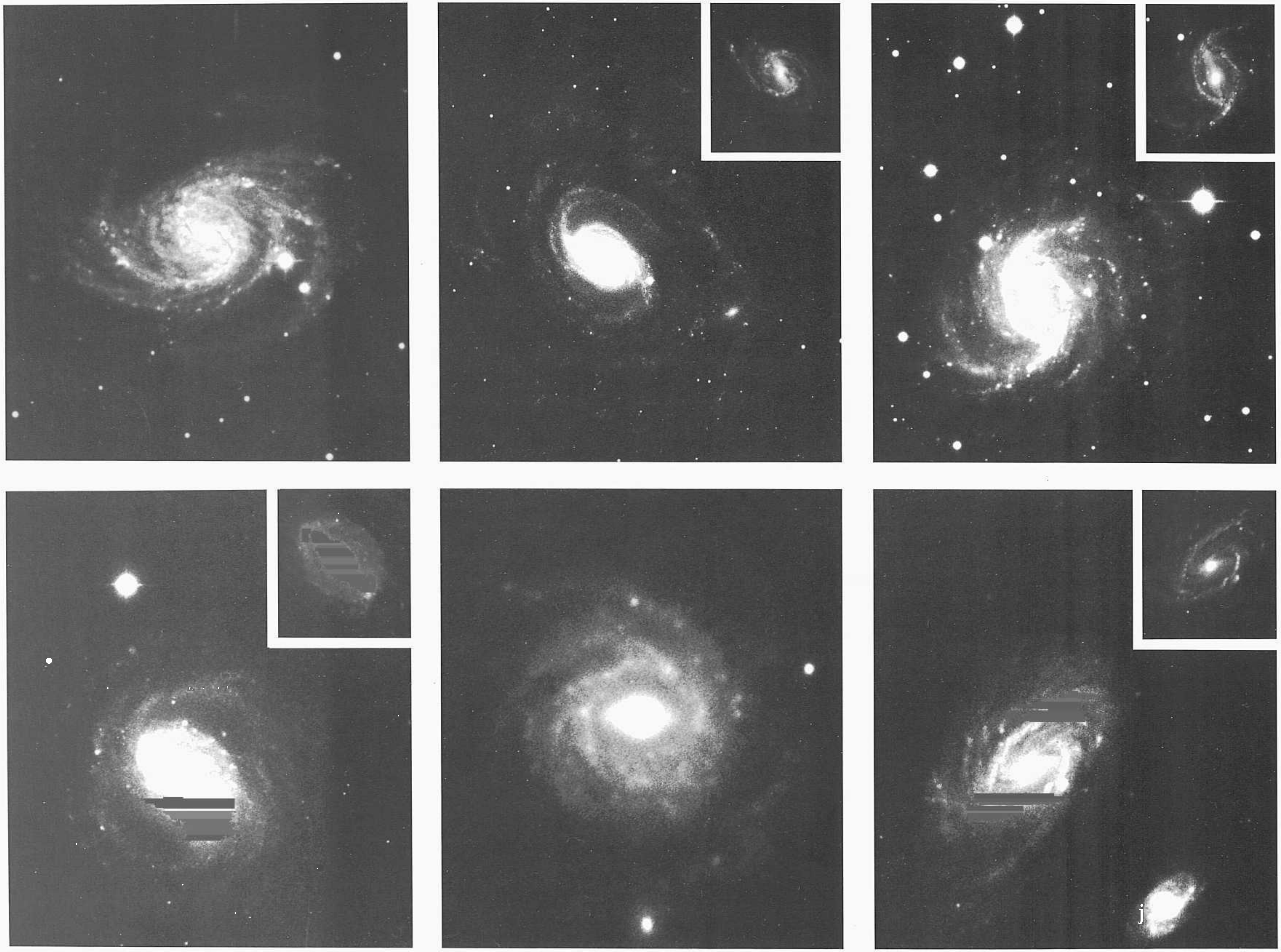
The spiral pattern in NGC 4891 starts with a grand design set of arms tangent to a very-high-surface-brightness internal ring (perhaps burned out in the reproduction here) which in reality, as usual, is an internal set of two tightly wound arms springing from the ends of the liar, as in NGC 1300. The principal outer grand design arms fragment after half a rotation beyond the ring to form a regular exterior multiple-arm pattern.

The largest fill region may resolve at the I" level.




PANEL
205


PANEL
206



This panel of six galaxies completes the early luminosity elass **I-II. MAS** spiral **type, SBbc morphological** class **section.**

NGC 3001 SBbc(s)I-II group?
CD-729-S
Feb 2/3, 1979
103aO + Wr2c
45 min

The arms in NGC 3001 begin at the center as two very thin, nearly straight (at first) dust lanes characteristic of the straight lanes on the leading edges of the bar in SBb and SBbc galaxies. The spiral pattern has features of both the grand design and the MAS types. The bright arms branch into multiple fragments that remain well defined.

The I-II I regions do not resolve at the 1" level. The redshift is v_o = 217 1 km s~'.

Three Im candidate companions exist at angular separations of 10', 12', and 12', which, at the redshift distance of 43 Mpc, are at projected linear separations of 125 kpc and 150 kpc. The candidate companions resolve into stars to the same degree as NGC 3001 itself, suggesting a common distance.

NGC 1640 SBbc(r)I-II
CD-2010-Bedke/Giegory
Oct 23/24, 1981
103aO + GG385
45 niin

The bar in NGC 1 640 is smooth and well defined. Two stubby dust lanes exist near both ends of the bar, where luminous tightly wound spiral arms begin; the arms form an almost-complete inner ring when each has unwound by half a revolution. Low-surface-brightness outer arms begin on the rim of this almost-complete inner ring.

The largest HI I region resolves at about 2". The redshift of NGC 1640 is v_0 = 1 600 km s~'.

NGC 289 SBbc(rs)I-U
CD-1578-S/Iir
Aug 10/1 I, 1980
103aO + GG385
45 min

The inner spiral pattern of NGC 289 is of the grand design type. Two arms of high surface brightness begin near, but no! a!, the ends of the bar. As in other eases that are similarly advanced toward the (r) spiral subtype from the pure NGC 1300 (s) type, each inner arm begins about 15° downstream from the ends of the bar. winding outward but missing the opposite arm after half a revolution. The inner arms in NGC 289 are not tightly wound. Consequently, there is no prominent almost-complete inner near-ring, as in earlier examples of the pattern such as NGC 3081 (SBa; panels 99. 107) and NGC 3 185 (SBa; panel 99).

The inner arms cover a high-surface-brightness disk, outside of which the delicate, thin. well-formed, very-low-surface-brightness, outer multiple-arm pattern exists.

These arms are fragments that cannot be individually traced for more than about a quarter revolution each.

The brightest knot in one of the inner arms has an angular diameter (core plus halo) of about 4". It may be a complex of several 1111 regions, unresolved at this resolution. The redshift of NGC 289 is r,,= 1834 km s~'.

NGC 3687 SBbe(r)I.2
PH-7606-S
April 3/4, 1979
IllaJ + GG385
30 min

The multiple-arm pattern in NGC 3687 begins from an almost-complete inner ring that defines the end of the inner smooth disk. The bright part of the bar terminates just before the inner edge of the internal ring.

The thin, regular spiral arms, which eventually divide into multiple fragments, wind outward for a radius over the outer disk that is about twice the radius of the inner ring. The pattern is regular, requiring an early luminosity class.

The redshift is u_0 = 245 6 km s^{-1}. 'The galaxy that is superposed on one of the outermost arms is probably a distant elliptical associated with a cluster that can be seen over the extended field.

NGC 5921 SBbc(a)I-II
CD-1539-S/Br
Aug 7/it, 1980
L03aO + GG385
15 mill

The two inner arms of high surface brightness and of the grand design type, are beautiful examples of the NGC 1300 type, springing from the ends of a well-defined smooth bar within which are the two characteristic straight dusl lanes on the leading side of the bar. The arms arc very tightly wound, giving the impression of an inner ring.

The largest of the numerous 1111 regions resolve al the *1"* level. The redshift of NGC 592 I is v_u = 1428 km s~'.

NGC 1241 SBbc(rs)I.2 pair
PH-7917-S Racine wedge
Nov 7/8, 1980
103aO
12 min

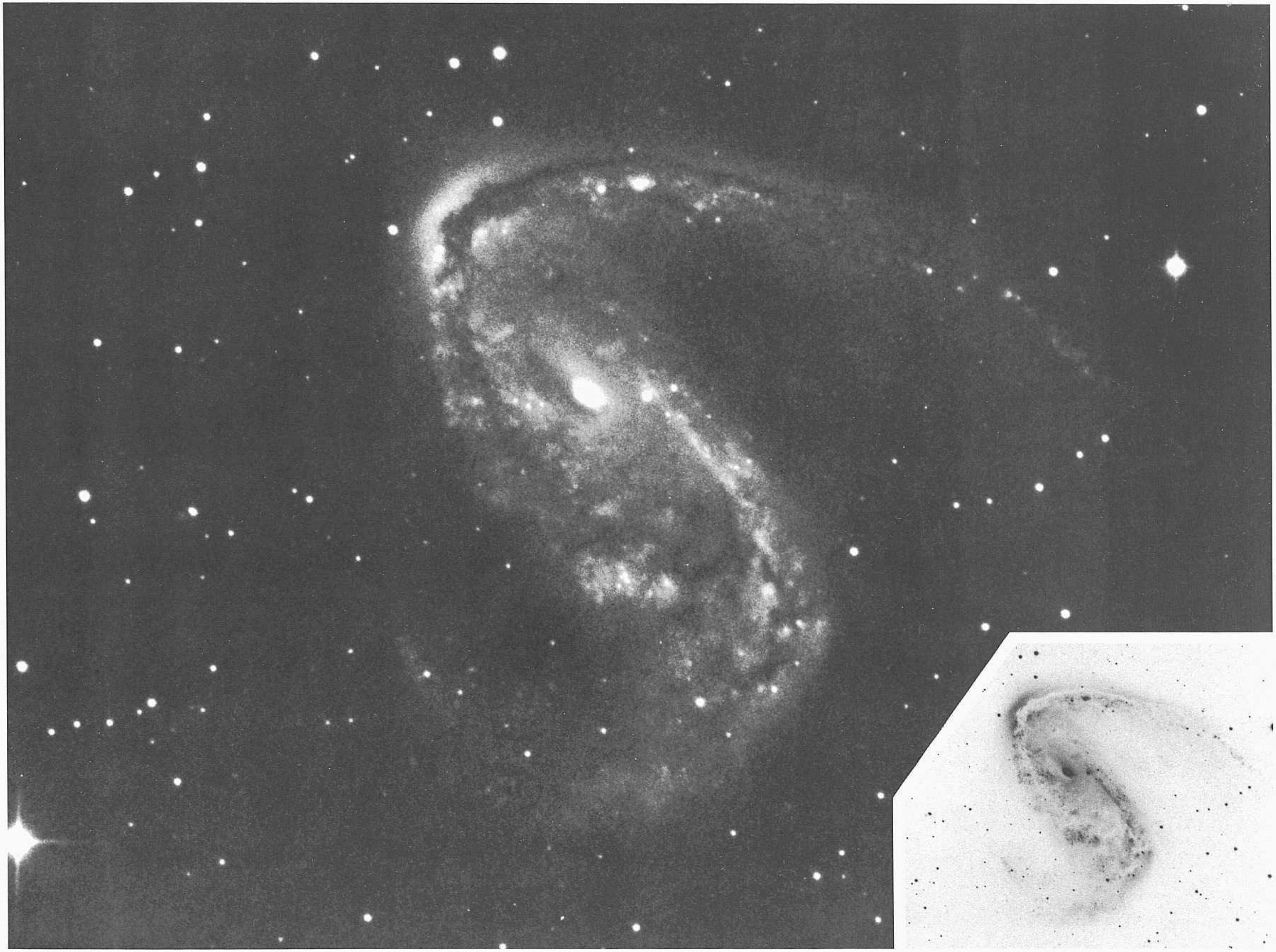
NGC 1241 forms a close pair with NGC 1242 (She; not in the RSA) at an angular separation of 1 .6'. The redshift of NGC I 242 is unknown, but if it is nearly the same as that of NGC I 2 4 1 . v_a = 4072 km s '. the redshift distance of the paii- is 8 1 Mpc (// = 50) giving the small projected linear separation of 38 kpc. However, there is no evidence of morphological distortion in either NGC 12 11 or NGC 12 12 that would lie evidence ol a close encounter; the pair may be optical rather than binary. (Rcrishifts are needed.)

The two high-surface-brightness inner arms begin at the ends of the central oval; the latter has the properties of a bar, signaled by the two characteristic dust lanes in the oval (bur) of prototype SBb and SBbc types. Multiple arms branch from the two main grand design inner arms.

NGC **2442** **SBl)c(is)II** **triplet?**
CD-149-S
Feb 2/3, 1978
103aO + **GG385**
45 min

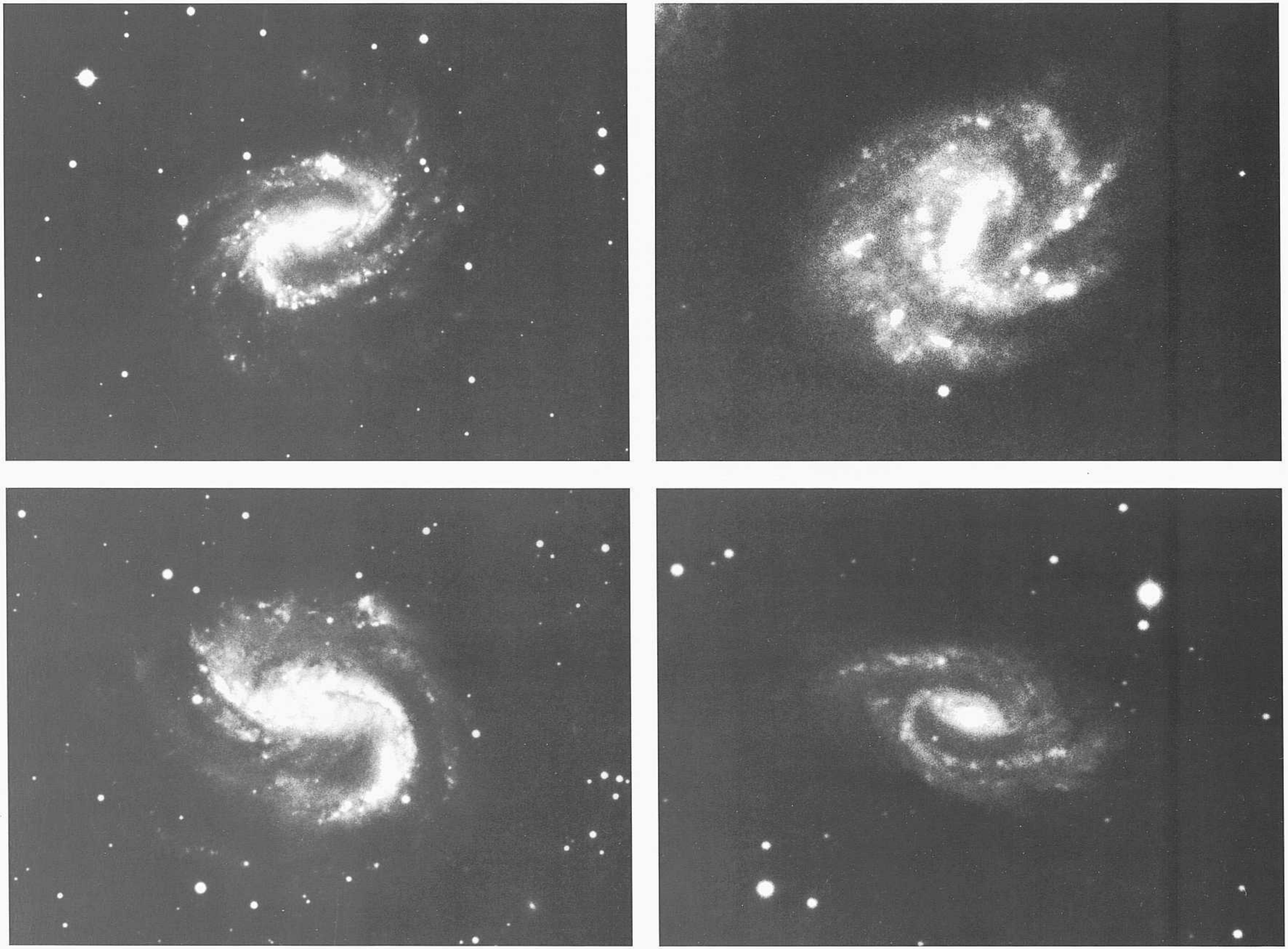
NGC 2442 forms an apparent pair with NGC 2434 (EO: panel I) **at** a **separation of** I 6.a'. **The redshifts** arc **u_o(2442)** = 1 **1** 57 km s'" and r,,(2434) =111!! km s⁻'. At the mean rod-shift distance of 23 Mpc (// = 50) the projected linear separation is 112 kpc. A possible distant association is with NGC 2397 (Sc; panel 279) at a separation of 85'at a **redshift of** v_o = 1044 km s^{-1}. The projected linear separation **would** be 570 kpc if there is a common distance.

The central part of NGC 2442 is an oval rather than a well-defined bar. Heavy dust lanes exist, **the** strongest **of** which threads the middle of the best-defined arm of the grand design pattern. The largest 1111 region in this arm resolves (core plus halo) at **about** the 5" level.



PANEL
207

PANEL
208



THe SBhc galaxies on this and the following panel arc all of the grand design type but arc of later luminosity class (greater geometrical entropy) than the galaxies on preceding panels.

NGC 4304 **SBbc(s)n**
CD-225-S
Feb **12/13,** 1978
103aO + GG385
45 niiii

The two principal arms in NGC 4304 spring from the ends of the bar, which is relatively smooth but is less well defined than in NGC 13 00. Dust exists in the bar, but the lanes are less regular than the two straight lanes that are characteristic of the strong shock lanes in SBb and SBhc galaxies of luminosity class I. Nevertheless, the dust-lane pattern is believed to trace the velocity field (the streamlines) near the bar (e.g., Huntley 1978, 1980). Note that the dust lanes are nearly perpendicular to the bar on one side and arc along the bar on the other.

Copious star formation occurs in both of the main arms. The Mil regions have high surface brightness. They are individually unresolved at the 1" level, but a complex of them in one of the arms has a halo diameter of about 5". The redshift of NGC 4304 is v_0 = 2327 km s"[1].

Low-surface-brightness spiral fragments of arms branching from the two main arms exist on the outside of the main pattern. Such sets of outer low-surface-brightness, often called fossil, arms, are common features of spirals of all types.

NGC 6907 SBbc(s)II
CD-553-S
Oct 4/5, 1978
l03aO + GG385
45 min

The spiral pattern in NGC 6907 is remarkably similar to that in NGC 4304, above. The bar is slightly less well defined. It is a highly flattened oval rather than a strong bar, but its dust pattern is the same as in NGC 4304. One heavy, nearly straight dust lane exits at one of the leading edges of the oval. The dust lanes on the other side are nearly perpendicular to the major axis of the oval.

The individual 11II regions are generally unresolved. The largest Mil complex, composed of several overlapping Till regions, lias a halo diameter of about 4". The redshift of NGC 6907 is u_0 = 3192 km s~\

IC 1953 SBbc(ra)II
CD-2001-Bedke/Gregory
Oct 22/23, 1981
L03aO + GG385
45 min

The arms spring from the ends of lite ill-defined bar in IC 1953 and overlap on one side to form a partial internal ring that is incomplete in one quadrant. The arm on the opposite side from that with the light pitch angle (and therefore the overlap) has a straight section causing it to miss the opposite arm. creating a partial rather than a complete internal ring.

Many bright MM regions exist throughout the arm pattern. The largest may resolve at about the 1.5" level. The redshift of EC 1953 is v_a = L856 km s"[1].

An apparent companion (anonymous; type Sc or SBc) of unknown redshift is at a separation of 2.6'. If it is at a common distance the projected linear separation would be small at 2 7 kpc. A second apparent companion (a blue compact dwarf, i.e.. type BCD; see Sand age and Binggeli 1984) at a separation of 6.1' would be at a projected linear separation of 64 kpc.

NGC 6923 **SBbc(s)H**
CD-1518-S/Br
Aug5/6, 1980
103aO + GG385
45 mill

The seeming bar in NGC 6923 is a small, very-high-surf ace-brightness internal ring. The two grand design main outer arms emerge from the ends of the major axis of the ring. The fact that the arms begin at the ends of the major axis of the projected image in this obviously inclined galaxy, suggests that the internal ring is a true oval rather than a circle seen in projection.

The Mil regions in the arms are unresolved. The redshift of NGC 6923 is u_0 = 2858 km s '.

The four galaxies on this panel continue the SBbc spirals of the (s)-arm subtype of the grand design. The luminosity classes are II and II-III.

NGC 5430 SBbc(s)I.8 Racine wedge
PH-7829-S
Sep 3/4, 1980
103aO
12 min

The central region of NGC 5430 is an oval rather than a well-formed bar. The arm pattern is not symmetrical. Threads of multiple arms exist on one side of the oval. A single low-surface-brightness, well-defined arm exists on the other side. The early luminosity class is based on the lack of chaos in the arm pattern, despite its lack of good symmetry.

The few HII regions are unresolved. The redshift of NGC 5430 is v_0 = 3016 km s~".

NGC 6217 RSBbc(s)II
PH-6601-S
Aug 23/24, 1973
103aE + RG2
30 min

The reproduction on the facing panel is from a red plate: the HII regions are emphasized because the Balmer-a line is in the band-pass of the plate.

The bar is very much better defined in the red here than on blue plates which emphasize the young stars. Clearly, such stars do not dominate the liar.

The (s)-type spiral arms originate from the ends of this smooth red bar. There is also a semblance of a straight dust lane in one of the legs of the bar, characteristic of SBb and SBbc systems.

The unusual feature of the spiral pattern is the third arm coming from the center as a double bar on one side of the image. On blue plates this arm begins at the center, as in normal Sbc or Sc non-barred galaxies, rather than at the end of the bar.

The redshift is v_o = 1598 km s^{-1}. The largest HII regions resolve at about the 2" level.

NGC 3887 SBbc(s)II-III
CD-1685-S
Jaii 2/3, 1981
103aO + GG385
45 min

The central region of [VGC 3887 is an oval rather than a well-defined bar. The principal reason for classification as a barred spiral is the presence of two thin dust lanes starting on opposite sides of the center, as is usual in prototype SBb and SBbc bars (e.g. NGC 5383: SBb; Hubble Atlas, p. *46:* panel 168 here). These remain straight throughout the oval but bend at the end where they begin to accompany the luminous arms.

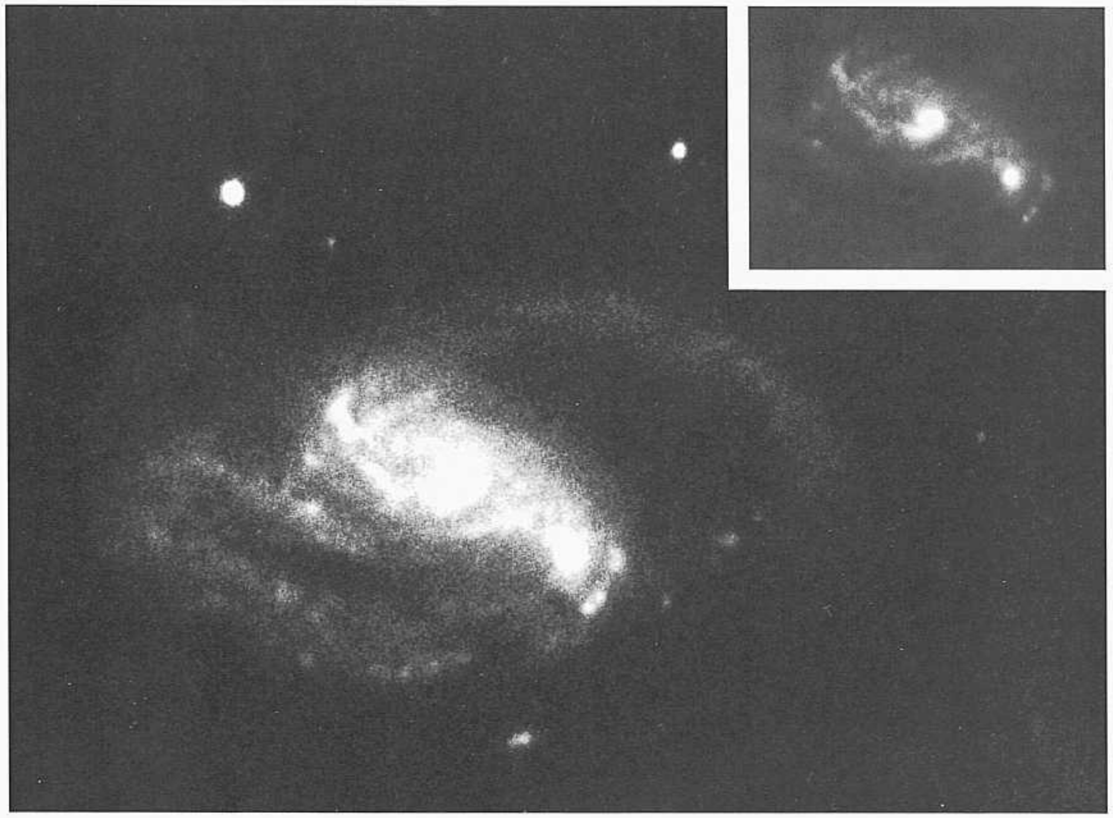
The largest of the many HII regions resolve (core plus halo) at the 2" level. The redshift of NGC 3887 is v_0 = 915 km s^{-1}.

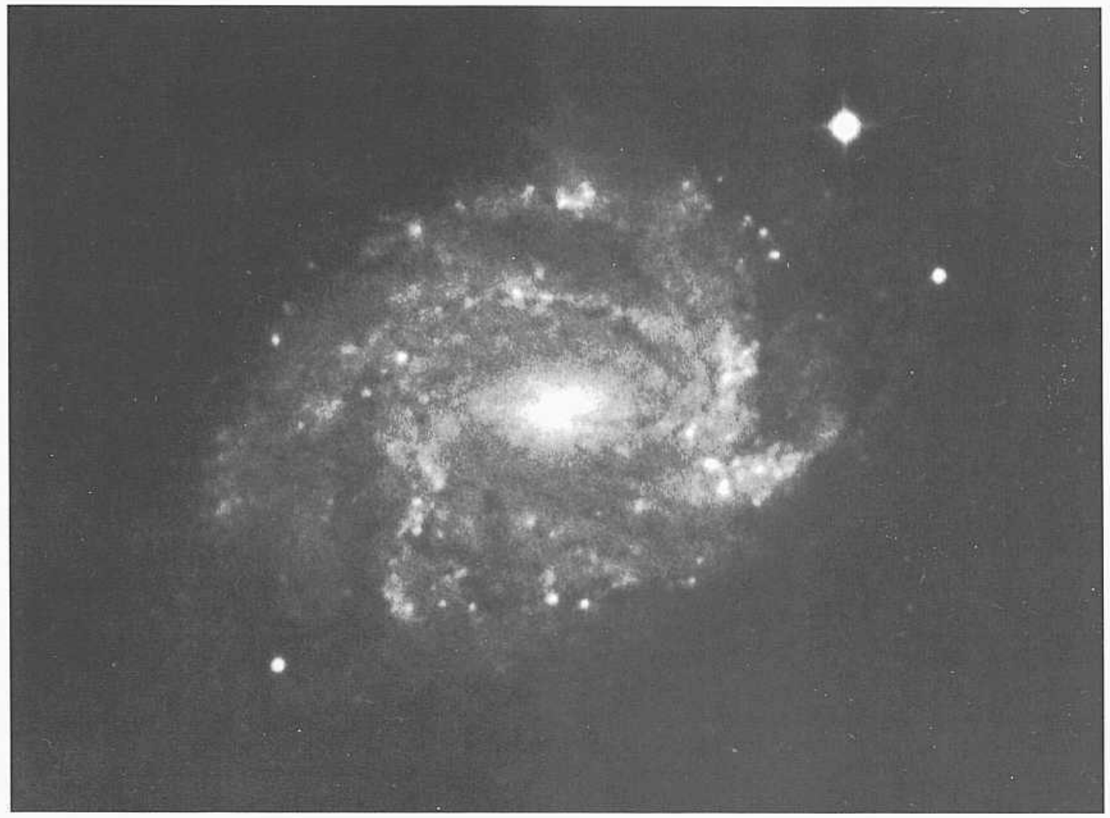
NGC 3686 SBbc(s)II group
CD-1841-HB
April 2/3, 1981
103aO
75 min

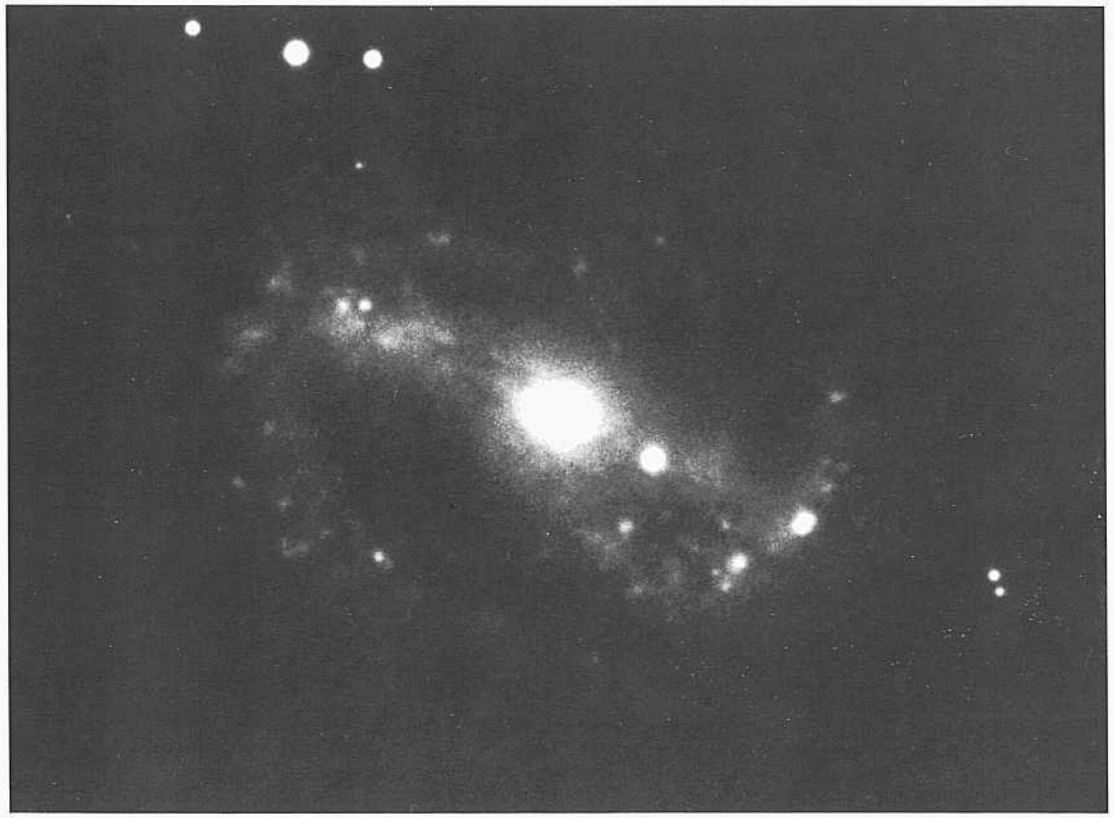
NGC 3686 is the brightest member of a small group of at least seven galaxies that have closely the same redshift and that are within about 1° radius from NGC 3684, which is the central member of the group. The brightest four group members arc in the RSA: NGC 3681 (SBb: 1135 km i"j panel 164), NGC 3684 (Sc: 1065 km s~': panel 256). and NGC 3691 (Scd: 947 km s~': panel 317). The redshift of NGC 3686 is v_o = 1034 km s^{-1}.

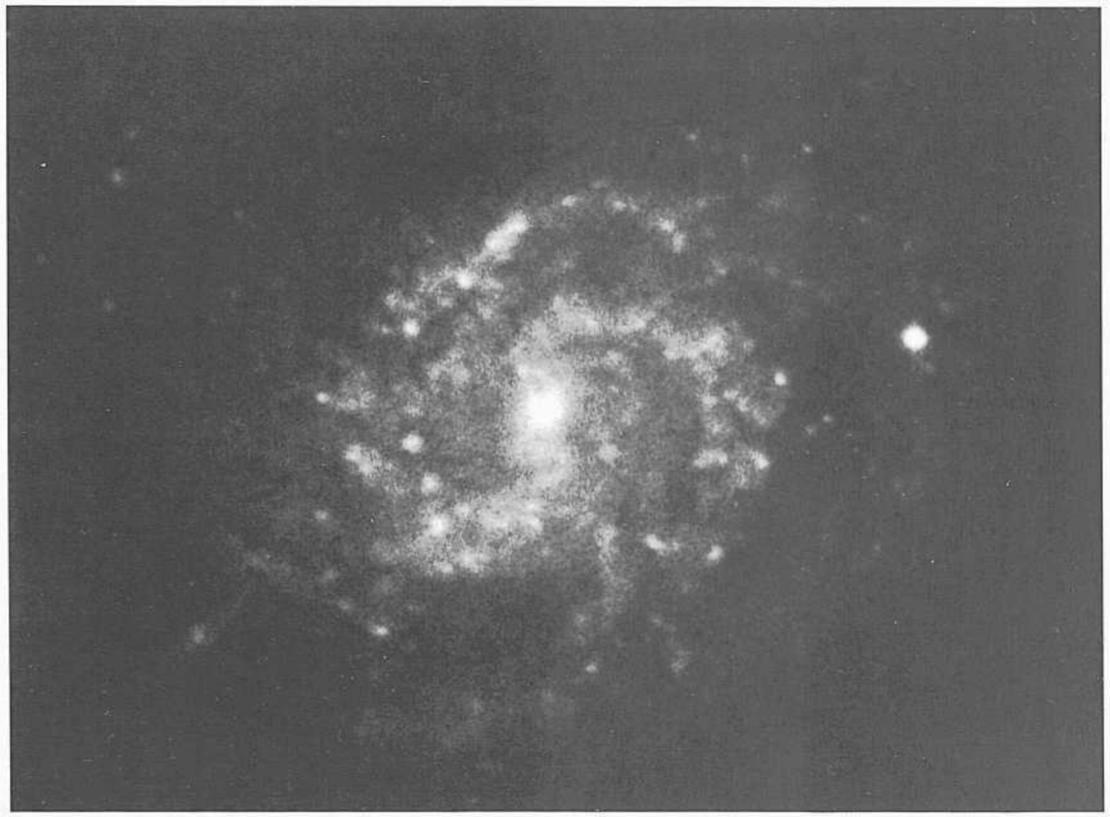
Three anonymous members for which redshifts and other data are available (Hoffman *et al.* 1987) arc A1127 + 1642 (Imlll-IV, u_D = 957 km s^{-1}), A1122 + 1709 (v_0 = 909 km s~'). and A1122 + 1721 (ImlV: v_o = 1209 km s"'). There arc also several candidates for dE dwarf ellipticals in the group. The mean redshift of the seven known group members is $\langle v_o \rangle$ =1021 km s^{-1}. At the redshift distance of 20 Mpc the linear radius corresponding to *an* angular radius of 1° is 360 kpc, similar to the radius of the Local Group.

The arm pattern in NGC 3686 is slightly better defined than in NGC 3887, above. The luminosity class is II here and II-III above.

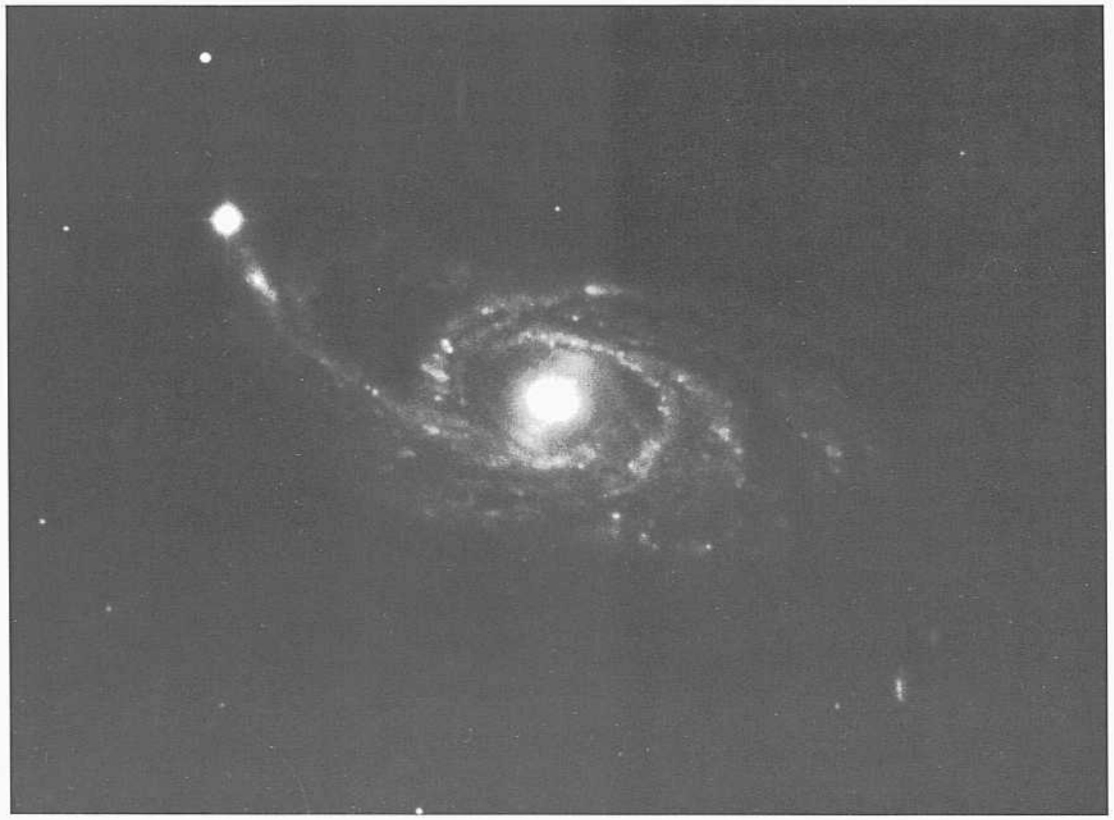


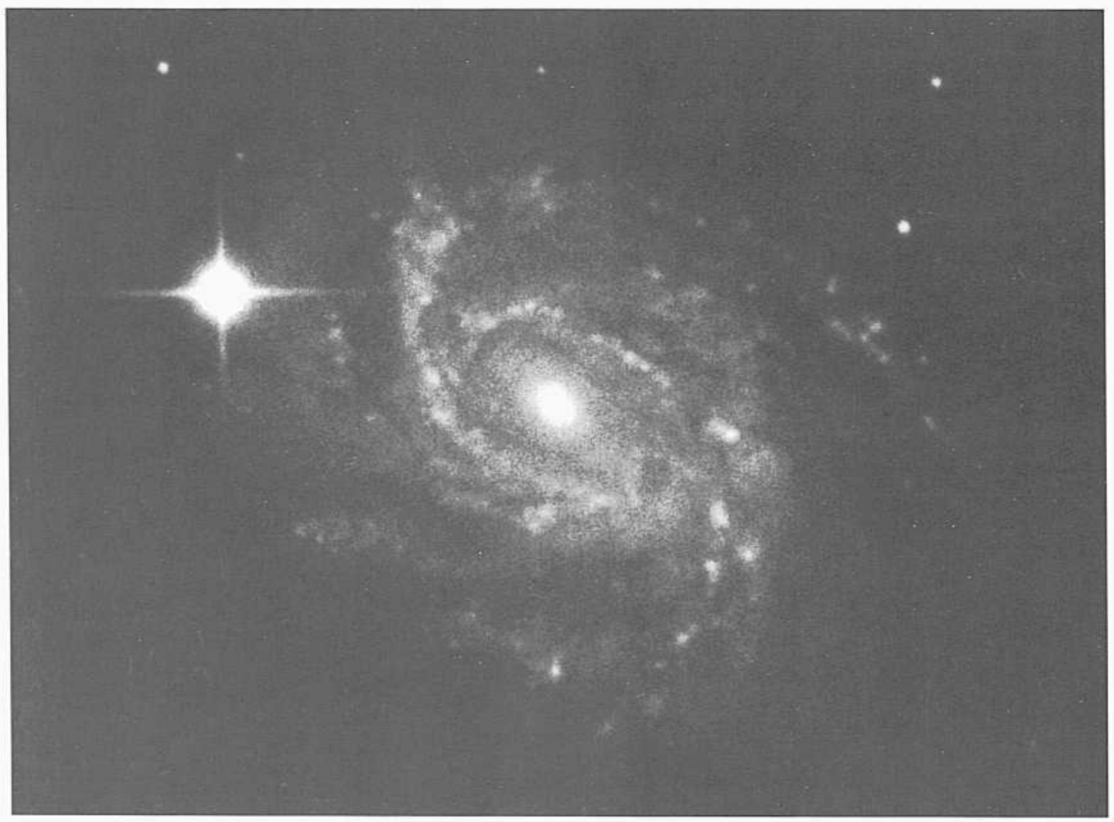






PANEL
210





NGC 151 SBbc(rs)n
PH-1076-S
Aug 25/26, 1955
103aO
30 niin

The **beautifully symmetrical grand design** in the pattern of NGC 1 51 contains a **smooth** central bar **which** terminates **at the place where** two inner arms begin. The arms do not **spring** from the ends of the bar but start from **two** symmetrically placed points about L 5° **downstream** from **the** termination **of the** bar—a common-enough feature, noted before on previous panels.

The two principal arms that **start** at these places relative to the bar. **fragment** as they move outward and form the multiple-arm pattern **in** which at least four arm segments can **be** traced on each side of the galaxy.

None of the many **III!** regions resolve at **the** 1" level.

NGC 4981 SBbc(sr)II pair
CD-1860-HB
Aug 6/7, 1981
103aO
75 min

NGC 4981 may form a wide physical pair with NGC 4995 (She; panel 183) which has a redshif t of v_o = 1645 km s **at**[1] **an a** n gu I a r separation of 65'. The redshift of NGC 4981 is v_o = 1492 km s^{-1}. If the pair is at the same redshift distance of 31 **MpC** (/•/ = 5 0). the projected linear separation is 593 kpc.

The arms in NGC 4981 begin at the **rim** of the inner disk where the oval **central** region ends. The numerous **111!** regions may **resolve** at about the **1"** level.

NGC **7121** **SBbc(ra)II-IIl**
CD-1080-Hr
Aug 17/18, 1979
103aO + GG385
45 miu

One **of** tin- two principal **arms** thai can **be traced** begins about a quarter turn downstream **from** one of **the** ends of the **bar.** The **opposite** arm seems **to begin** at **the** end **of** the **other** side **of** the bar.

These arms fragment almost immediately into a **semi-chaotic** filamentary **arm structure;** hence **the late luminosity classification** is **required.**

The redshift is v_a= **1838** km s~'. **The** largest 1111 region may resolve at the *2"* **level.**

NGC 1781 SBbc(r)II
CD-1677-S
Jan **1/2. 1981**
103aO + GG385
45 **min**

The bar in NGC 1 784 is well **developed.** Dust lanes and patches exist in Ihe bar: their description would be similar to the paragraphs on NGC 4304 **and** NGC 6907 two panels back.

The two. very tightly wound inner arms spring from the ends of the well-defined bar and overlap, **forming** a **nearly complete inner** ring. The **continuation** of these arms **results** in an outer pattern of **low-surface-brightness** spiral fragments that cannot be individually traced over more **than** about a **quarter** revolution each.

The **redshift** is v_o = 2254 km s"[1]. The **Mil** regions are **unresolved.**

T he nine galaxies on this panel complete the illustrations of normal SBbc systems in the RSA. All are of luminosity class II or II-III, and all are of the multiple-armed (MAS) type.

ISGC 5970 SBbe(r)II
S-530-H
June 4/5, 1926
E40
45 mill

The print of NGC 5970 here is from a Mount Wilson 60-inch plate.

The arms hegin from the ends of the bar that terminate at the edge of an inner smooth disk. The pattern is a prototype (r) configuration where the outer arms are an extension of the apparent inner ring at the edge of the disk.

The numerous HII regions in the disk are unresolved at the 1" level. The redshift of NGC 5970 is v_0 = 2047 km s^{-1}.

NGC 5483 SBhc(s)II-III
CD-1526-S/Br
Aug 6/7, 1980
103aO + GG385
45 min

The two principal grand design arms are of the prototype (s) configuration, yet the entire disk is filled with spiral arcs, many of which are dust lanes. These arcs are not branch fragments from the principal arms. Rather they originate in the disk independently, like the arms in the MAS prototype galaxy NGC 2841.

One large HII complex appears to be multiple, having a combined halo diameter of about 4". The redshift of NGC 5483 is v_o = 1517 km s^{-1}.

NGC 3318 SBbc(rs)II.2
CD-1481-S/Br
May 12/13, 1980
103aO + GG385
35 nlin

NGC 3318 is in the complicated region of the Hydra-Centaurus Supercluster, about 6.5° south of the core of the embedded Antlia Group (Ferguson and Sandage 1990). A map of the region containing the neighborhood of NGC 3818 is given by Hopp and Materne (1985).

The redshift v_o = 2306 km s^{-1} for NGC 3318 is among the lowest in the region. Hopp and Materne have identified six redshift groups with $<v_o>$ values ranging from 2700 to 4500 km s^{-1}. The adopted mean redshift of the Antlia Cluster is $<v_o>$ = 2503 km s^{-1} (Ferguson and Sandage 1990).

NGC 4961 SBbc(s)II
PH-8091-S
Feb 6/7, 1981
103aO
12 min

The ill-defined bar in NGC 4961 terminates where the spiral pattern begins. The arm pattern is not well defined. Several bright Mil regions are evident. Each is unresolved at the 1" level. The redshift of NGC 4961 is v_o = 2508 km s^{-1}.

NGC 4763 SBbc(r)II
CD-1458-S/Br
May 7/8, 1980
103aO + GG385
45 min

The spiral pattern in NGC 4763 is of the classic (r) barred subtype: the multiple outer arms begin tangent to an almost-complete inner ring which begins at the end of a smooth, well-defined bar. As usual, the near-ring is composed of two coils of tightly wound principal spiral arms which spring from the ends of the bar.

The redshift is v_o = 3961 km s^{-1}.

NGC 3485 SBbc(s)II
CD-2128-S
March 21/22, 1982
103aO + GG385
45 min

The arm pattern in NGC 3485 is a particularly good example of the NGC 1300 (s)-type arm beginning at the ends of the bar but with almost-complete overlap after each arm has unwound by half a revolution to form an almost-complete inner ring. The ring, however, is broken, and the outer arms branch outward from the extension of these tightly wound inner arms.

The redshift is v_o = 1395 km s^{-1}.

NGC 4385 SBbc(s)H
CD-698-Br
Jan 28/29, 1979
103aO
45 min

The bar in NGC 4385 is not well defined except by the non-symmetrical luminosity distribution of spiral-like fragments; there is no smooth, definite bar as in NGC 1300.

The redshift is v_o = 1969 km s^{-1}.

NGC 491 SBbc(r)II
CD-2006-Bedke/Gregory
Oct 23/24, 1981
103aO + GG385
45 min

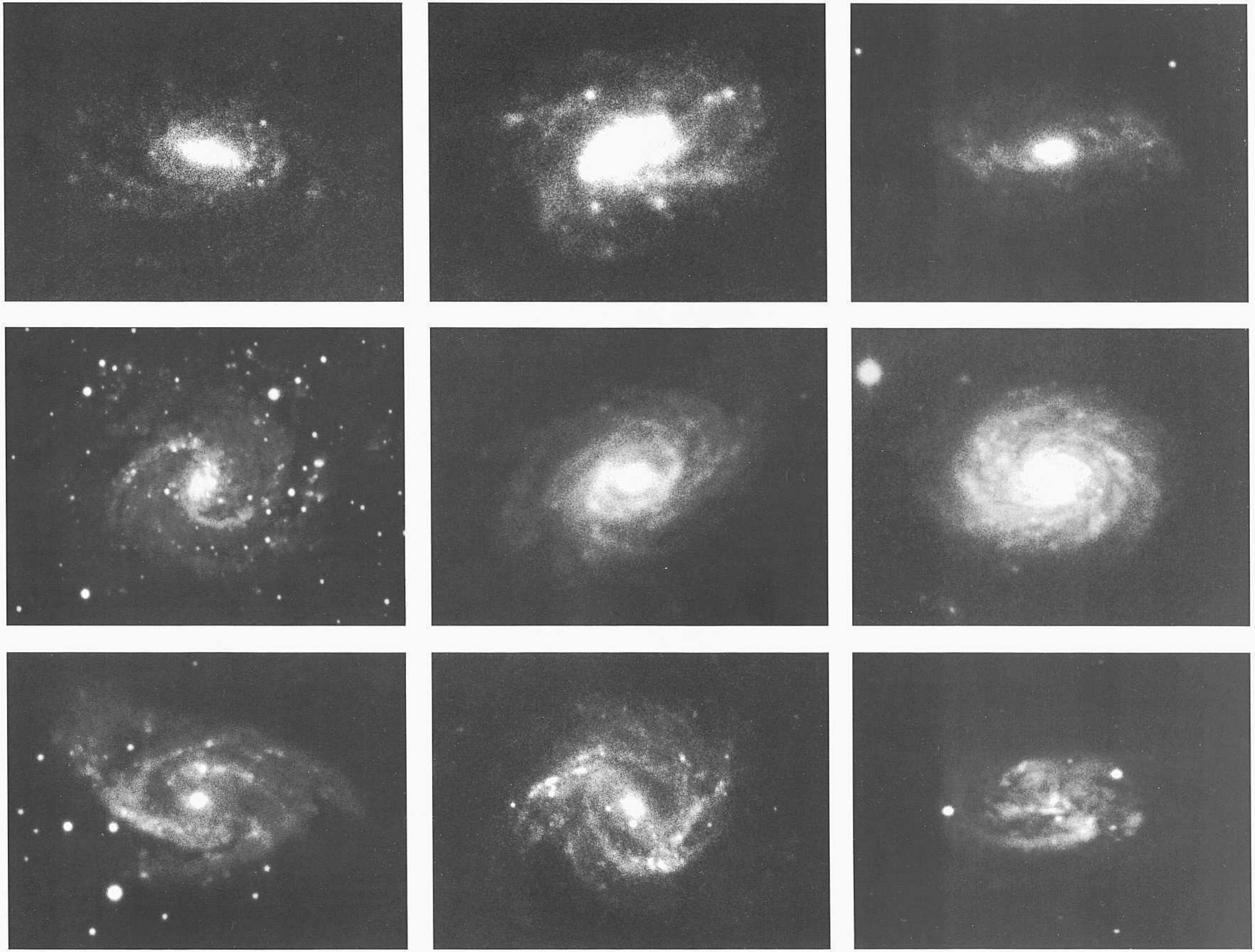
The spiral pattern is multiple in NGC 491, starting from an internal ring upon which the bar terminates. The galaxy is remote compared with most others in the RSA: the spatial resolution is about a factor of four less than in the average RSA galaxy.

The redshift is v_o = 3890 km s^{-1}.

NGC 5188 SBbc(s)II-III pec
CD-1153-Br
Aug 22/23, 1979
103aO + GG385
45 min

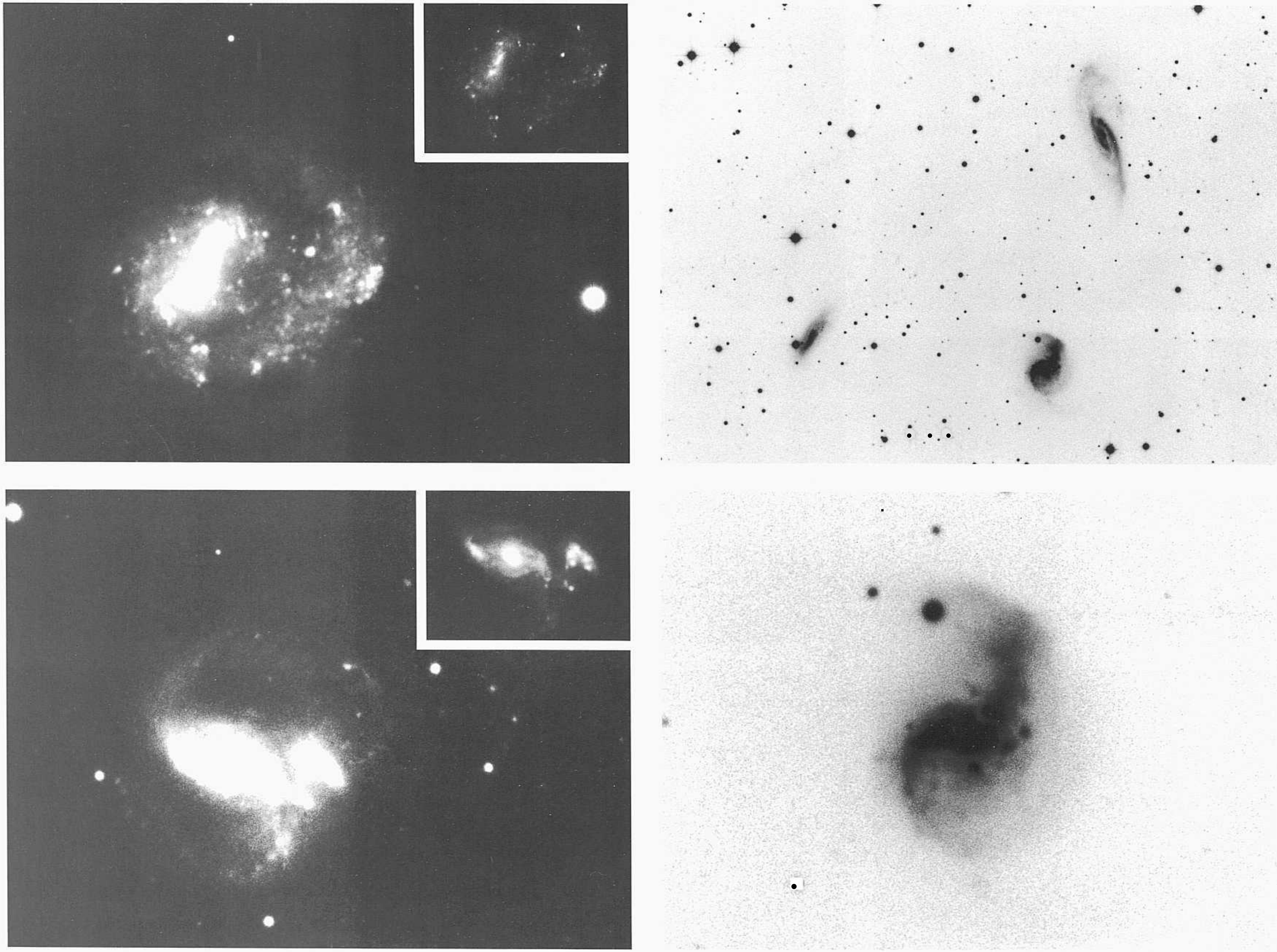
The bar in NGC 5188 is suggested by *a* straight luminous segment on one side of the image. The form is unusual; NGC 5188 may not, in fact, be a true SB spiral but rather may simply have a semi-chaotic inner spiral morphology where one of its features imitates a bar.

The redshift is v_o = 2107 km s^{-1}.



PANEL
211

PANEL
212



NCC4618 SBbc(rs)II.2 pec M51 Gr
PH-7666-S Karachentsev 349
April 29/30, 1979
103aO
6 min

NGC 4618 forms a physical **pair** with NGC 4625 (Sc **pec) at** a **separation of** 8.5'. **The redshifts** are $u_o(4618)$ = 563 **km** s~' and $u_o(4625)$ = 641 **km** s^{-1}. **At the mean redshift** distance of 12 Mpc (// = 50) tlic **projected linear separation** of the pair is small, at 30 kpc.

Both galaxies show **evidence of** interaction. Each has an asymmetrical spiral **pattern characterized** by a single prominent arm, presumably made by the **action** of tides in the manner calculated by **Toomre** and **Toomre** (1972).

Both NGC 4618 and NGC 4625 are well resolved into brightest stars and **HII** regions. These galaxies are in the nearby complex Ursa Major region, which Tammann **(unpublished)** has divided into three separate kinematic groups plus the great Ursa Major Cluster at $<v_o>$ = 980 km s^{-1}. The three groups are (1) a very highly resolved nearby group at $<v_o>$ = 285 km s^{-1}, containing NGC 4144, 4214, 4244, 4395. 4449, 4736. and 1C 4182 among others, (2) the M51 Group at <v0> = 595 km s^{-1}, containing NGC 4258, 4490. and 4618, and NGC 4625 here, and (3) a group at <i\,> = 750 km s~[1]. containing NGC 3675. 4013, 4051, 4085. 4088,4147,4242,4389.and **1C** 750.

NGC 5534 SBbe(s)II(tides, merger?)
CD-1330-S/Br
March 13/14, 1980
103aO + GG385
50 **min**

NGC 5534' may he a **composite** image of two galaxies in the process of merger. The main body has a normal SB oval in the central regions. Two small satellite objects exist on one side of the main body **from** which an apparent tidal plume emerges. The outer thin spiral arms of wide extent may also be a result of a response to tides.

The redshift is u_o = 2483 km s'" .

NGC 5915/59**16/59 16A SlJhc(s) pec triplet?**
CD-1433-S/Br So pec/? panel HI
March 25/26, 1980
103uO + **GG385**
45 min

Based on the near' ecpiality of their r() **redshifts,2** 116 km s ' and 2 I 65 km s~', **NGC** 59 15 and **NGC** 59 16 (panel 81) form an **obvious** physical **pair. The group** may **be a triplet** formed also with NGC **5916A,** bin **the redshift** of ibis galaxy is **presently** (1990) unknown.

At the mean **redshift distance of 43 Mpc** (// = 50). the **projected** linear separations of both NGC 59 16 and **NGC** 5916A from **NGC** 59 15 are small at 59 kpc.

The morphologies of both **NGC** 59 15 ami NGC 59 I 6 appear disturbed, presumably due to tidal interaction. Note that the form of NGC 59 16 (Sa) is similar to that of NGC 32!l 1 (Sa: panel 65) in tin[1] Antlia **Cluster.**

NGC 5915 SBbc(s) pec
CD-1433-S/Br
March 25/26, 1980
103aO + **GG385**
45 min

NGC 5915 is outside the classification system. It is called SBbc(s) based (Hi the "arms" that spring from the ends of the **central region** in the manner of NGC 1300.1 lowever. the form may be due to tidal interaction with NGC 5916. shown above.

The Sc Classification Section

THE SCI SUBCLASS

Sc galaxies of luminosity class I are shown on this and the next eight panels. Galaxies with two principal arms of the grand design are on the first three panels; those with multiple arms are on panels 216—221.

NGC4321	**Sc(s)I**	**VCC 596**
PH-742-S		**HA, pp.** ***28, 31***
April 8/9, 1954		**M100**
103aE + RG2		
90 inin		

Two **of the** largest spirals in the Virgo Cluster are shown **on** this page. As listed in the RC2. the angular sizes of NGC 4321 and NGC 4303 are 6.9' and 6.0'. **respectively,** measured to an isophote of 25 mag arc see". Photographs of many Virgo Cluster spirals are shown elsewhere (Sandage, Binggeli, and Tammann 1985a), printed to a common angular scale, showing thereby that the two galaxies on this panel are among the largest **spirals** in the cluster.

The print shown here of NGC 432 I is from a red plate sensitive to Ha radiation. It was from this plate, taken in 19 54, that it came to be understood that most of the knots in spiral galaxies which Hubble (1936a) had used with his calibrations of brightest stars are **HII** regions (Humason. Mayall. and Sandage 1956, Appendix C). From this it was evident that Hubble's distance scale must be revised upward by a much larger factor than the correction determined by Baade **for** M3 **1** .

The **two principal** arms in NGC 4321 begin near the center as dust lanes. A side of one lane **attaches** smoothly **to the** beginning of one **of** the **principal** luminous **arms.** The **principal** dust lane on the other side cuts across the beginning of the first luminous arm at a steep angle.

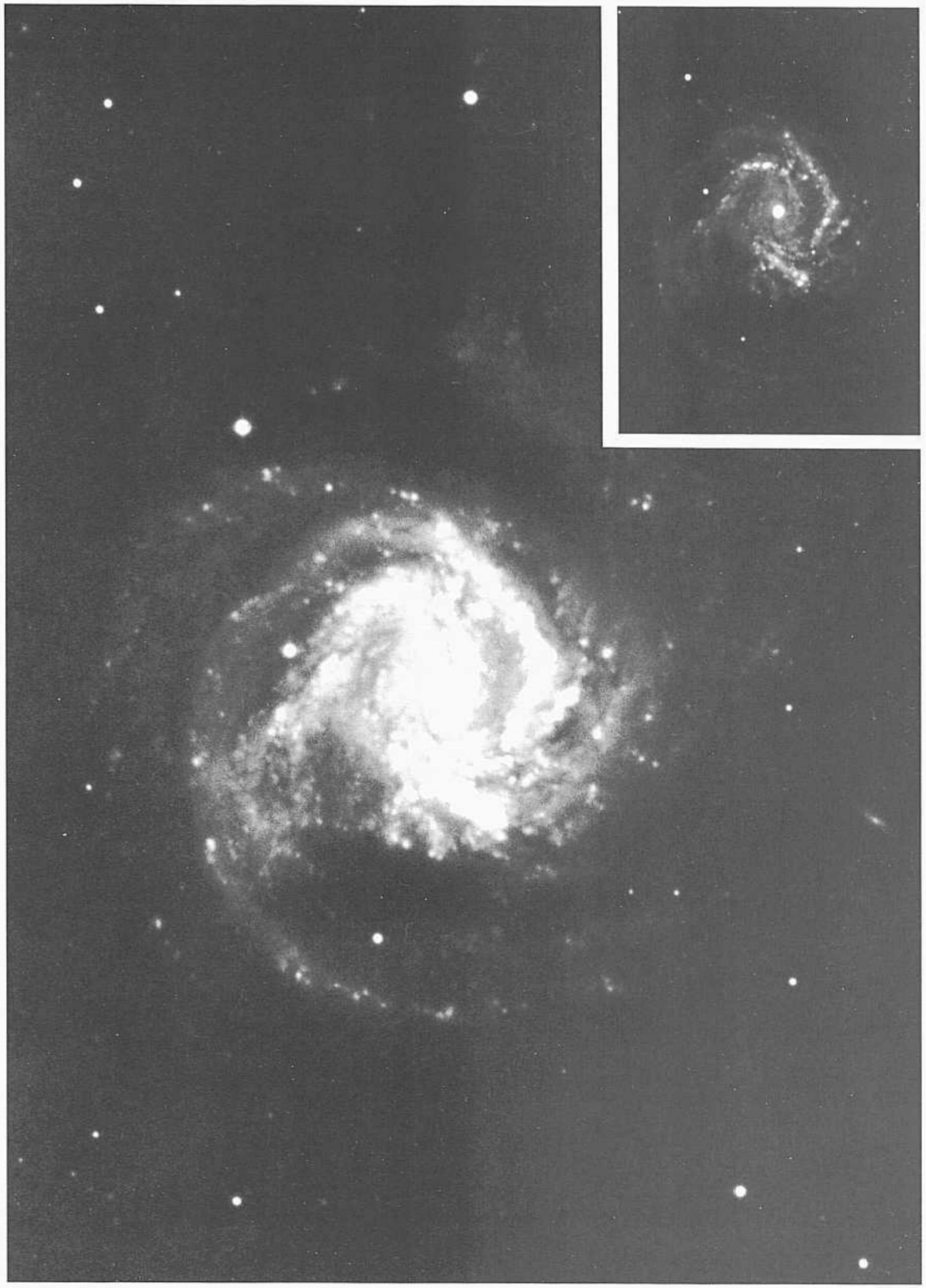
The largest **HII regions** resolve at about **the** 2" **level. Individual** brightest stars are difficult to separate from **HII** regions on blue or red plates. On yellow plates, where **no Hll-region** emission lines exist, brightest-star candidates may exist, starting at **apparent** magnitude **about** ***V = 2*** **1 .5.**

NGC 4303	**Sc(s)1.2**	**VCC 508**
CD-2136-S		**HA, p.** ***29***
March 22/23, 1982		**M61**
103aO		
50rain		

As with NGC 432 1 at the left, NGC 4303 is among the largest-angular-sized spirals in the Virgo Cluster region. Both are **considered** members of the cluster. Both have redshifts larger than the Virgo Cluster mean of $<v_o> = 976$ km s^{-1} (Sandage and Tammann 1990). The **redshift** of NGC 4321 is v_o = 1464 km s"': that of NGC 4303 is v_o = 1404 km s~'.

The arm pattern in NGC 4303 begins at the center as two thin dust lanes that wind **outward** through the inner disk, meeting the two principal luminous arms of the grand design type at the edge of the bright part of the disk. One of the principal arms is bent into **two** straight sections that meet at a sharp angle.

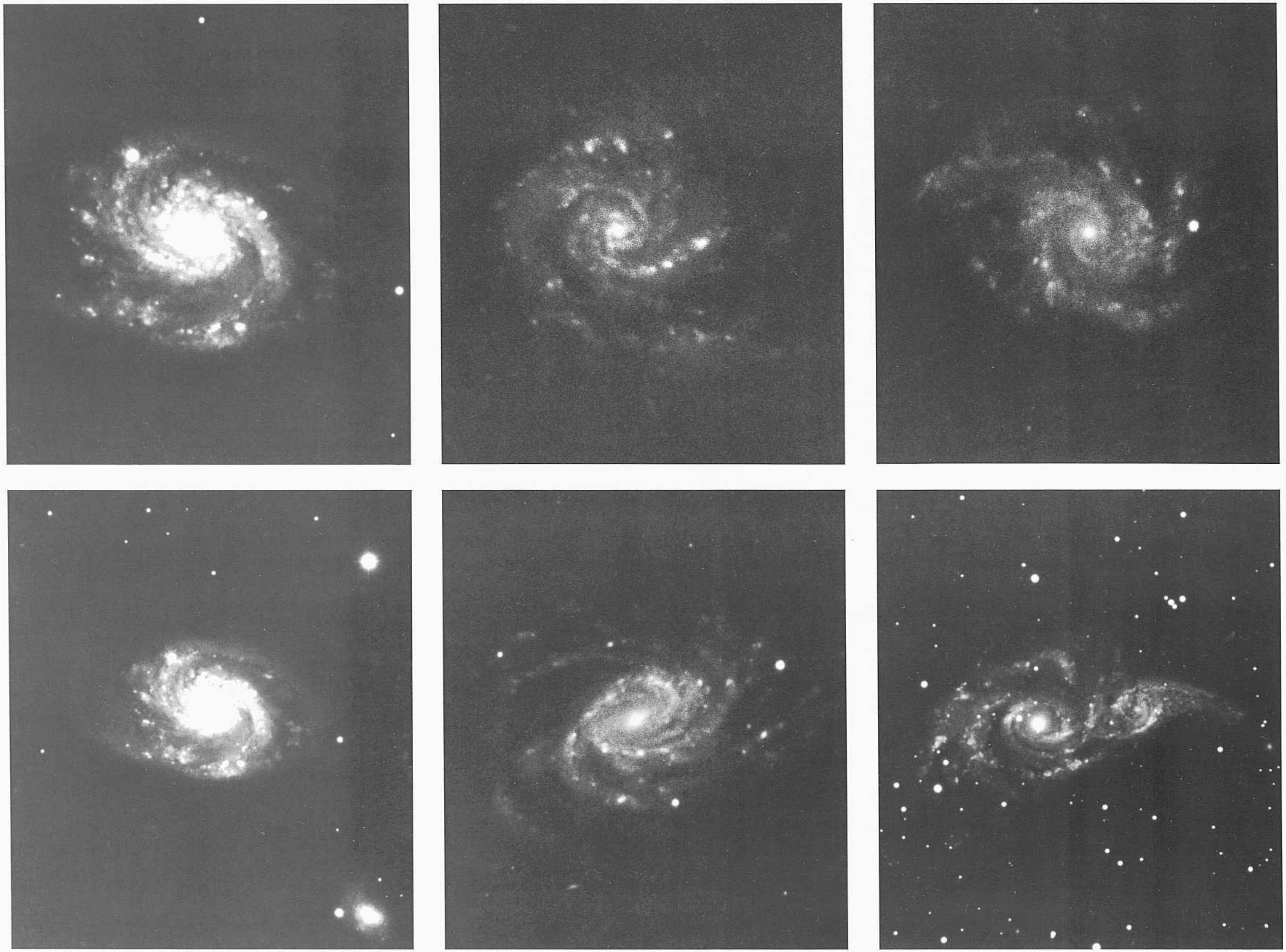
The arms are filled with **HII** regions that must be identified and eliminated from a candidate list before a survey of the brightest stars can be made.

PANEL

213

PANEL
214



NGC 3893 Sc(s)1.2 Karachentsev 313
P1I-7636-S Ursa Major Cluster
April 28/29, 1979
103aO
12 min

NGC 3893 and its companion, NGC 3896, arc members of the Ursa Major Cluster, whose mean redshift is about $<v_{(t}>$ = 980 km s^{-1}. The angular size of the galaxy is large at D95 = 4-.4' listed in the RC2. The size is slightly smaller[1] than the largest galaxies in the Virgo Cluster sueh as NGC 432 1 and NGC 4303 on the preceding panel.

The spiral pattern of NGC 3893 is of the grand design type having two principal spiral arms, both of high surface brightness for at least hall a turn from their place of origin near the center. The largest of the numerous HII regions in the arms resolve (core + halo) at about the 2" level.

NGC 3893/3896 Sc(s)1.2 Karachentsev 313
PH-7636-S BCD Ursa Major Cluster
April 28/29, 1979
103aO
12 min

NGC 3896 (BCD. for blue compact dwarf) is a companion to NGC 3893 at an angular separation of 3.7'. At the mean redshift distance of 19.6 Mpc for the cluster *(11* = 50) the projected linear separation of the pair is small, at 21 kpc.

NGC 5660 Sc(s)l.2 pair?
PH-7864-S
Sep5/6, 1980
I03a0
12 mill

NGC 5660 may form a wide pair with NGC 5676 (Sc; panel 245) at a separation of 30.5'. ll also has a likely dwarf hnlll companion of unknown redshift at the small separation of 2.6'. Tin- rcrlshifts are <>„(5660) = 2433 km s~' and u_o(5676) = 2239 km s~'. At the redshift distance of 47 Mpc (// = 50) the projected linear separations are 4 1 7 kpc for NGC 5676 and 35 kpc for the I in 11 I companion.

The spiral pattern in NGC 5660 is prototype Sc(s) of the grand design type where the two main arms begin at the center.

NGC 34-64 Se(rs)I/SBc(s)I
CD-199-S
Feh 8/9, 1978
103aO + GG385
45 min

NGC 3464 is shown in the Se section here rather than with the SI3e galaxies because we decided in preparing the KSA2 that the bar (or central oval) is weak enough to ignore. However, our sober second opinion is that the bar is strong enough, as viewed at this favorable inclination angle, to acknowledge. If the galaxy were viewed from an angle sueh that the central near-ring, which is almost complete, would appear circular, the bar would be considered to be as weak as those of others classed simply as Sc with arms starting from the edge of the inner disk.

The redshift is $v_{(t}$ = 3571 km s^{-1}.

NGC 2912 Sc(a)1.3
I'H-771 I-S
Feb 11/12, 1980
l03nO
12 min

The spiral arms in ibis highly symmetric early-luminosity-class prototype Sc(s)l galaxy arc well-formed, thin, and of the grand design type. The galaxy is remote by KSA standards, The rcdshifl is r,, = 4399 km s '.

NGC 2207/IC 2163 Se(s)1.2 puir
CD-580-S Sc(s)II-lll
Oct 8/9, 197!!
I03a0 + GG385
55 min

The pail- is clearly interacting, based both on the morphological distortion of 1C 2 1 63 (note the outward sweep on one side of the spiral pattern) and on the near equality of the redshifts. The redshifts derived from the 'rluchtmeier/Richter Catalog (1989) arc ,-,,(2207) = 2597 km s"[1] and i..,,(2 163) = 2 118 km s'" .

The angular separation of the centers ul the pair is 1 .5'. At (he mean redshift distance of 50 Mpc (// = 50). the projected linear separation is small, at 22 kpe. However, it may be that the tine separation is larger than this, and thai the separation is mostly in the line of sight. The plane of NGC 2207 may be warped, but because the image is nearly face on, the warp, if present, would not be visible.

Note that although 1C 2 163 shows evidence of tidal distortion, NGC 2207 docs not. This point illustrates thai interaction cannot be judged by morphological distortion, al least in some cases.

NGC 958 Sc(s)1.2
PH-7843-S
Sep 3/4, 1980
103aO
12 mill

NGC 958. **with redshift** u_0 = 5738 km s~\ is one of the most distant galaxies in the RSA (see the distribution of **redshifts set out in RSA2**, **Fig.** 2. p. 92). There **are** two major arms of the **grand** design type. Their beginning near the **center** is difficult to **trace** because of the high **inclination** to the sight line: the **(s)-subtype** designation is uncertain **for** that **reason.**

NGC 2955 Se(s)I Racine wedge
PH-8071-S
Feb5/6, 1981
103aO
12 inin

NGC 2955. with $v_{,,}$ = 7051 km s~'. has the second-largest redshift in the RSA: consequently the number of resolution elements in the image is among the smallest in this atlas. (The galaxy with the largest redshift is NGC 7119. Sell, panel 282, with v_o = 9825 km s~'.)

There are two main arms of the grand design type beginning at the center in NGC 2955.

NGC 3478 Sc(s)I
PII-8074-S
Feb 5/6, 1981
103aO
12 inin

The redshift of NGC 3478 is v_B = 6730 km s~J , the sixth-largest in the RSA, giving a distance of 135 Mpe (77 = 50). Hence the resolution of the image here is poorer than for most galaxies in this atlas.

The unusual feature of NGC 3478 is its six principal arms, each of which is thin and well defined. Each starts from the center and is generally smooth, although a few II11 regions exist in the outer parts of three of the arms.

New **6 = A2120-46 Sc(s)I**
CD-1543-S/Br
Aug 7/8, 1980
103aO + GG385
45 niin

The nearly edge on inclination of New 6 makes the classification of a grand design spiral **pattern uncertain;** what is evident is that the arms are thin, well **defined,** and well separated.

The redshift of New 6 is u_0 = 2600 **km** s~'.

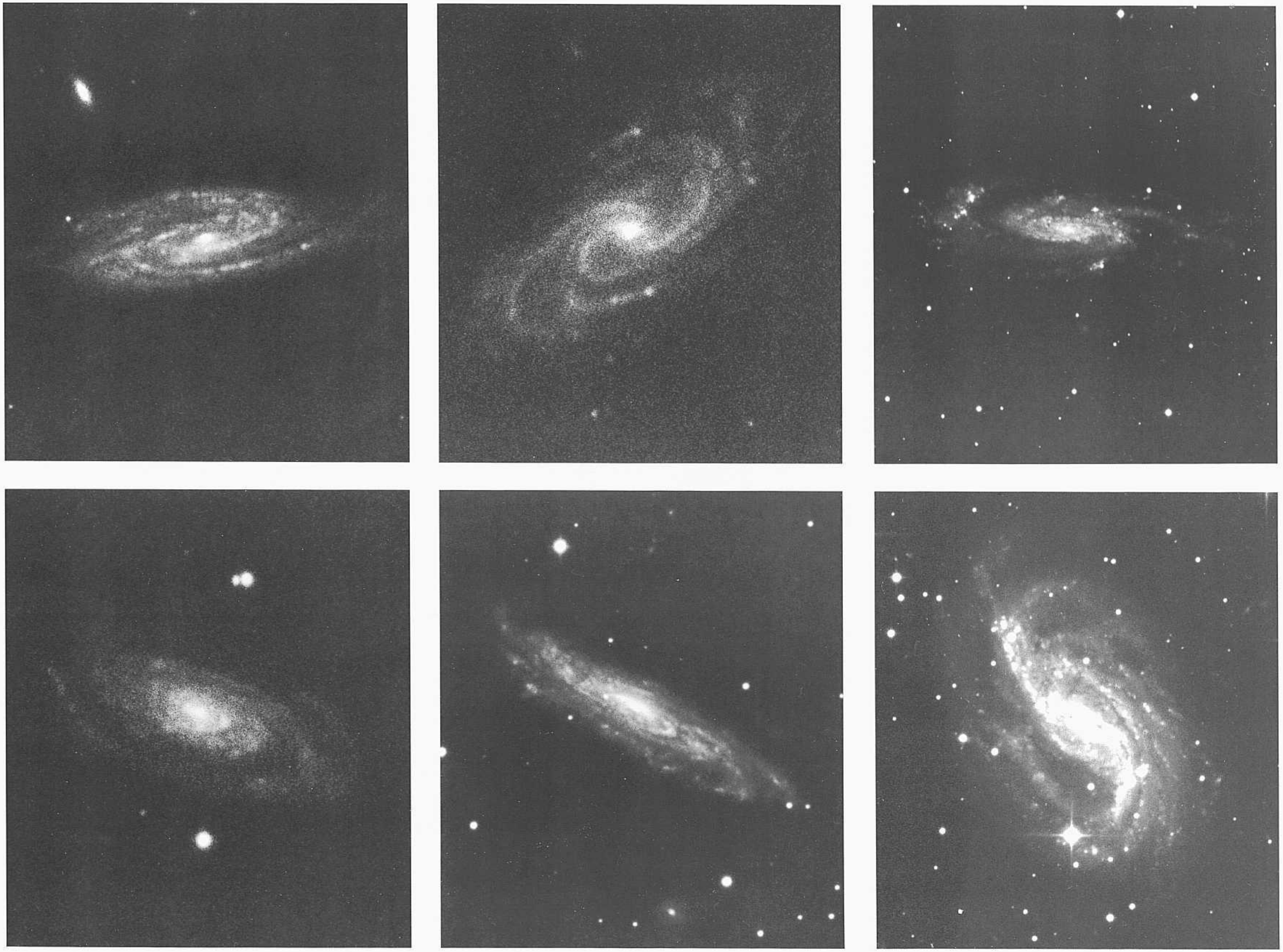
IC 764 Sc(s)1.2
CD-1706-S
Jan 5/6, 1981
103aO + GG385
45 inin

The **spiral** arms in IC 764 are well defined and begin at the center. A central bulge is absent; the center is defined by a very small nucleus; hence the Sc classification is **required.**

Many HII regions exist in one of the two principal arms. The largest have core + halo diameters of about 3". The redshift of IC 764 is $v_{3,}$ = 1851 km s"[1].

NGC **3095** **Sc(s)I-II** pec pair
CD-128-HB
Jan 5/6, 1978
103aO + GG385
80 min

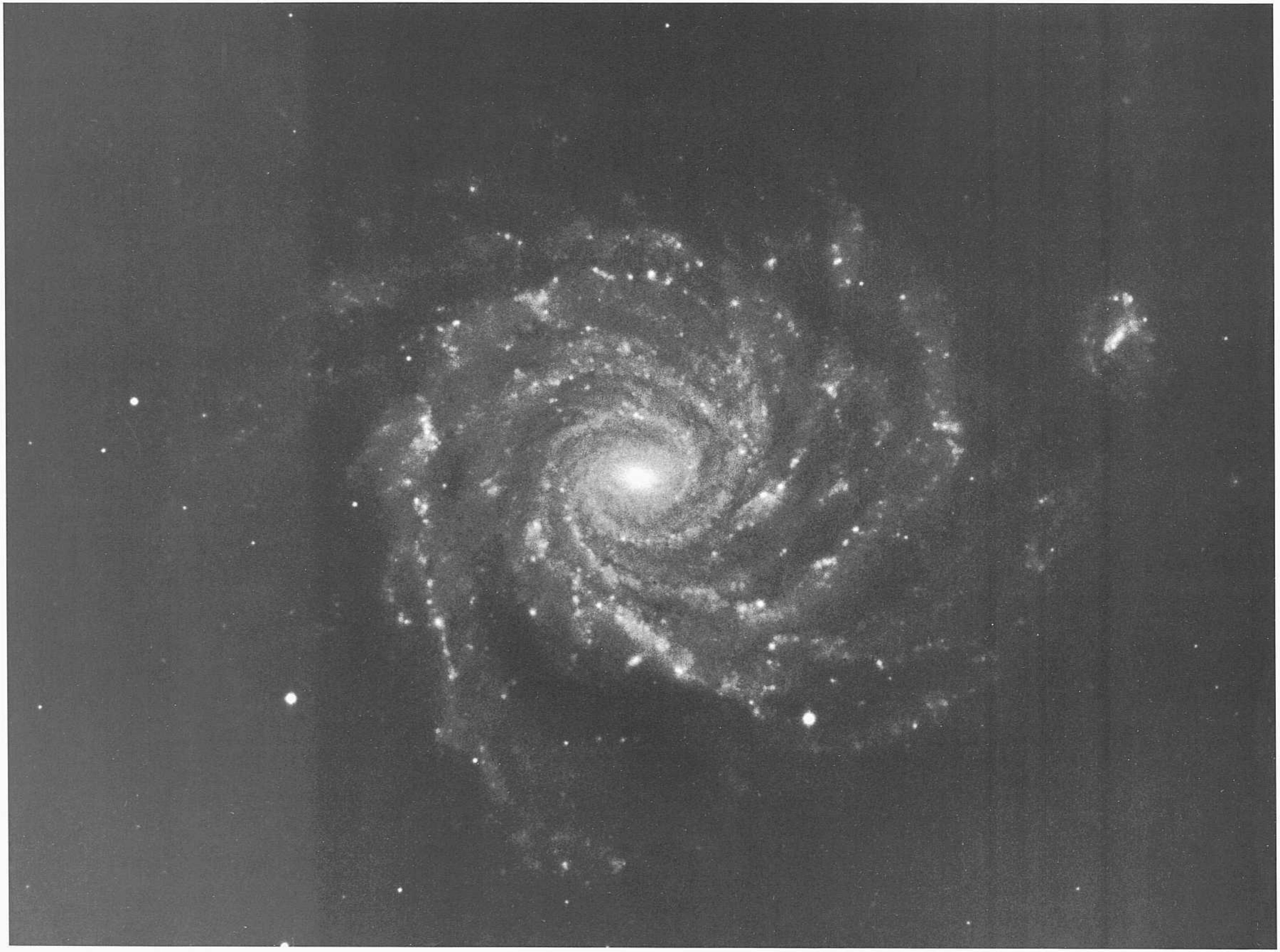
NGC 3095 forms a wide **apparent** pair with NGC 3100 (S0$_{J}$ prolate: not in the RSA) at an **angular separation** of 10'. The redshift of NGC 3095 is v_o = 2564 km s"': the redshift of NGC 3100 is unknown. **If** the **pair** is physical **rather** than optical in the line of sight, the projected linear separation is 149 kpc. If the pair is in fact binary it is important because the large difference in morphological type (Sc vs. SO) **would** have important implications for the yet-unsolved **problem** of galaxy formation and subsequent evolution as related to the classification sequence.



PANEL
215

PANEL

216



NGC **1232/1232A**	**Sc(ra)l**	**HA, p.** ***32***
CD-679-Br	**SBmlll**	**panel S13**
Jaii 26/27, 1979		
103nO + GG385		
45 niin		

NGC **L232 is** one **of the wonders** in the sky. **It** is **the prototype** of a **highly regular multiple-armed** spiral **of the earliest luminosity** class.

The arms start **at the edge of** a **high-surface-brightness** disk. Only **two major** arms **begin al this rim. After about one-quarter revolution,** each **branches into two fragments which after further unwinding branch again** until a **highly multiple armed structure spreads over the outer disk.**

Each fragment is **well separated from Lhe** others; **the geometrical entropy** of **the** pattern is as low as in any galaxy in **the RSA, equal or** somewhat lower than in **other highly regular** *Sc* galaxies **such as** NGC 309 **(Hubble** Atlas, p. *32:* panel 22 1 here) and NGC 536 **1 (Hubble** Atlas, p. *32;* **panel** 2 **1** 7 here).

The arms are Tilled **with III]** regions and candidates **for brightest stars.** The **largest 11II** regions have core + halo **diameters of 3".** The **redshift is** $v_0 = 1775$ km s^{-1}.

The SBm 111 companion **to the** east is separated from NGC 1232 **by** 4.0'. Tin-re is confusion (c. 1992) **as to whether this highly** resolved galaxy is at the same distance as NGC 1232. The **redshift** of NGC **12** 32 A measured **by Welch, Chincarini,** and Rood (1975) **of** v_0 = 1780 km **s**$^{-1}$ was rejected **by de Vaucouleurs, de** Vaueouleurs, and Nieto (1979) in favor **of** u_o = 6496 km s^{-1} **measured by them** from **an I** let **line.** However, a 2 **1 -cm 111 redshift of** v_0 ~ **1** 772 **km** s^{-1} **by Reif, Mebold, Goss,** van **Woerden,** and **Siegman (1**9H2) **confirmed** the **early value** liy Welch *el al.* **But** an even **later** *2* 1 -cm redshift confirms **the larger** redshift near v_0 = **6500 km** s^{-1}.

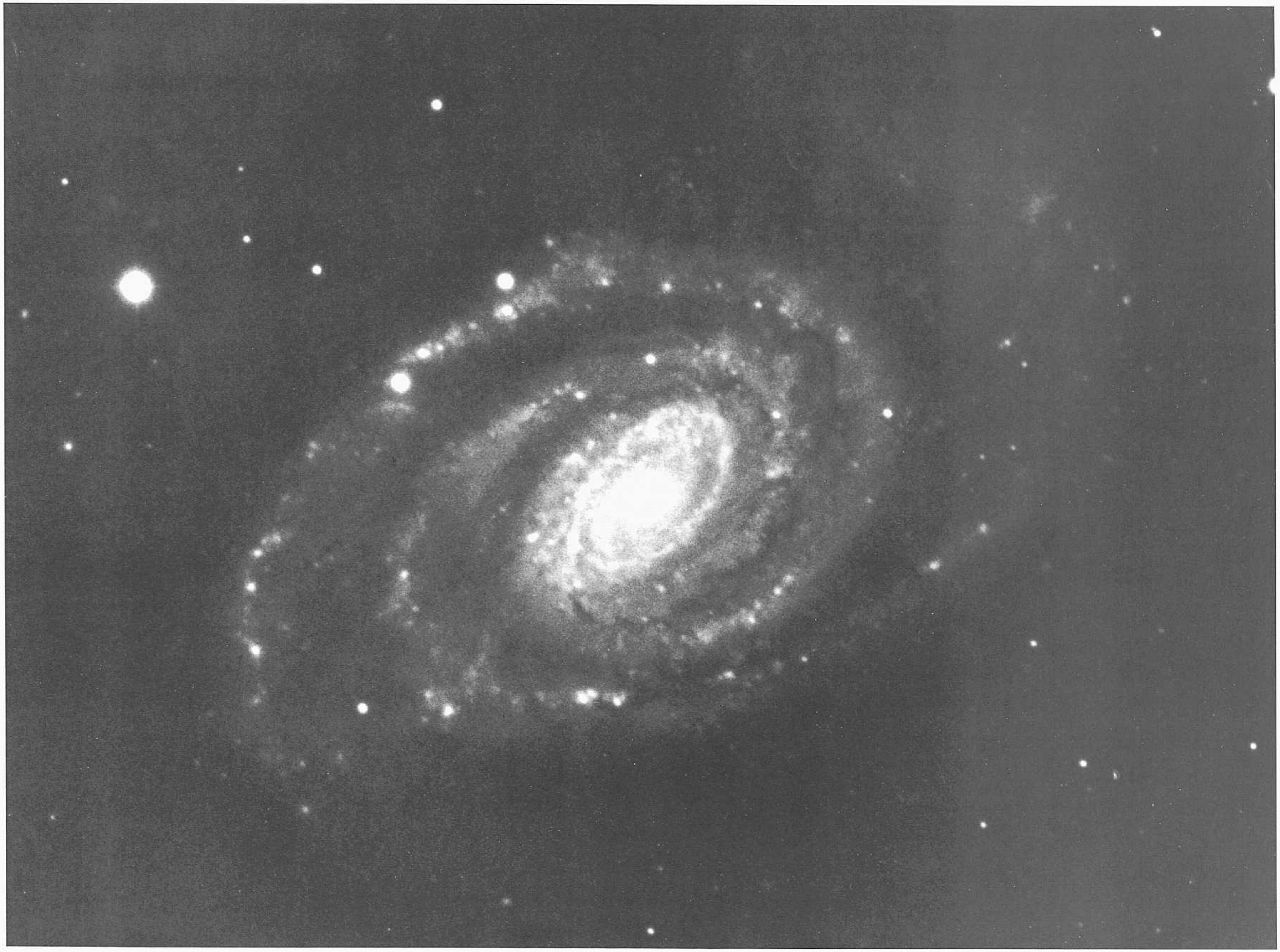
The resolution of INGC 1232A into star's and 1111 regions at **the** same **Level** as in **NGC** 1 232 itself makes no sense in **the** conventional interpretation of **redshifts** as a precise **distance** indicator **if** the high **redshift** value is correct. The case remains an important mystery (c. 1992).

At the mean **redshift distance of 35 Mpc,** the projected linear separation of NGC **12** 32 A **from** NGC 12 32 is small at 4 1 **kpc** if they are at the same distance. **If** not, the mystery remains.

NGC **5364** **Sc(r)I** **triplet**
PH-193-MH **HA, p.** ***32***
May 13/11, 1950
103aO
30 min

NGC 5364 has one **of** the most regular **spiral patterns of** all the RSA galaxies. The arms start tangent to a complete inner ring. The ring is not made by the near **overlapping** of opposite principal arms, as is the usual case. It is fed by two spiral arcs that start near the center. The description in the Hubble Atlas **of** the outer arms is still valid and is **not** repeated here.

NGC 5364. **with** a **redshift** v_n = 1140 km s^{-1}, forms a physical triplet with NGC 5360 (BCD: **not** in the RSA: v_o = 1060 km s^{-1}) at a separation **of** 7.7'. and with NGC 5363 ($S0_3$ in the RSA but not shown in this atlas: v_o = 1018 km s^{-1}) at a separation of 14.4'. At the mean **redshift** distance **of** 21 **Mpc** (/•/ = 50) the projected linear separations from NGC 5364 are 47 kpc and 88 kpc, **respectively.** The large morphological difference between NGC 5363 (SO) and NGC 5364 (Sc) is noteworthy.



PANEL
217

PANEL
218

NGC 5457 Sc(s)I HA, pp. 27,*31*
PII-81-B M101
June 9/10, 1950
103aO
30 **niin**

M101. like NGC 1232 two panels back, is the **prototype** of the multiple-armed Sc class, luminosity class I, subtype (s), where the arms begin at the center rather than from **an** internal ring. The two main arms at the center branch into multiple fragments **outward. Thin,** intricate dust lanes are closely associated with the luminous fragments. The entire face of the galaxy is well resolved into individual brightest stars and **Till** regions.

Ml 0 1 . the closest **Sc]** galaxy to **us,** has been important in the steps toward a correct calibration of the extragalactic distance scale.

Hubbie's (1936a) distance modulus for Ml 01 was small, at m - M = 24.0. The modulus was increased in the Hubble Atlas to m — M = 27.0 (D = 2 .5 Mpc). It is now known that even this value is 2.3 magnitudes too small. Following work on the distance scale in the early 19 70\s when Cepheid variables could not be found with the 200-inch telescope (Sandage and Tammann 1974c), the modulus was increased to m - M = 29.3, which is 5.3 magnitudes farther than Bubble's 1936 value.

This large increase provided the third step upward in the revision of Hubble's distance scale. The first was Baade's increased distance to M31 in 1952. The second was the increased distance to NGC 2403 (Tammann and Sandage 1968) based on the identification and measurement of Cepheids beyond the Local Group.

The 1974 photometry of the stellar content of M101 was extended in the 1980\s (Sandage 1983b). Brightest blue stars, of which some are bright irregular supergiant variables, begin to resolve at magnitude V = 18.9. The brightest red supergiants resolve beginning at V = 20.3.

M10 1 is al the center of a group of highly resolved **dwarf** galaxies all with small redshift. The **companions** include **NGC** 5201. 5171. 5477, 5585. **and** Ho IV. A discussion of the group and photographs of the companions are given elsewhere (Sandage and Tammann I 974c). The mean **redshift** of **the group is <*•,,> = 402 km s~'. The redshift** of **Ml 0 1 itself is** u_a **=** 372 **km s^-1^**.

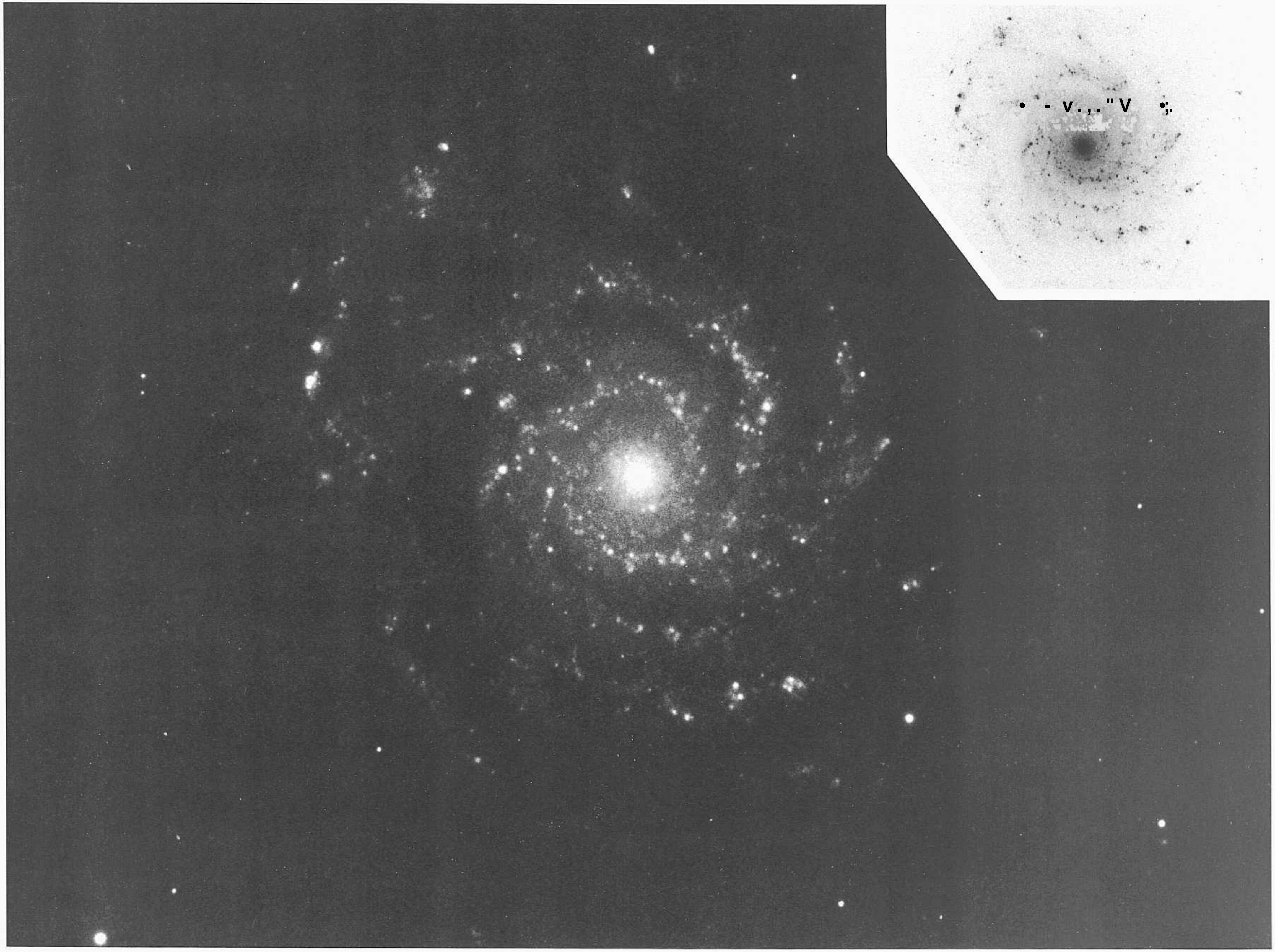
Tin- **angular** diameter of M 10 I to an isophote of 25 **mag** arc **sec** $^{-2}$ is large al 27 '. A pictorial **comparison** of **the angular** diameters ol tin- **giant** Sri galaxies M 10 1. M51, *MIC (>2l\.* NGC **5248,** and the three **largest** spirals in ihe Virgo **Cluster** (iNCC 4254. 4303, and 4H2 1) is given elsewhere (Sandage and Tammann I"76b). where it is shown that the angular sizes scale well as the inverse of the measured redshifts. This is (tnc of several independent ways to demonstrate that there is very little noise in the local llulihle linear expansion velocity flow.

NGC 3938 Sc(s)I Ursa Major Cluster
PH-4523-S panels 220, S5
April 15/16, 1964
103aE + Ha interference
120 min

NGC 3938 is **a** millLipie-armed, early luminosity class Sc(s) galaxy- similar to NGC 1232 anil Ml 01 on the preceding panels. The **print** here is from a **Palomar** 200-inch Hex interference red plate. The image in the blue **continuum** is **on the** following panel at the upper **left** (panel 220).

The **HII** regions define the arms as beads on **a** string. As in M5 1 and Ml 0 1. the two principal arms begin near the center and unwind for about half a revolution, branching thereafter. Thin dust lanes are present throughout the inner arm region, the inner disk, and the inside of the **principal** luminous arms.

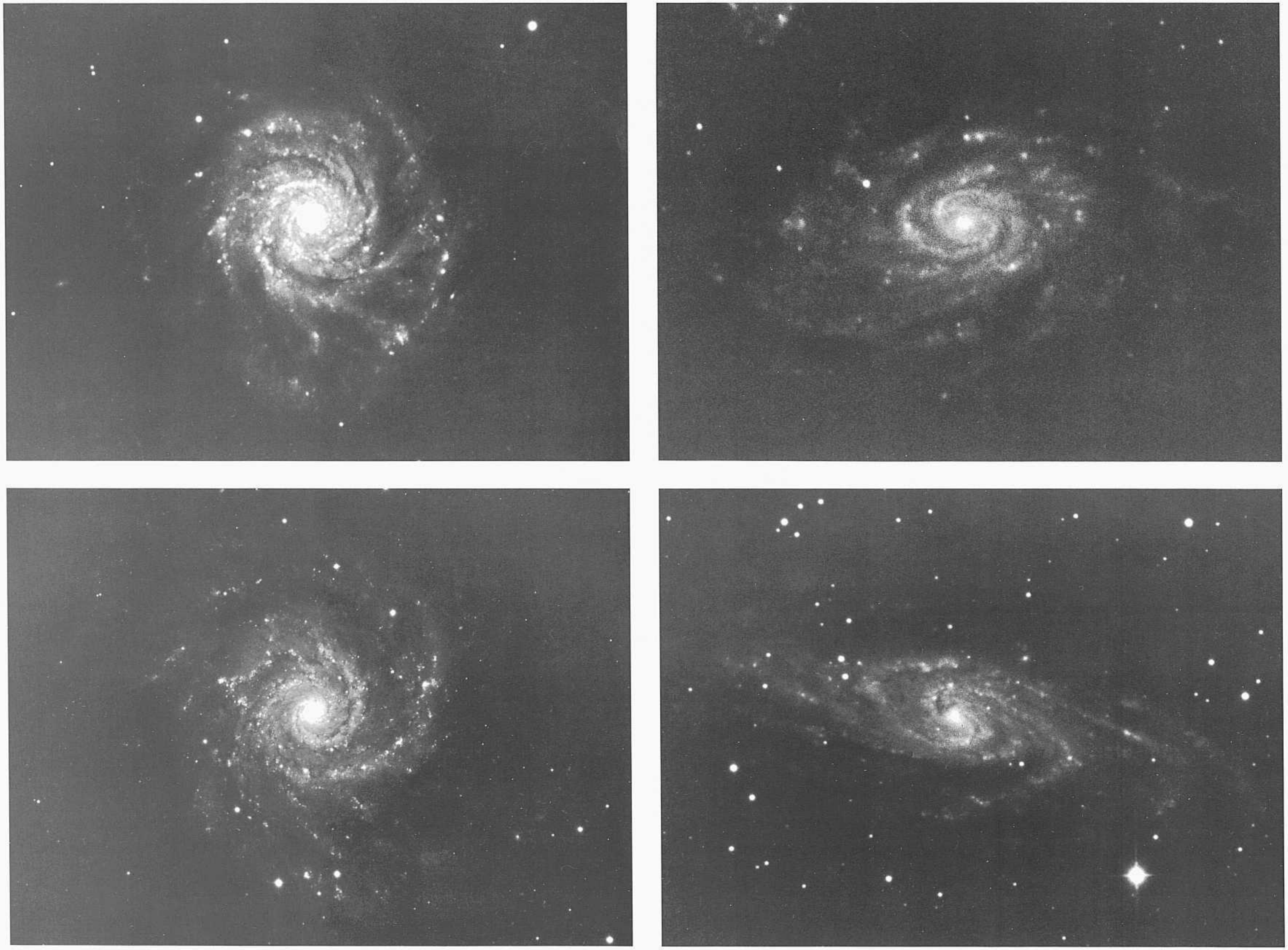
The largest **HII** regions have diameters (core + halo) of about 5". The **redshift** of NGC 3938 is $v_o = 844 \text{ km s}^{-1}$.



PANEL

219

PANEL
220



NGC 3938 Sc(s)I **panels 219, S5**
PH-7637-S
April 28/29, 1979
103aO
12 min

Tlie image here is made from a blue plate taken with the Hale 200-inch telescope at Palomar. The resolution into individual brightest stars is not as evident as, and will lie more difficult to identify and measure photometrically than, in M I 0 I or NGC 628. Nevertheless, the size of the largest HI I regions at 5" shows that the low redshift of v_0 = 844 km s^{-1} correctly indicates that the galaxy is close enough to permit study of the brightest stars at a level more favorable than in the Virgo Cluster Scl spirals, where the Hll-region diameters are not larger than about 3".

NGC 628 Sc(s)I HA, p. *29,31*
PH-1151-S
Oct 24/25, 1955
103aO + GG13
25 min

The spiral pattern in NGC 62 8 is the prototype of a highly regular, two-principal-arm, grand design type. The central parts of the two major arms begin at the center as dust lanes. The lanes accompany luminous arms after about a quarter-rotation. The thin dust lanes then are generally on the inside of the luminous ridge-lines of the star-forming arm regions.

The resolution into individual stars begins at the bright apparent magnitude of about *B* = 20. This galaxy is one of the prime candidates wherein we must obtain (c. 1990) brightest-star photometry; the background surface brightness of the luminous arms is low compared with the much more difficult cases of M5 1 (panels 172, 177) and M83 (panels 300, 301), making this galaxy ideal for study.

The largest HII regions in NGC 628 are complex. Several with multiple nuclei have tore + halo diameters of 5". The redshift of NGC 628 is v_0 = 861 km s^{-1} . The resolution into stars is easier seen in NGC 628 than in the Virgo Cluster and Ursa Major Cluster spirals, but is more difficult than in M101 and its satellites, consistent with the intermediate value of its redshift.

NGC 3614 **Sc(r)l** **pair:**[1]
PH-8051-S **Racine wedge**
Feb **1/5,** 1981
l03aO
1 2 min

The spiral pattern in NGC 3614 is thai of the multiple-armed type, starting with two main arms thai begin from an internal ring and that branch after about three-quarters ol a revolution. The arms are thin and can be well traced, requiring the early luminosity classification.

A candidate for a clos<. . . .mpanion exists ai a separation of 2.6'. Its redshift is presently (1990) unknown. If it is similar to the value for NGC 36 14 of !•„ = 2362 km a ', the projected lineal" separation of the pair would be small. 36 kpc at the redshift distance of 47 Mpr (// = 5 0). The brightnesses of the HH-region knots in the two galaxies are similar enough to argue for equality ol distances.

NGC 5161 Se(s)I
CD-1478-S/Br
May 11/12, 1980
103aO + GG385
45 min

Two opaque dust lanes begin at the small nucleus in a prototypical (s) pattern. These lanes change into luminous arms close to the center, whereupon the arms soon branch into a multiple-arm pattern similar to that in M31 (panel 149). Going outwards, the arms cross the major axis five times on one side of the major axis: on (lie other side four crossings are definite. An arm fragment that would provide (he filth crossing is present, but is of very low surface brightness.

The numerous I1II regions in the arms are unresolved. The redshift of NGC 5161 is v_o = 2 113 km s~'.

Many of the galaxies on this panel are more distant than most RSA galaxies. As a consequence, the prints have fewer resolution elements than do most prints on preceding panels. Despite the relative lack of resolution, it is evident that all galaxies here have very regular spiral patterns of small geometrical entropy, requiring the luminosity class I category.

NGC 309 Sc(r)I HA, p. *32*
PH-15-MH
Nov 15/16, 1949
103aO
20 min

The internal ring from which the highly branched multiple arms begin in NGC 309 is almost complete. The ring may attach to the ends of a central bar. similar to the pattern in the prototype SBbc(rs)II galaxy NGC 1073 (Hubble Atlas, p. *49:* panel 294 here), but any bar that is present in NGC 309 is weak.

Many HII regions are present in the arms, but none are resolved. The distance is large, as is also shown by the high redshift of v_o = 5786 km s^{-1}.

NGC 2776 Sc(rs)I
PH-7991-S
Feb 2/3, 1981
103aO
12 niin

The reproduction here is made from a weak 200-inch Palomar plate taken through clouds.

The spiral arms start from the outer edge of a smooth inner disk of moderately high surface brightness [not a luminous inner ring as in most (r) subtypes]. Three, rather than two, arms begin from this edge. None of the HII regions resolve into disks at the 1" level. The redshift of NGC 2776 is v_o = 2673 km s^{-1}.

NGC 2280 Sc(s)I.2
CD-664-Br
Jan 22/23, 1979
103aO + GG385
45 min

As in the pattern of NGC 5161 on the preceding panel, tile multiple-armed pattern of NGC 2280 can be traced to show five crossings of the major axis on one side and four on the other. Six crossings on either side of the *minor* axis can be counted.

The redshift is v_o = 1709 km s^{-1}.

NGC 2989 Sc(s)I
CD-683-Br
Jan 26/27, 1979
103aO + GG385
45 min

The angular diameter of NGC 2989 is small at 1.4': the redshift is v_o = 3916 km s"'. The spiral pattern is regular and of the multiple-armed type, similar to all others on this panel.

NGC 1376 Sc(s)I
PH-7919-S
Nov 7/8, 1980
103aO
12 min

The spiral pattern of NGC 1376 is similar to that of NGC 309 at the upper left except that the inner ring is absent; the inner arms begin at the nucleus as in M101 (Hubble Atlas, pp. *27,* 31; panel 218 here) rather than in the (r) pattern as in prototype NGC 309.

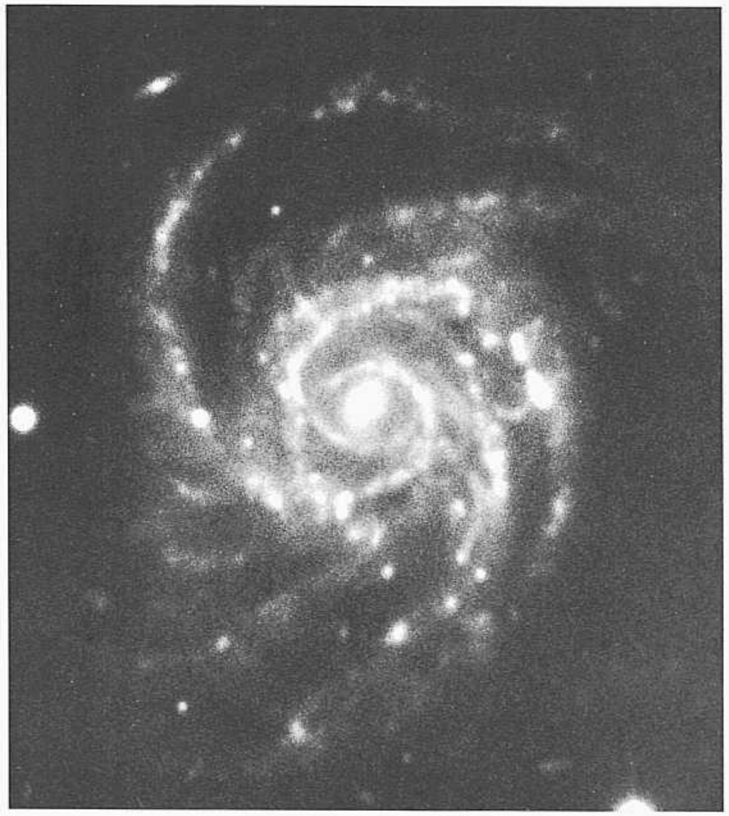
The redshift of NGC 1376 is v_o = 4198 km s^{-1}.

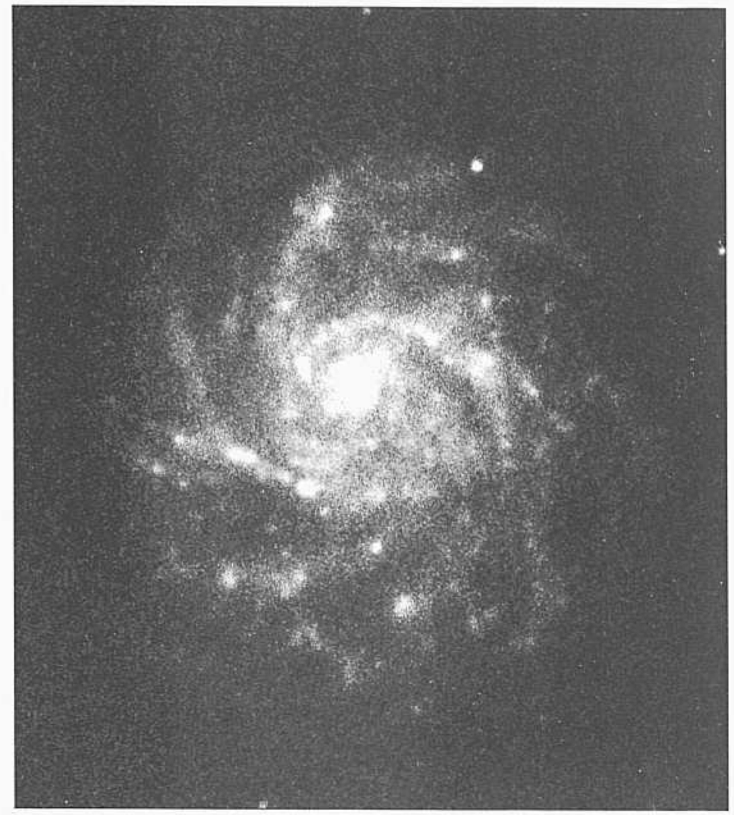
NGC 2998 Sc(rs)I
H-2346-H
Nov 27/28, 1946
103aO
30 niiii

The spiral pattern of NGC 2998 is of the same type as that of the other five galaxies on this panel. Five arm crossings can be counted on each side of the major axis. The arms are thin and very well defined, requiring the early luminosity class.

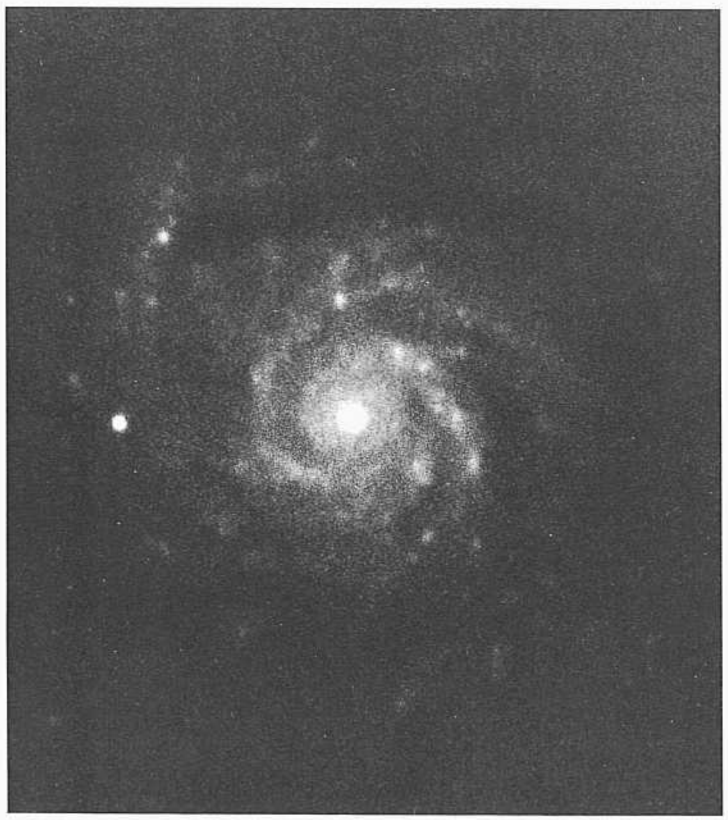
The reproduction here is made from a plate taken in excellent seeing with the Hooker 100-inch telescope on Mount Wilson.

The redshift of NGC 2998 is large, at v_0 = 4813 km s"'.





PANEL
221



PANEL
222

NGC2997 **Sc(s)1.3** **panel S5**
CD-710-S
Feh 3/1, 1979
103aO + GG385
15 min

The spiral pattern in **NGC** 2<>"7 is **of the grand design** type; **two** main **arms** in **the** central **region branch** into **thick fragments covering** the **outer** disk, filling il much as in **NGC** 5 **I 94** (MS **I** ; **Hubble** Atlas, pp. *26, .'I I* : pain-Is 17 2. 177 **here),** hut **less extreme here.**

The inner disk **is covered with** thin, **tightly** wound spiral **dust** lanes. **The two most** opaque lanes **begin** at **the center** [(s) type] silhouetted **against the high-surface-brightness** inner disk. Tin[1] **two** main luminous arms associated with these dust lanes begin some **distance from the** center, each after about half a turn **outward from** the parent dust lanes. The **arms** become luminous on the outside **of** the **accompanying** spiral dust pattern.

A group of "hot spots" **exist** in **the complex center (Sersic** and **Pastoriza** L965).

Many **till** regions exist in the high-surface-brightness luminous arms. The largest are complexes of several centers.

As in M5 1 , the identification and **photometry** of individual stars will be difficult because of the problem of identification and elimination of **the** small **III** I regions. **The** high **surface** brightness of the **arms** also will make **photometry** difficult.

The **redshift** is v_{ss} = *199* km s"[1].

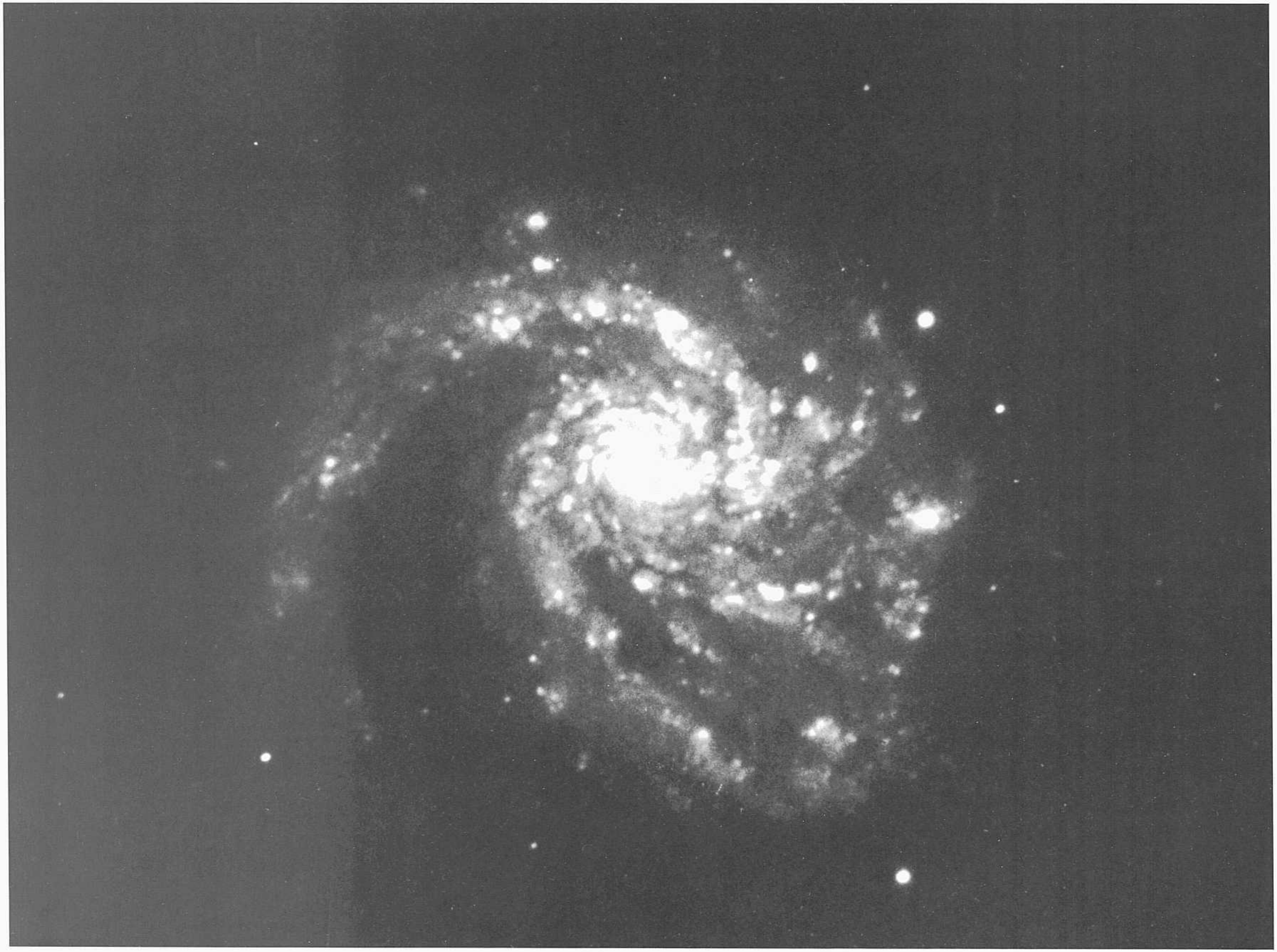
NGC 5247 **Sc(s)I-II** **panel S5**
CD-908-IIB
April 29/30, 1979
103aO + GG385
45 mill

NGC 5247 is a prime example of spiral **structure** of the grand design type. Two very-well-defined principal arms start as narrow luminous spiral lanes at the center and can be traced at **high** surface brightness for slightly more than half a revolution. A set of **fainter-surface-brightness** arms exist **inside** the main **set.** These also begin near the center, but are thicker and less well defined.

The largest **Hll-region** complexes in the main arms have core + halo diameters of about 4". No resolution into individual stars is evident brighter than about magnitude $V = 22$. The red-shift of NGC 5247 is $v_o = 1143$ km s^{-1}.

PANEL
223

PANEL
224



NGC 4254 **SC(B)I.3** **VCC** 307
H-1697-B **HA,** p. *29*
April 3/4, **L946** **M99**
L03a0 + UG2 (ultraviolet.)
90 miii

NGC 4254 is among the ten largest spirals of the Virgo Cluster members listed in the VCC. The isophotal angular diameter from the RC2 is D_{25} = 5.4'. Comparison of the size of NCC 4254 with other large Virgo Cluster spirals is seen from the photographs printed i> a common scale given in the Virgo Cluster photographic alias (Sandage, IJin^jjrli, and Tammann L985a),

The print here is from an ultraviolet plate taken by Baade with the Mount Wilson I 00-inch Hooker reflector. The print in the Hubble Atlas (p. 29) is from a red (103aE, no filter) plate made by Humason with the Palomar 200-inch telescope. Both photographs favor the 1111 regions rather than the continuum radiation of unresolved stars in lln* arms emphasized in the blue photograph in the Hubble Atlas cited above.

The two principal arms are of the grand design type. A complex set of arm fragments exists in the disk on one side of the grand design arm pattern.

Thin dust Lanes accompany the main spiral arms, generally on their inside edges, as is usual.

NGC 157 **Sc(s)II-III** **HA, p.** ***29***
PH-1054-S
Au~ 24/25, 1955
103aO
SO **min**

Although the spiral pattern **in** NGC 157 **consists** of two **main** grand design arms of high **surface** brightness **beginning** near **the** center, the entire disk is filled with thick arm fragments. The pattern **differs from that** of NGC 5247 **two** panels back, where the grand design arms are thin and cover only a small fraction of the disk area.

The main arms in NGC 157 branch such that eventually three crossings of separate arm fragments occur on one side of the major axis, proceeding outward. On the other side, spiral dust fragments cover **the disk.** The geometrical entropy is high. **The** luminosity class given in the HSA2 is **I-II.** It is revised **here to II-III** because of the **disorder** in the arms.

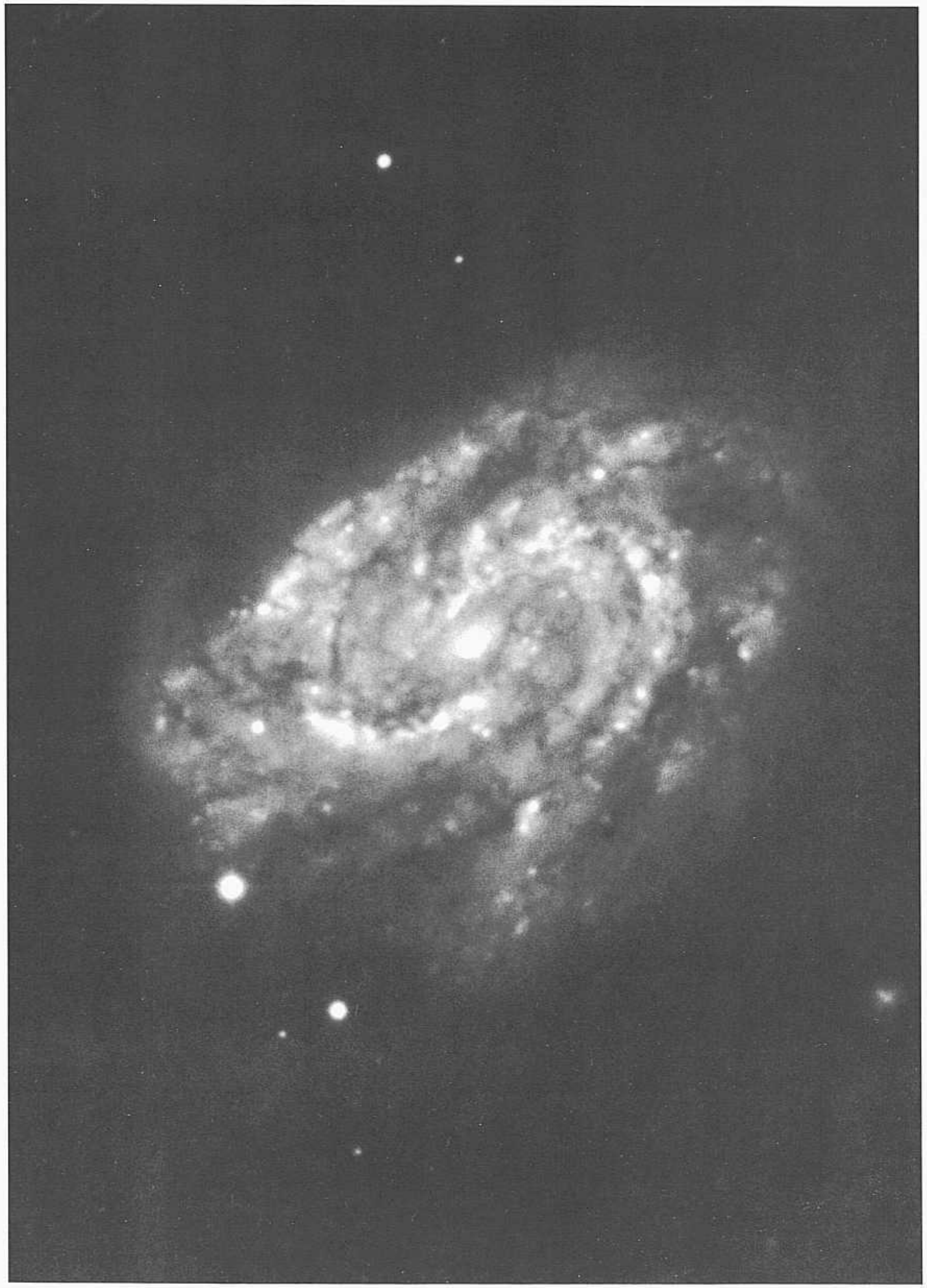
The **1III** regions are unresolved at the 2" level. Brightest stars are not easily resolved on the high-surface-brightness background. The redshift **is** v_n = **1813 km s"'.**

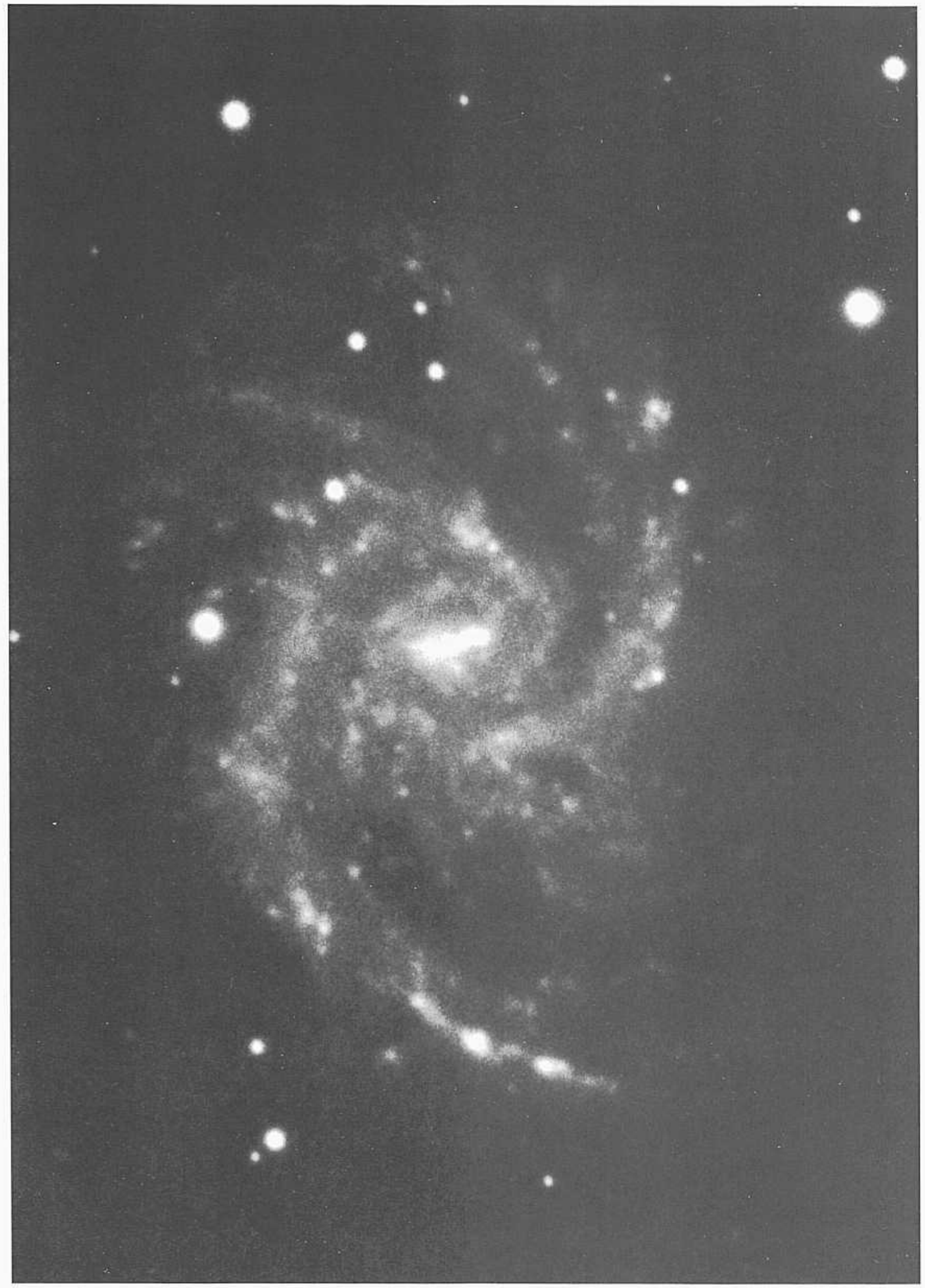
NGC 7125 **Sc(rs)I-II/SBc(s)I-H** pair
CD-1520-S/Br
Aug5/6, 1980
103aO + GG385
45 min

NGC 7125 forms a physical pair with NGC 7126 (Sab: panel 1 1 1) at 6.2' separation. The **redshifts are** y_o**(7125)** = 2910 km s*[1] and u_o(7126) = 2888 km s \ At the mean redshift distance of 58 Mpc (// = 50), the projected linear separation is 105 kpc.

A short bar exists in the central region of NGC 7125 from which the two principal arms begin at each end. The two main arms can be traced for a complete revolution as the principal **spiral** features, albeit with branching into fragments that generally parallel the main pattern as it **unwinds** outward.

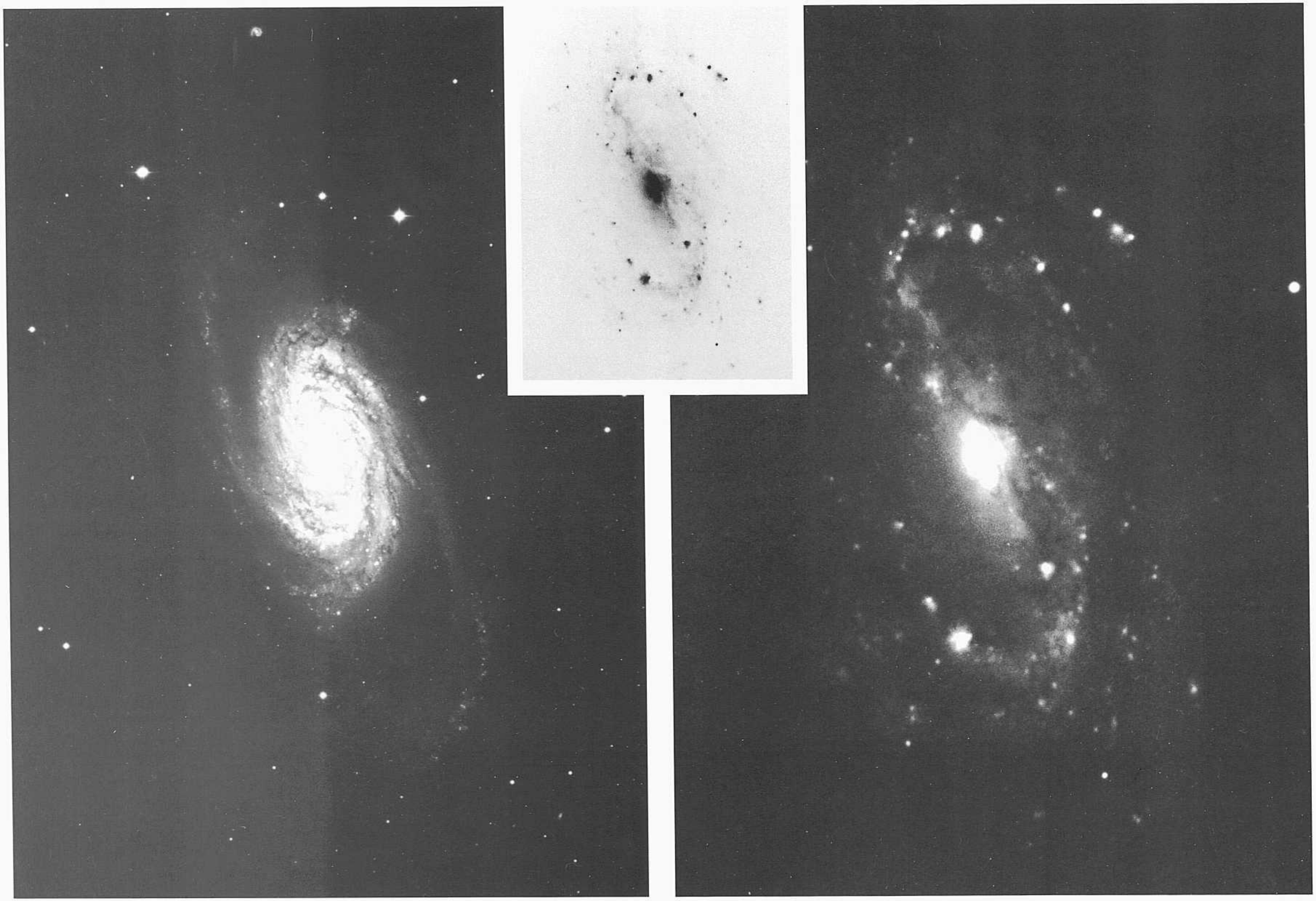
The **HIT** regions are unresolved. No candidates for brightest stars exist to this plate limit.





PANEL
225

PANEL
226



NGC 2903 Sc(s)I-II HA, p. *35*
PH-71-MH
Feb 15/16, 1950
103aO
30 ntin

NGC 2903 is nearby, as judged by **the** degree of resolution **into individual stars beginning** at about $B = 22$ in the two very-low-surface-**brightness** outer **spiral** arms. Resolution is not as easy as in Ml 0.1 , but is much easier **than** in any of the Virgo Cluster spirals **such** as **Ml 00. The redshift of** NGC 2903 is $v_0 = 472$ km s"[1].

The surface brightness of the inner **spiral** pattern is exceptionally high. The arm **pattern** is thick. **In addition to** the **two** main arms, **well** seen in the print at **the** right, the outer arm pattern **is multiple,** filling **the** disk. On **the** short exposure on the right, the **central** pattern is a weak **bar** from which one of the **two** principal **arms** springs. The opposite arm forms part of the slightly curved bar on that side.

The dust lanes throughout the disk are **spiral** fragments. Their opening (pitch) angles near the edges of the bar are very steep **(the** lanes begin almost **perpendicularly** to the bar), flattening to the pitch angles of an ordinary **non-barred** spiral in the outer pattern. These dust lanes undoubtedly trace the flow pattern of the interstellar medium as its **hydrodynamic** response to the gravitational potential **of** the **rotating** bar, including shocks near the **leading** edges of the bar (e.g., Huntley 1978, 1980, and references therein).

NGC **2903** SC(B)I-I1 **HA, p.** *35*
PH-3902-S
Feb 5/6, 1962
L03aE + Ha interference
90 nün

The weak bar pattern is seen **well** in this Ho. interference **filter photograph** taken **with** the **Palomar 200-inch Hale Telescope,** The bar is **not** well defined **but** is definite. **U** ran **also** lie **seen as** an intensity enhancement across tin* disk in **the continuum** photograph on the **left.**

The dust lanes along the bar **on** either side, situated as usual on **tlit*** leading **edges** of [lie bar **relative to the** direction **of rotation, are characteristic** of dusty **barred** spirals. **They are thought to** be **the** result of shocks **in** the vicinity of **the bar caused** by **the** bar's rotation **(Prendergast** 1962, 1983: Peterson and Iluntley **1980;** Ilunlley 1978. 1980).

The **largest Hll-region complexes seen** here have **core** + halo **diameters** of about 6". The redshift of NGC **2903** is small, **at** $v_0 = 172$ **km** s^{-1}.

Nole **the difference in the** enlargement of this image **compared with** that at the left.

The four galaxies on this panel and the six on the next continue the spiral pattern of two principal arms. In the galaxies here, the arms either fragment themselves or are joined near the center hy lower-surface-brightness secondary (fossil) arms which, together with the two main arms, cover the disk with a high-surface-brightness spiral pattern. Yet the arms and their fragments are definite, not filamentary as in NGC 2841 (panels 142, S4, S12).

NGC 2441 Sc(r)I-II
PH-7551-S
Nov 6/7, 1978
103aO
12 min

At first dance the spiral pattern in NGC 2441 seems similar to that in NGC 309 (panel 221). where an almost-complete internal ring exists from which the spiral arms originate. The impression, however, is deceptive. Very-low-surface-brightness, luminous thin inner arms in NGC 2441 connect with the center, together with two associated dust lanes. After half a revolution the nearly invisible arm on one side increases in surface brightness and, after nearly overlapping a segment of the opposite bright arm, winds outward for another nearly half-revolution. At that point it overlaps with a section of the other arm which, in the meantime, has itself branched at nearly right angles to form part of the apparent inner ring. Hence the pattern is disturbed on one side with overlapping arms, which, however, still are narrow and well defined as fragments.

The redshift is high, at $v_o = 3815$ km s^{-1}.

NGC 7412 Sc(s)I-II
CD-1510-S/Br
Aug 4/5, 1980
103aO + GG385
45 min

The spiral pattern is similar to that of M51 (panels 172. 177). The arms are of the grand design type and are massive in the sense of Reynolds (1927a.li). The two major arms start at the center, each dominated at the beginning by a thin dust lane which continues outward on the inside of each luminous arm. Secondary, lower-surface-brightness arms exist, one inside of one of the main arms and the other outside of the opposite main arm.

None of the MI! regions arc resolved at the 1.5" level. The redshift of NGC 7412 is v_0 = 1691 km s~'.

NGC 908 Sc(s)I-II
CD-1513-S/Br
Aug 4/5, 1980
103aO + GG385
45 min

As in NGC 7412 below at the left, the arms are massive in the sense of Reynolds (1927a,b). Although the spiral pattern is of the grand design, there are more than two dominant arms. Going outward along the major axis, four crossings of the major axis can be counted on either side.

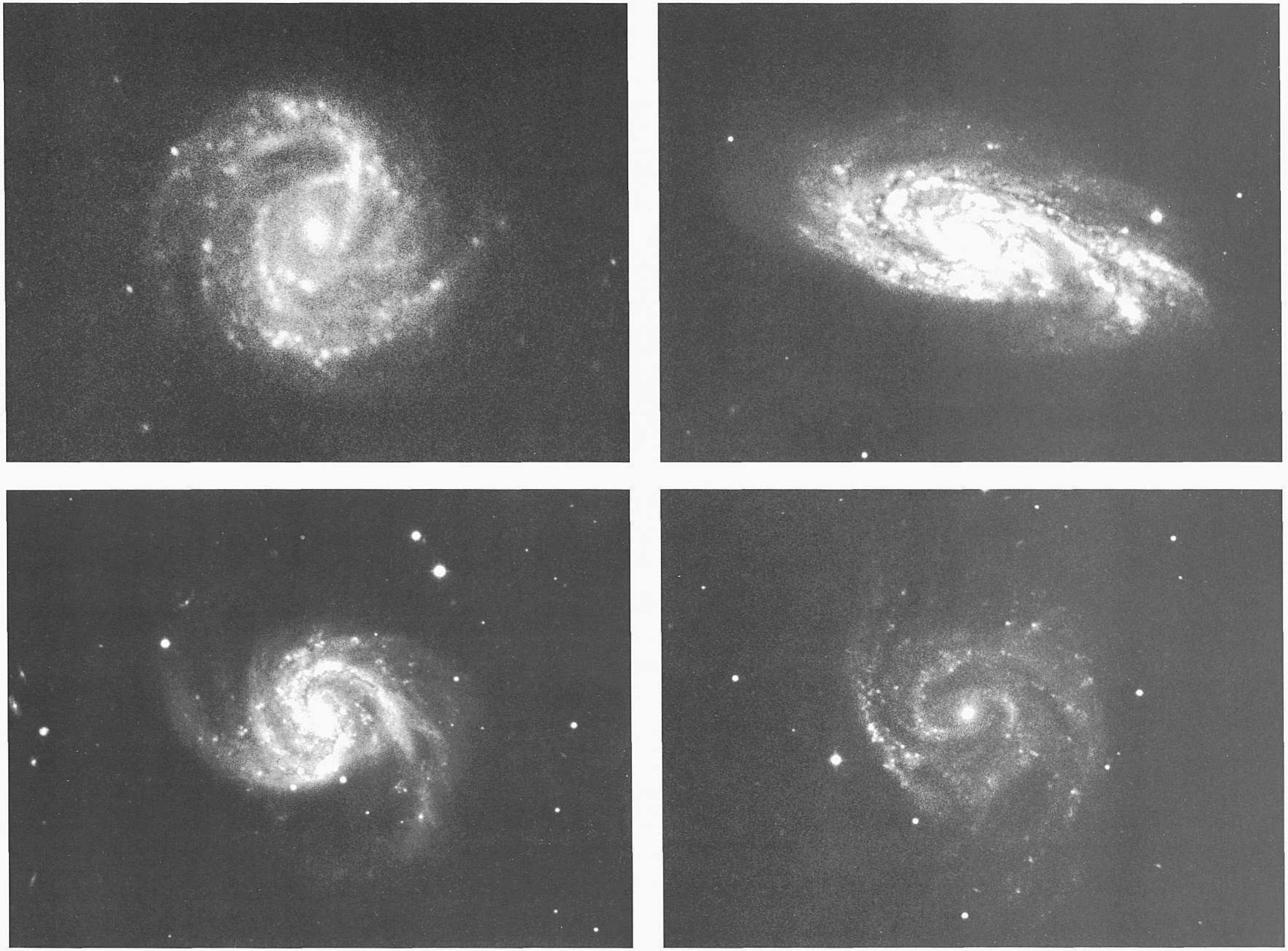
The redshift of NGC 908 is v_o = 1563 km s^{-1}.

NGC 1042 **Sc(rs)I-U** pair
CD-1579-S/Br
Aug 10/11, 1980
103aO + GG385
45 min

NGC 1042. redshift v_a = 1436 km s"', forms a probable physical pair with NGC 1035 (Sc; panel 291) whose redshift is v_0 = 1307 km s^{-1}. The angular separation of 22.5'. at a mean redshift distance of 27 Mpc (H = 50), gives the projected linear separation of 177 kpc.

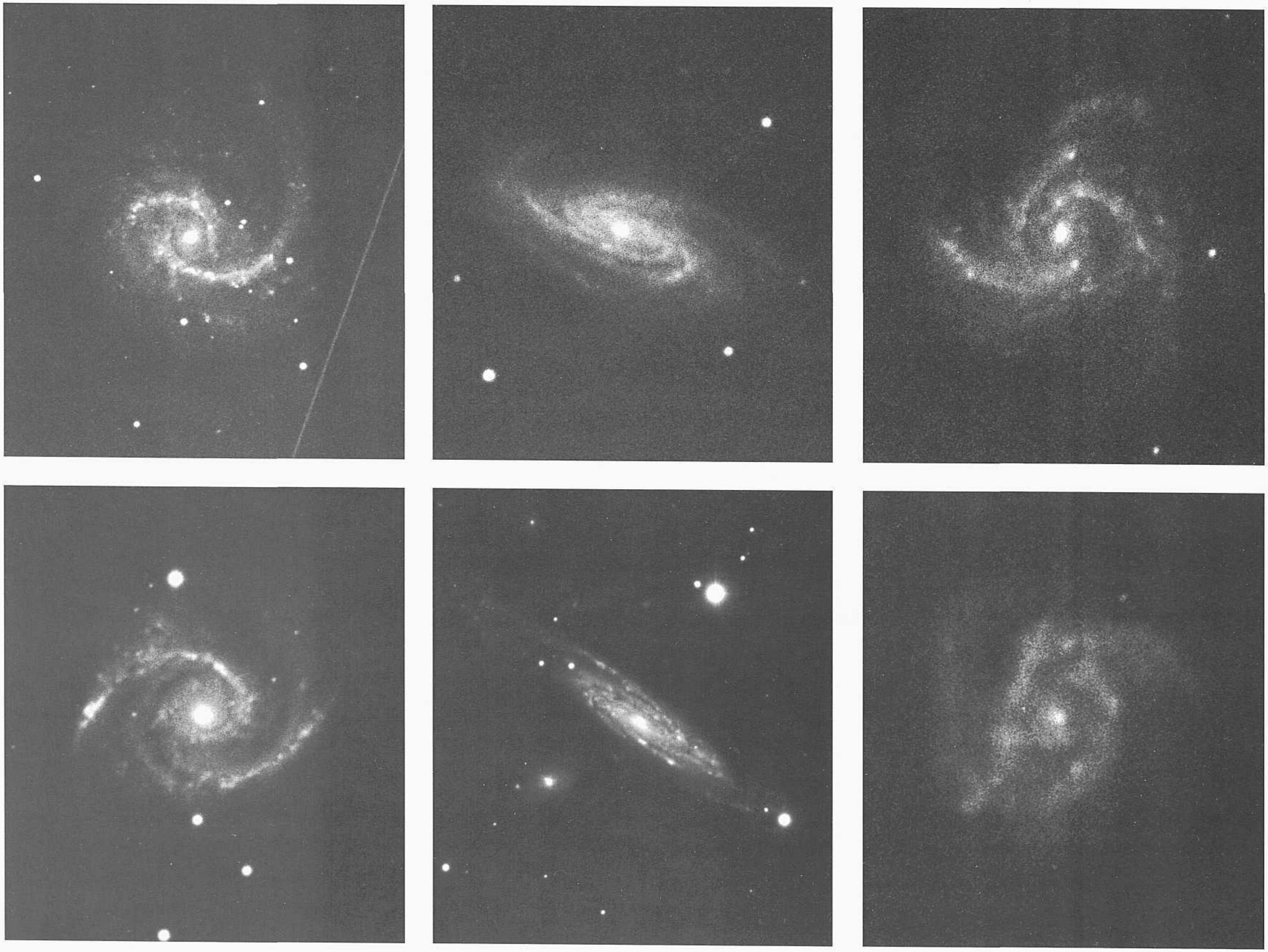
Two principal arms begin near the center but on the rim of a smooth central disk. The arms branch into fragments, one after a quarter revolution outward, the other after half a revolution.

The largest of the **Hll-region** complexes is about 1" in diameter (core + halo).



PANEL
227

PANEL
228



The six galaxies on this panel show spiral patterns of the grand design type, although four have multiple arms rather than simply two principal arms.

IC 2627 **Sc(rs)I-II**
CD-1666-S
Dec 30/31, 1980
103aO + **GG385**
45 min

IC 2627 has only two principal arms, **which** are thin and do not branch into secondary arms of the kind that cover the underlying disk in other galaxies of this type. The disk here is threaded only by the two high-surface-brightness principal arms.

The arms begin near the center, yet on the edge of the small smooth central disk.

The redshift of IC 2627 is v_0 = 1804 km s^{-1}.

NGC 6878 **Sc(r)1.3** **group?**
CD-1107-Br
Aug 18/19, 1979
103aO + GG385
45 **min**

This exquisite spiral is of small angular diameter, D_{25} = 1.6'; its redshift is large, at v_0 = 5791 km s^{-1}. It is in a field of several other galaxies of similar angular diameter, which may form a physical group. NGC **6878A** (RSabII) is at a separation of 10.3' toward the north (the declination in the RC2 is incorrect) at a projected linear separation of 347 kpc. An anonymous high-surface-brightness closer candidate **companion** (unknown redshift) at a separation of 6.7' has a projected linear separation of 226 kpc. Many other galaxies of similar angular size over a wider but still nearby **field** are seen on the Palomar Schmidt survey prints. However, this field is in the neighborhood of the Telescopium Group, whose mean redshift is $\langle v_o \rangle$ = 2733 km s^{-1} (Sandage 1975b); NGC 6878 may simply be in the background.

The spiral pattern is prototypical ScI: two principal arms start at the edge of a smooth, central high-surface-brightness inner disk.

NGC 7300 **Sc(s)I-II**
CD-1573-S/Br
Aug 10/11, 1980
103aO + GG385
45 **min**

The multiple arms in this **highly** inclined galaxy arc thin and **well developed. The** nucleus is small, characteristic as a **classification criterion** for Sc galaxies.

The **redshift is** v_o **= 5** 021 km s^{-1}.

NGC 5297 **Sc(s)I-II** **Racine** wedge
PH-8093-S **Karachentsev 394**
Feb 6/7, 1981
103aO
12 min

NGC 5297 forms a close physical pair with an anonymous (S0 pec) companion at an angular separation of 88". The redshift from **the RSA** is v_0 = 2654 km s^{-1}. Karachentsev (1987) lists v_0 = 2755 km s^{-1} for the S0 companion. At the redshift distance of 53 Mpc, **the** projected linear separation of the pair is very small at 23 **kpc.**

The multiple arms in NGC 5297 are thin and well defined but the pattern is mostly hidden by the high inclination.

NGC 7309 **Sc(rs)I-II**
P11-7688-S
Sep 26/27, 1979
103aO
10 min

The angular size of this **remote** (v_0 **= 4082** km s^{-1}**) exquisite** spiral is small **at** D_{25} **= 2.1'. Three principal,** high-surface-brightness arms exist: **fragments** of **lower-surface-brightness** outer arms **are present.** The **nucleus** is small.

NGC 5936 **Sc(r)I-II**
S-1601-II
April 23/24, 1936
Imp. Eel.
60 min

The reproduction **here** is from a plate **taken** in excellent seeing by Hubble **with** the 60-inch telescope on Mount Wilson. **The** angular size **of** the galaxy is small at D_{25} = 1.5': **the** number of resolution elements in this image is smaller than **for** most other prints in this atlas. The **redshift** of NGC 5936 is v_o = 3995 km s^{-1}.

The **arm** pattern is peculiar in a similar way to NGC 2441, described on the preceding panel.

Galaxies on this and the next five pages, all of early luminosity class **I-II,** have multiple arms rather than two major ones as in the extreme examples of the grand design spiral type. Some of the multiple-armed galaxies still have elements of the grand design, while many are totally of the flocculant type (El**megreen** and Elmegreen 1982, 1987), having arm fragments such as those in NGC 488 (panels 115, 116, S3,S12) and NGC 2841 (panels 142, S4, S12).

NGC **6070** **Sc(s)I-II**
PH-7830-S
Sep3/4, 1980
103aO
12 niin

Five arm crossings on one side of **the major** axis and seven on the other define the **multiplicity of** the well-defined arm pattern in NGC 6070. Although the outer pattern is multiple, all arms are **branched** from two main arms that begin near the small central region.

The **redshift** of NGC **6070 is** v_0 **= 1979** km s^{-1}. Two **of** the largest **Hll-region** complexes may resolve (core + halo) at about 1.5".

NGC **4100** **Sc(s)I-II**
S-1982-H
Feb 20/21, 1947
103aO
60 **niin**

The reproduction **of** NGC 4100 here is from a plate taken with the 60-inch telescope on Mount Wilson. The spiral structure near the small nucleus is defined by thin dust lanes. Three major luminous arms can be identified in the outer disk on each side of the major axis.

The redshift of NGC 4100 is v_o = 1135 km s^{-1}.

NGC 6118 Sc(s)1.3
CD-1403-S/Br
March 22/23, 1980
103aO + GG385
10 nill

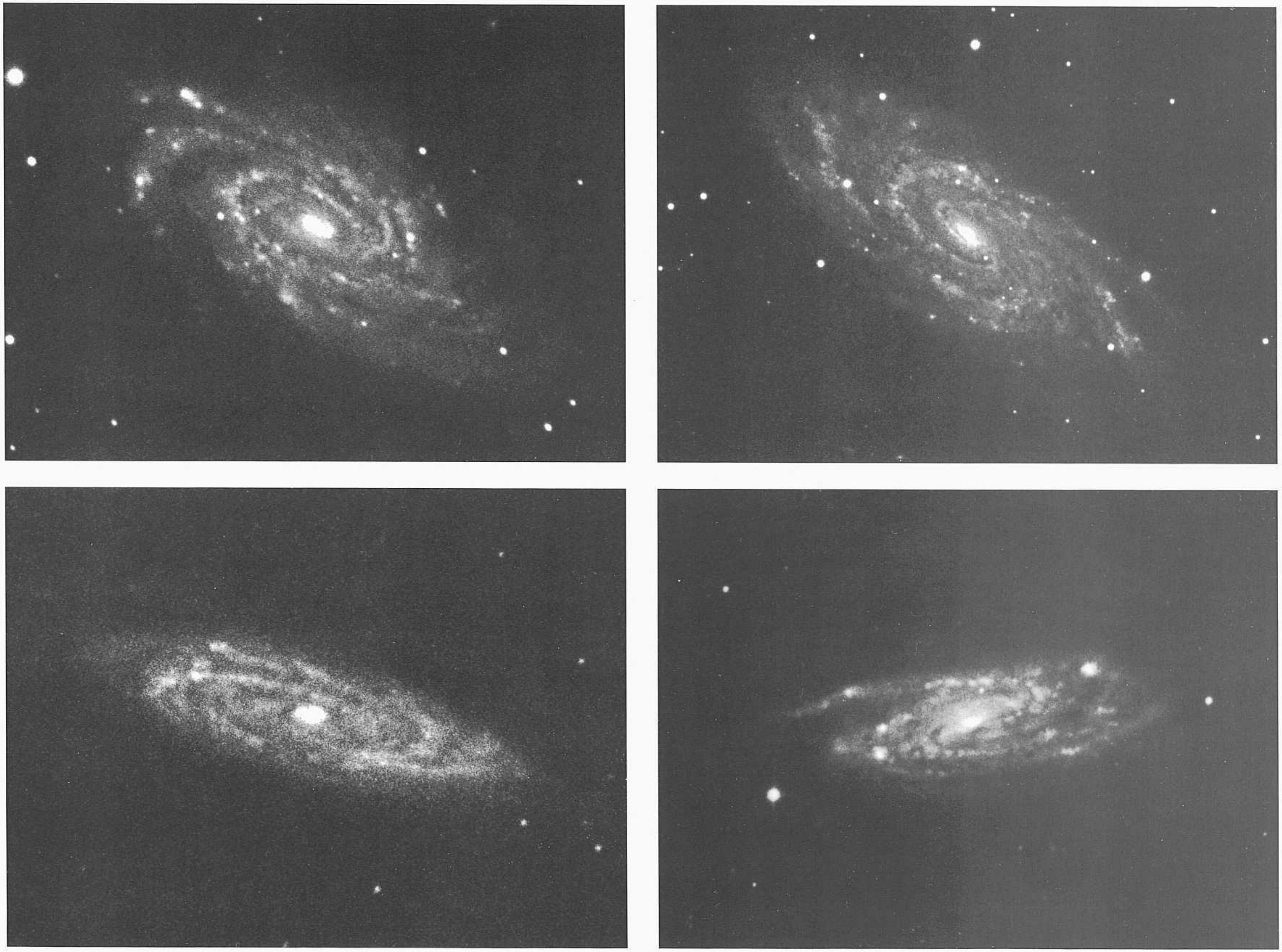
The spiral pattern consists of two principal arms, which begin at the center and branch into fragments **which** constitute the outer multiple **spiral** pattern.

The redshift is v_o = 1535 km s^{-1}.

NGC **4602** **Sc(r)MI**
CD-1400-S/Br
March 22/23, 1980
103aO
75 niin

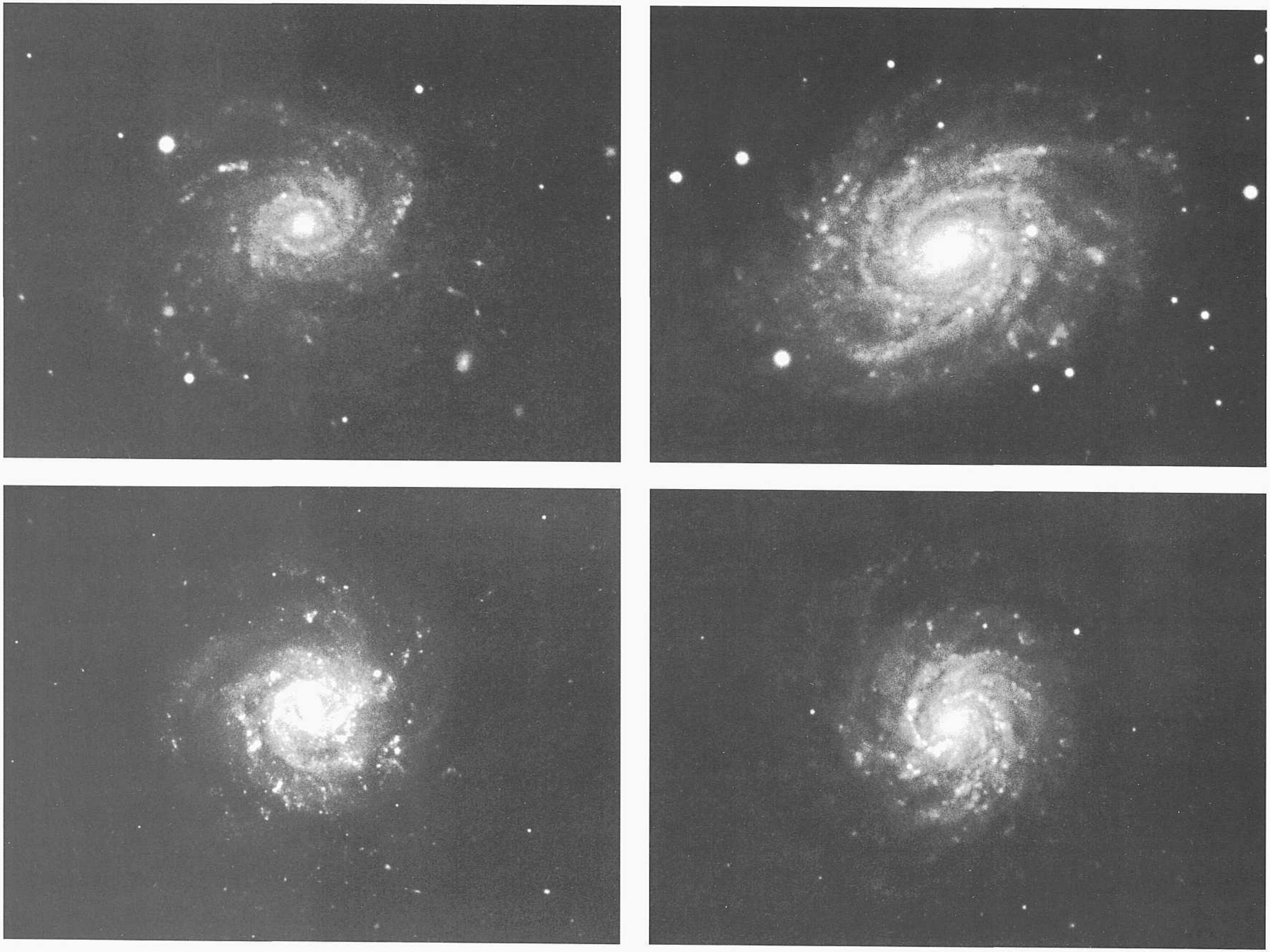
The spiral pattern of multiple outer arms fed **by** two major arms which start near the center is similar to that of the other three galaxies on this page. The high inclination of NGC 4602 obscures the details of the pattern near the center, but two thin dust lanes emerge from the center in a manner similar to the straight lanes along the bar in SBb and SBbc galaxies, suggesting here a mild bar.

The redshift is v_n = 2347 km s"'.



PANEL
229

PANEL
230



NGC 4653 **Sc(rs)1.3** **pair**
CD-1411-S/Br
March 23/24, 1980
103aO
75 min

NGC 4653, with redshifi r,, = 2433 kins'. forms a close physical pair **with** iNGC **4642 (Sc** nearly **on** edge; not in **the RSA), with v_0 = 2 47 1 km s^{-1}. The angular** separation **of** ').}{' **corresponds** to a **projected linear separation of I 40 kpc at the redshift distance of 49** iMpc (// = 50).

The **outer** spiral **arms are branches from** two main arms that **begin** on opposile sides of a central disk, similar to the (s)-lypc arm **origins in SBb** galaxies **such** as NGC 1300 (panels 154. S8). However, there is no additional evidence of a bar or of a **strong** oval central **region.**

NGC 4136 Sc(r)l-ll
PH-8029-S
Feb 3/1, 1981
103aO
12 nün

The inner[1] **spiral** pattern begins **tangent** to an almost-complete inner ring similar to **the** pattern in NGC 309 (Hubble Atlas, p. *32;* panel 22 1 here) and NCC 5364 (Hubble Atlas, p. *32;* panel 217 here).

The outer arms are more massive in the sense of Reynolds (1927a,b) than in NGC 309; hence the slightly **later** luminosity class is **required** here.

Brightest stars begin to resolve in the arms at about **magnitude** *li* = 22, **much** more easily than in the Virgo Cluster spirals such as NGC 4321 **(M100;** Hubble Atlas, pp. 28. ***31;*** panel 2 1 3 here), but not as easily as **in** Ml 0 **1 (Hubble** Atlas, **pp.** 27, *31;* panel 218 **here) which** has nearly the same **redshift. The redshift of NGC** 4136 is v_{tl} = 409 km s"'j that of Ml 0 1 is v_0 = 3 72 km s"' . However, the absolute magnitudes of these two galaxies differ by 3.2 mag, NCC 4136 being very faint at ***Mg*** = -18.3. Because **the** absolute *B* magnitude **of the** brightest **resolved** blue stars is a strong **function of the** absolute **magnitude** of **the** parent galaxy (Sandage and Tammann **1974b;** Sandage and Carlson 1988) the difference between NGC 4 136 and NGC 4321 in ease of resolution into stars is **understood. That** the distance determined from redshift is reliable within this range of very small redshift values follows from **the** low random velocities about a linear redshift-distance relation for the nearby galaxies (Sandage and Tammann 1975a, Sandage 1986a).

The five largest HI! regions each resolve at about the 5" level, showing again that the galaxy is nearby.

[C2537 Se(s)l-ll
CD-1327-S/Br
March 13/1 I, 1980
l()3a() + GG385
45 miu

The two main arms in 1(1 2537 **thai** begin near the center, along **with** their associated thin dust lanes, branch **outward until** about **fivti arm** crossings of the major avis can be counted on each side.

The rrdshil'l is r,, - 2523 km s '.

NGC 2967 **S<-(rs)l-II**
CD-1358-S/Br
March 16/17, 1980
I03a0 + GG385
45 miu

The spiral **pattern** in **NGC** 29fi7 is remarkably similar lo the pattern and the character of the arms in M 1 I) 1 (11ubide Atlas, pp. *27. 31:* panel 2 I }{ here), **requiring** no **further** description here.

The redshift of **NGC** 2967 is ,•,, = 2065 km s^{-1}.

NGC **3756** **Sc(s)I-II** Racine wedge
PH-7127-S
Jan 31/Feb 1, 1976
103aO + GG13
30 niin

Three arms emerge from the **central** region of NGC 3 756 . As **the** arms wind outward they fill the area of the disk, being of the massive variety in the sense of Reynolds (192 7a,b) lacking a thin, well-defined form.

The **redshift of** NGC 3 75 6 is v_0 =1372 km s^{-1} . The galaxy is in the region of the Ursa Major Cluster but is considered to be a probable background galaxy.

NGC 3198 **Sc(s)I-II**
PH-7960-S
Nov 8/9, 1980
103aO
12 min

The arms in NGC 3 198 **are** moderately thin and fairly well defined. However, the inclination angle is so high that the pattern, although regular, is not easily traced. If one views the image at an angle and at an **optimum** orientation by tipping and rotating the panel to compress the major axis until it is **equal** to the minor axis, the image presents two principal arms that start at the center [the (s)-type attachment to the center]. Each can he traced for about half a revolution before each branches to form the multiple pattern.

The redshift of NGC 3198 is small, at 702 km s~^{1} , but the HII regions remain unresolved at the 2" level.

NGC 3672 **Sc(s)I-H** **HA, p. 30**
CD-1832-HB
April 1/2, 1981
103aO + GG385
45 **min**

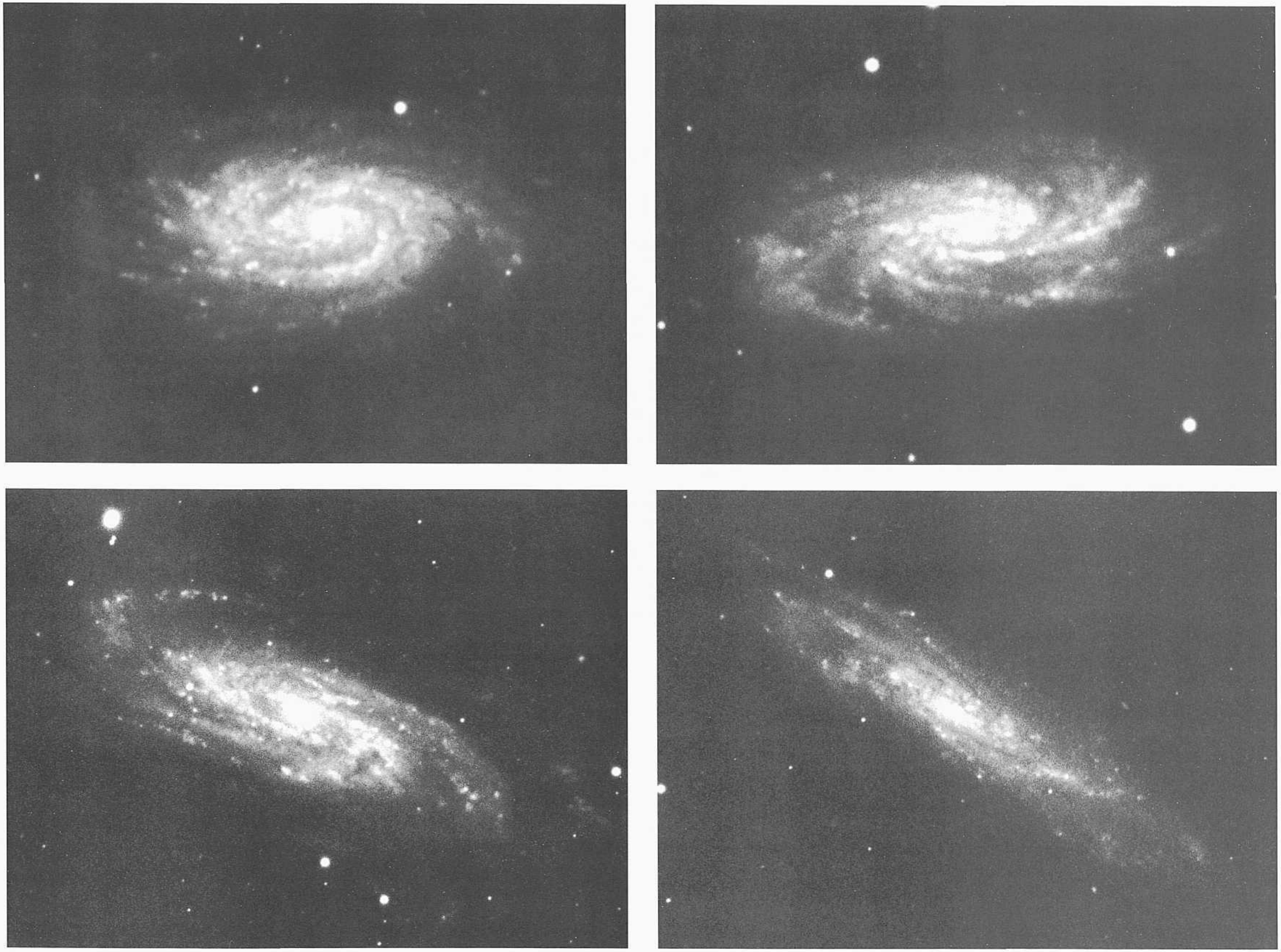
Although the spiral pattern here has multiple arms, it is not filamentary **(flocculent;** EI**megreen** and Elmcgreen 1982, 1987) but rather is of the grand design: four rather ill-defined arms start near the center and wind outward to cover the disk.

The redshift is v_o = 1633 km s~^{1}.

NGC **1337** **Sc(s)I-II**
PH-7699-S
Sep **26/27, 1979**
103aO
12 min

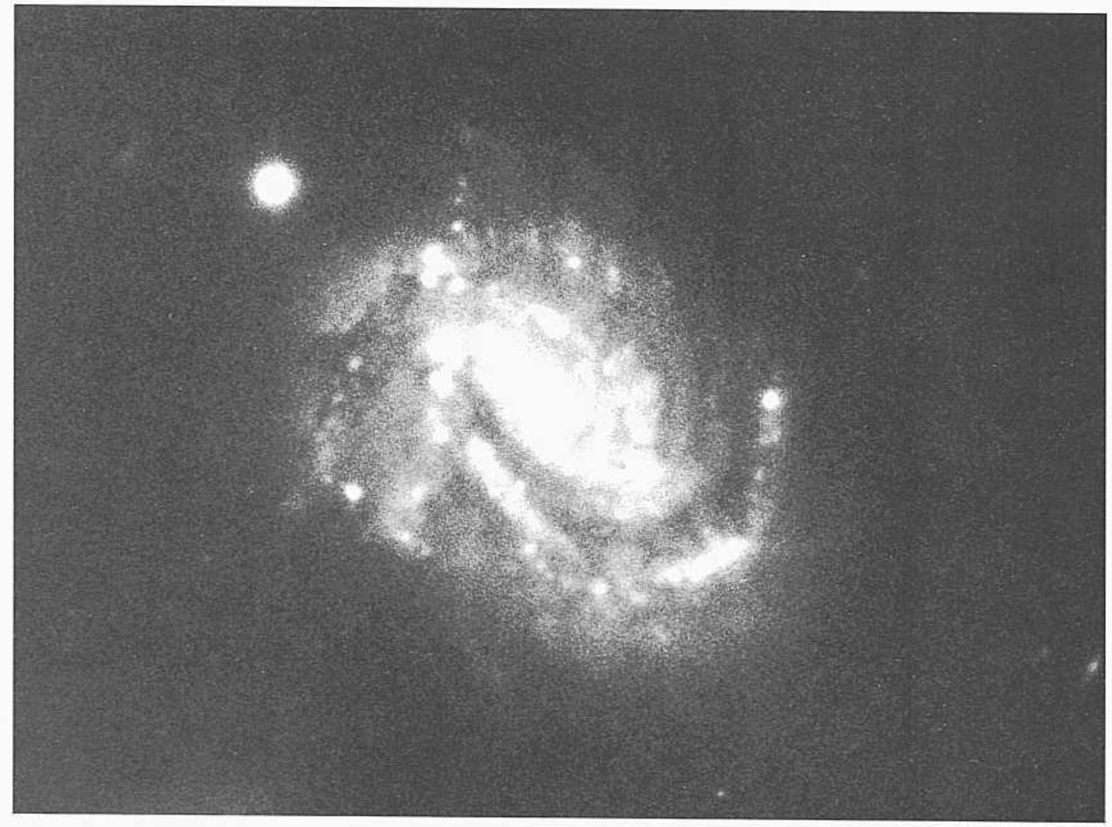
NGC 133 7 is seen only about 10° from edge on, making the spiral pattern difficult to trace. It is evident that the nucleus is small (the type, therefore, is Sc). The arm pattern is multiple, similar to the other highly inclined galaxies on this panel.

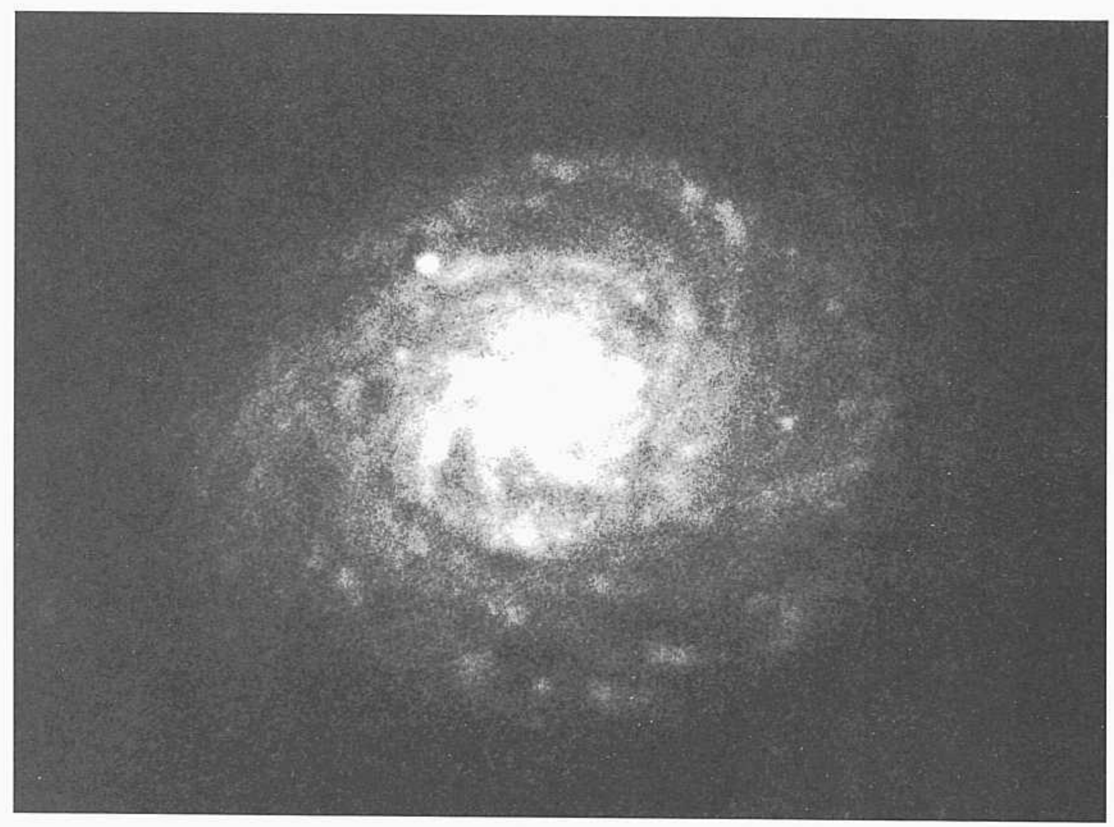
The redshift is v_{n_e} = 12 70 km s~'.



PANEL
231

PANEL
232





NGC 3294 **Sc(s)1.3**
H-2330-H
Oct31/Nov I, 1946
I03a0
30 mill

NGC 3294 and NGC 877 **to the right have** spiral arms of the grand **design type,** albeit **with a multiple-arm** outer **pattern. The two galaxies below** arc **of the flocculent** type whose **prototypes** are NGC 488 and NGC 284 i .

The one **highest-surface-brightness** arm **which** starts at the center in an (s)-type configuration can be traced for a full I 1/2 revolutions outward before it fades below detectability on this 100-inch Hooker Telescope **plate. The corresponding** opposite arm can **be traced for a** whole revolution, **which** is unusual.

The redshift of NGC 3294 is 1566 Um s"'.

NGC 4899 **Sc(s)I-II** **triplet**
CD-1842-HB
April 2/3, 1981
103aO + GG385
75 **min**

NGC 4899 is the **middle** galaxy of a wide triplet, **with** NGC 4891 **(SBbc; panel** 205) **to the** north by 30' at a redshift of v_o = 2418 km s~^{1}, and NGC 4902 **(SBb;** panel 162) to the south by 34' at a redshift of v_0 = 2426 km s~\ The redshift of NGC 4899 **ist>$_0$ = 2437 kms'.Atthe** mean redshift distance of 48 Mpe, **the** projected linear separations of NGC 489 1 and NGC 4902 from NGC 4899 are 419 **kpc** and 475 **kpc,** respectively. The group is of a **similar** size to the Local Group.

The arms are flocculent. **of the** NGC **284] type.**

NGC **877** **Sc(s)I-II** **group**
PH-7531-S
Nov 4/5, 1978
I03a0 + GG13
15 mill

NGC 877 **is the brightest galaxy in *a* field of** other **Dreycr** galaxies **(NGC** 870. 87 I . 1176. and 877) within I 2' of each **other,** ll seems likely **thai** at least sonic **of these form** a physical group. **The** r,, **redshifts are** similar at **3830** km s^{-}' **for NGC** 87 **I** (low-surf acc-brighlness Sc **at** 8.-1' **separation), 4006 km a"^{1}** for **NGC** 876 **(edge-on S0$_3$? at a separation of 2.2'). and 4010 km s^{-1} for** NGC 877 **itself.** At **the** mean redsbifi **distance of 79 Mpc (// = 50), the projected** linear separations of NGC 87 1 and **NGC 876** from NGC 877 arc **193** kpc and 50 kpc-. respectively.

The arms in NGC 877 are semi-massive in the sense **of Reynolds (1927a,b). The** arm pattern is **of the** grand design, although **not** prototypical.

NGC **4047** **Se(s)I-II**
PH-7642-S
April 28/29, 1979
103aO
12 **min**

The exquisitely line, multiple-spiral **pattern** of NGC 4047 is similar to **the** MAS patterns **in** NGC 488 and NGC 284 **1 but** is **farther** along the classification sequence. A **better match,** later in the sequence but still earlier than NGC 4047. is with **NGC** 5055 (She: Hubble Atlas, p. Z5; panels 19 **1.** S5 **here)** and NGC 352 1 (She: Hubble Atlas, p. *15;* panel 188 here).

The redshift of NGC 4047 is v_o = **34** I 6 km s^{-1}.

The six galaxies on this panel and the four on the next complete the Sc section of luminosity class I-II. Most are of the grand design type, but many have more than two arm fragments in the outer regions.

NGC 3888 **Sc(s)I-II**
PH-7635-S
April 28/29, 1979
103aO
12 min

The **high-surface-brightness** parts of each **of** the **two** inner **luminous** arms in NGC 3888 begin a* dust lanes near the center. They become luminous after about a **quarter** of a **turn** from the center. The arms arc thin and do not branch into as many multiple fragments outward as in the prototype MAS pattern of Ml 01. The pattern in NGC 3888 is primarily two-armed throughout.

The redshift is v_o = 2454 **km** s^{-1}.

NGC 4651 **Sc(r)I-II**
H-2534-H
May 4/5, 1948
103aO
30 miii

NGC 465 1 is in the Virgo Cluster region, 4° north of NGC 4486, which is near the center of Virgo **subcluster** A. This position is just outside the survey area for the Virgo Cluster Catalog **(Binggeli, Sandage,** and Tammann 1985), so that NGC 465 I is not listed in the VCC.

Four crossings by the arms of the major axis on both sides can be counted. The arms are thin and well **defined, requiring** the early luminosity classification.

The small redshift of v_o = 723 km s^{-1} **indicates, but** does not **require,** a small redshift **distance** of 14 **Mpc (m** - *M* = 30.8) (// = 50) because the resolution into stars and **1III regions** is similar" to that **in** Virgo Cluster **spirals** such as NGC 43 2 1 . The large velocity dispersion of the Virgo **Cluster** members **accounts** for the small observed redshift of NGC 465 1 . despite its large indicated **resolution-distance** of *m* — *M* of about 3 1.8.

NGC **237** **Sc(s)I-II**
PH-7833-S
Sep 3/4, 1980
103aO
12 min

NGC 23 7 is a two-armed spiral where each arm can be traced for nearly a whole revolution, causing two crossings of the major axis on each side. Faint spiral fragments from mild branching also exist in the outer regions.

The redshift is v_0 = 4308 km s~'.

NGC 753 **Sc(s)I-II** **Racine wedge**
PH-7850-S
Sep 4/5, 1980
103aO
12 min

The spiral pattern is extremely regular in the inner region of NGC 753 where the two grand design arms of very high surface brightness originate. The regularity of the **pattern** is similar to that of the inner arms of NGC 1566 (She; panels 171, S5), which is one of the most symmetrical galaxies in the RSA.

The arms branch into well-defined fragments at the place where the surface brightness of the principal arms decreases rather abruptly after about three-fourths of a turn.

The redshift of NGC 753 is *v,,* = 5145 km s^{-1}. The absolute magnitude is bright at *Mg* = **-22.7, similar to** M_B **=-22.3** for NGC 1566.

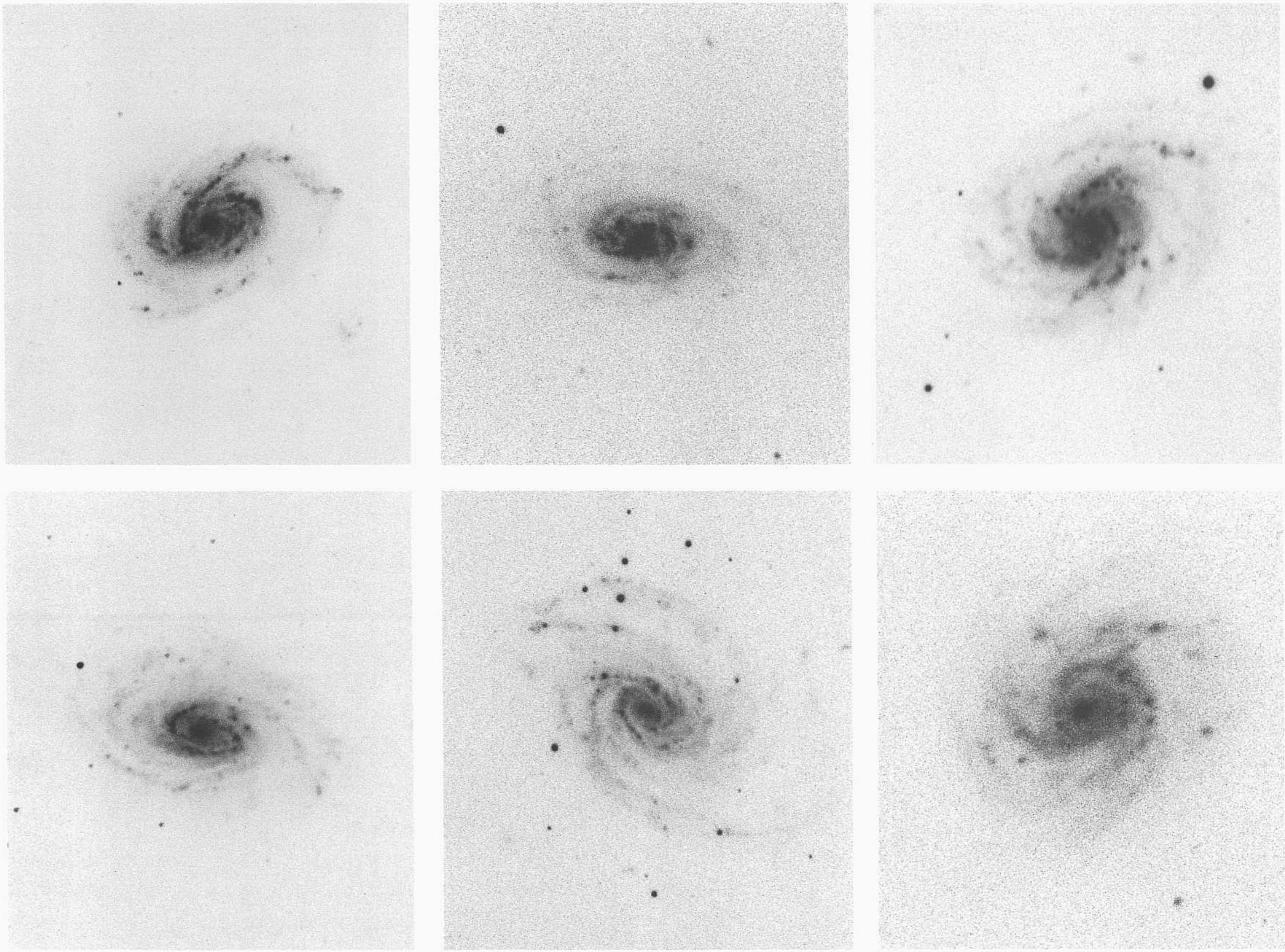
NGC 4152 **Sc(r)1.4** **VCC 25**
CD-2137-S
March 22/23, 1982
103aO
50 min

NGC 4152 is listed in the VCC. though no decision is given there on membership. It is located in the extreme northwestern corner of the survey field. The redshift is large, at v_o = 2055 km s^{-1}, but is not higher than the upper **redshift** cutoff of v_o = 2 7 00 km s^{-1} adopted in the VCC for cluster membership (justified by a symmetrical velocity distribution), with the low-velocity cutoff observed to be at v_o = —700 km s^{-1} (Binggeli, Sandage, and Tammann 1985).

The arms in NGC 4-152 start **from** an internal ring similar to the pattern in NGC 309 (Hubble Atlas, p. *32:* panel 221 here).

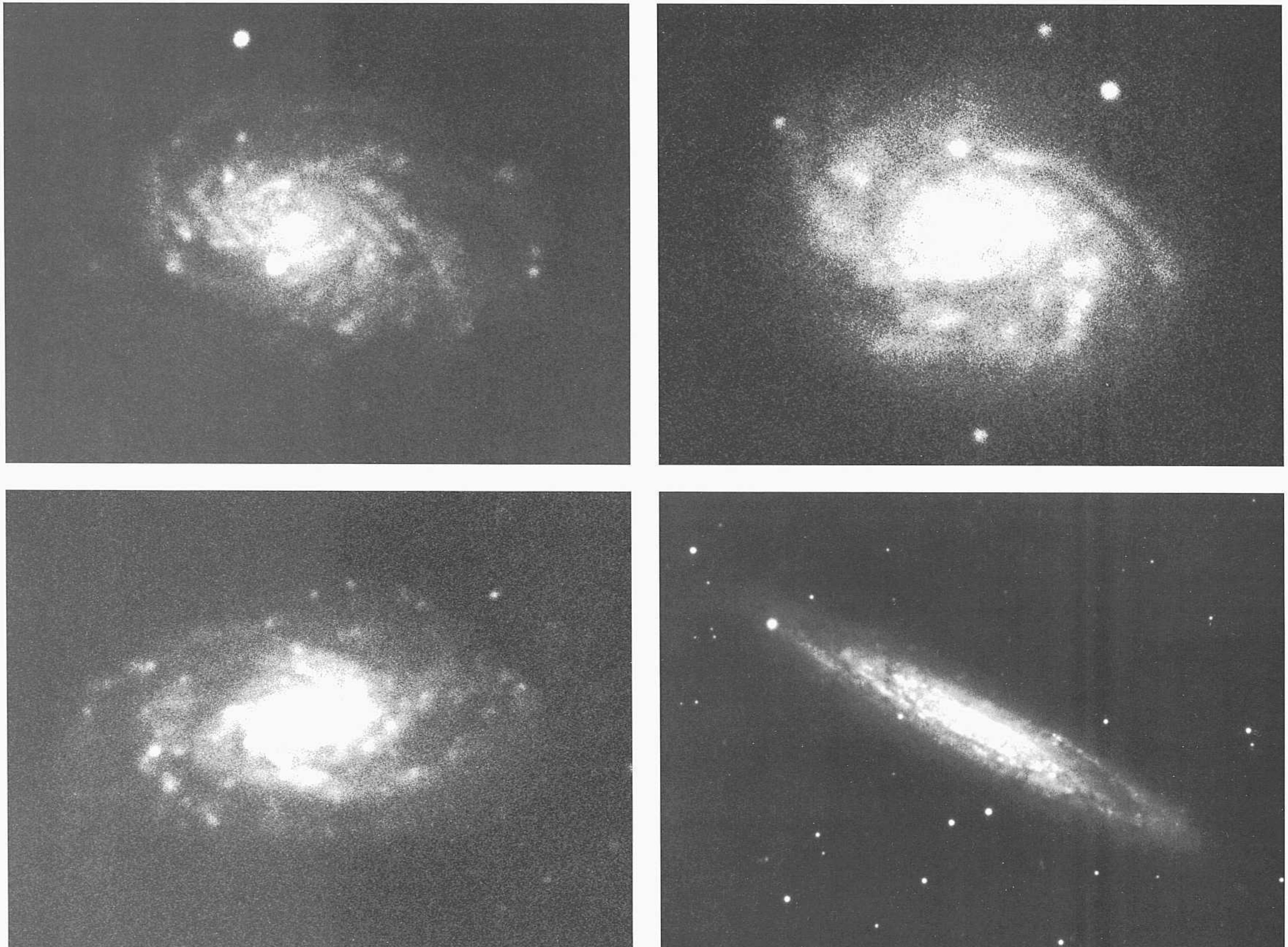
NGC 3512 **Sc(rs)I-II** **group**
H-2347-H
Nov **27/28, 1946**
103aO
30 min

NGC 3512 is at the center of an apparent group of three **bright** galaxies; the other two are NGC 3504 (Sb/SBb; panel 169) at an **angular** separation of 12', v_o = 1480 km s^{-1}, and NGC 3515 (She, not in Lhe RSA) at an angular separation of 13.7' but whose redshift is presently unknown (e. 1990). The redshift of NGC 35 12 is v_0 = 1340 km s~J . At the mean redshift distance of 2 7 Mpc, the **projected** linear **separation** of NGC 35 12 **and NGC** 3504 is 96 kpc.



PANEL
233

PANEL
234



The four galaxies on this panel complete the Sc I-II luminosity class illustrations.

NGC 4162 Sc(i-)MI
H-2390-H
Feb 23/24, 1947
103aO
30 niiii

The spiral pattern in NCC 4 162 is multiple-armed throughout the image. There arc not two principal arms from which a multiple pattern develops; rather, the arms begin tangent to an inner disk at many places on the rim.

The redshift is v_0 = 248] km s"'.

NGC 3370 Sc(s)I-II
PH-8019-S
Feb 3/4, 1981
103aO
12 min

Four arms (three of which are bright) emerge from the center, forming the multiple-arm pattern on the outside.

NGC 1667 **Sc(r)I-II**
PH-7896-S
Nov 6/7, 1980
I03a0
\'2 min

The three main spiral arms begin tangent l> a high-surface-brighlness inner ring similar !> the pattern in NGC 309 (panel 22 1).

The redshift is v_0 = 1562 km s '.

NGC 3936 Se(s)MI
CD-769-S
Feb 21/22, 1979
103aO + GG385
-15 miii

NCC 3936 is viewed within ')° of edge on, making assessment of the spiral pattern and the luminosity classification uncertain. The nucleus is small, indicating the Sc (-lass. The arm fragments are narrow and well separated, suggesting the early luminosity class.

The redshift is v_n = 1 738 km s~l.

THE Sell SUBCLASS

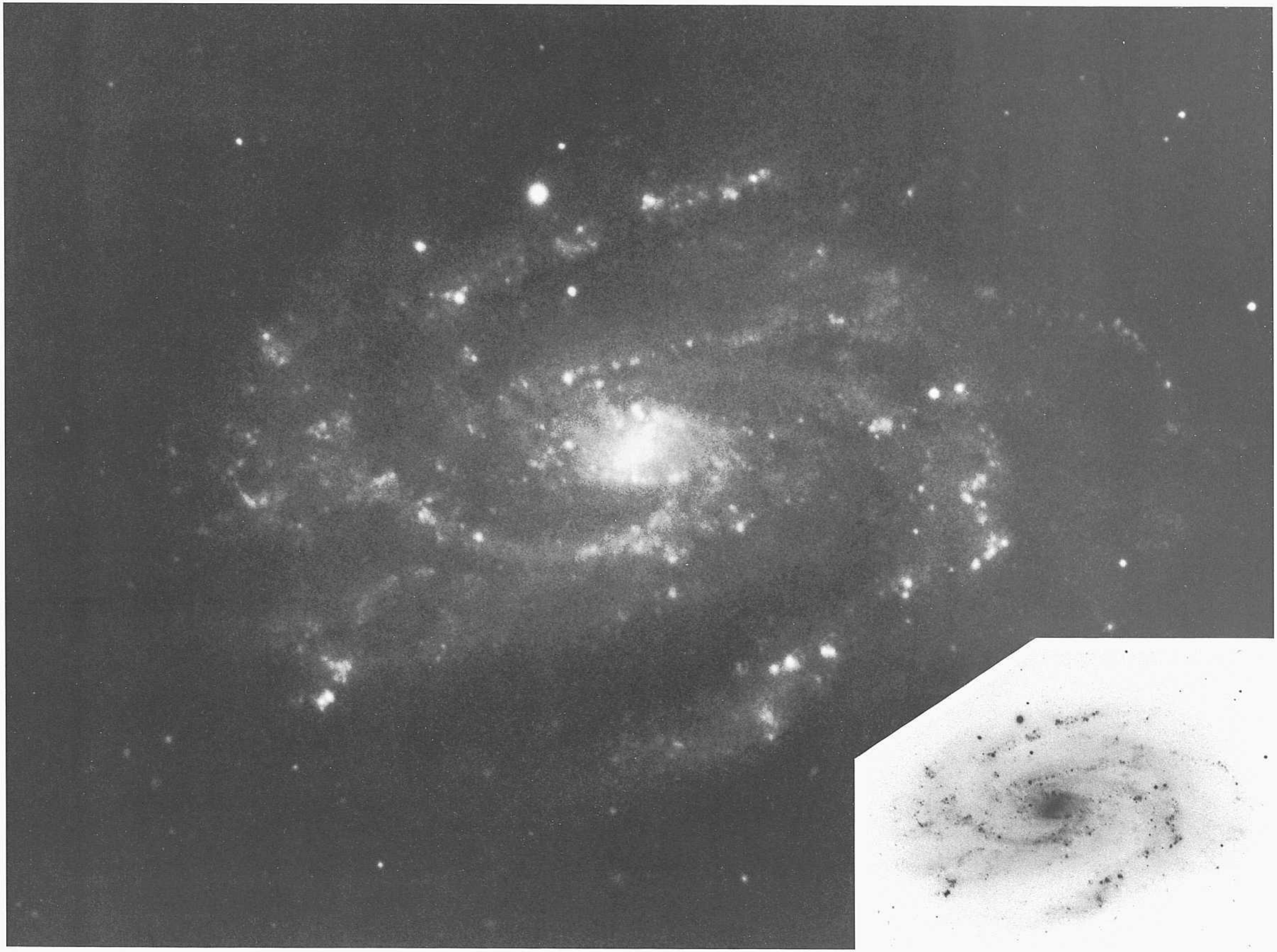
S ell galaxies constitute the largest subclass of the Sc section. The RSA galaxies of this type and luminosity class illustrated on the next 24 panels are arranged in two parts. Those where the spiral pattern is predominately of the grand design type, dominated by two principal arms, are set out on the next six panels. Galaxies of the multiple-armed type, some grand design and others of the filamentary (flocculent) type, are on the remaining 18 panels, 241-258.

NGC 4145 **Sc(r)II** Ursa Major Cluster
PH-8028-S
Feb 3/4, 1981
103aO
12 mill

NGC 4145 is a **large-angular-diameter** (O95 = 5.8') spiral. **It is** one **of the principal** galaxies in the Ursa Major Cluster, which is dominated by spirals. The mean redshift of the cluster is <!•,> = 980 km s~ with a dispersion of about 100 km s \ The redshift of NGC **4145 is** v_a **- 1030 km** s^{-1}.

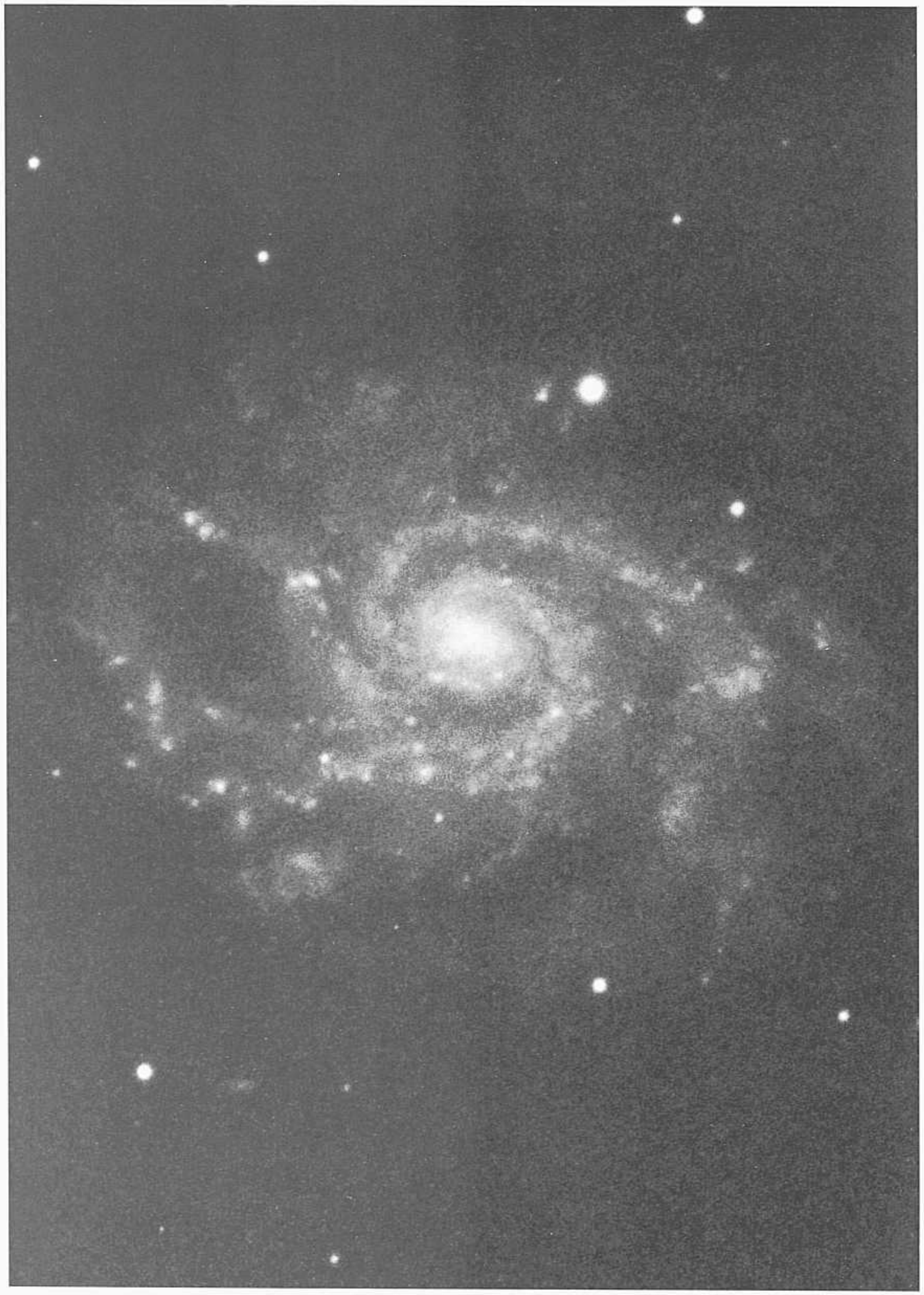
The two principal spiral arms begin on the rim of an inner disk, across which there is a weak bar. Each of **the** arms begins to fragment after about half a revolution, **but** two main fragmented extensions of the original segments can be traced for an additional half rotation.

The arms are well resolved into individual **brightest** stars beginning at about B = 22. This is somewhat brighter than in the giant **spirals** of the Virgo Cluster, but much fainter than in the galaxies of the Ml 01 Group and the **very nearby** NGC 4395 Group. Many HII regions also exist in the arms, the largest of which resolve at about the 2" **level.**



PANEL
235

PANEL
236



HA 85-1 = A0509-11 **Sc(s)II**
CD-720-S
Feb 1/2, L979
103aO + GG385
45 **niin**

The **spiral patterns of** both **galaxies on** this page arc similar.

The two principal arms in HA 85-1 start near the center **at opposite edges** of the **small** central region. **Each** arm is well defined **for** more than **half** a revolution. Major **branching** occurs in one of the arms beyond that point, **giving four** arm segments on one side. **The branching** is less complete on the other side.

The **redshift of HA** 85-1 **is** v_0 = 2063 km s^{-1}. The evident HII regions are bright but **are** unresolved at the 1" level. Individual **brightest** stars are **not** identifiable **because** of their faintness **at** this distance.

NGC3052 Sc(r)II
CD-8U-S
Feb 26/27, 1979
103aO + GG385
45 mill

The arm **pattern of NGC 3052** has very **high** surface **brightness over almost** all **the image.**

Each of the two principal arms **near the center** are highly symmetrical **for the first quarter-turn.** One **of the inner** principal **arms** blanches **into two major** arms, which retain their thinness and good definition for **another** half **revolution. The opposite** arm only widens **without** becoming double. As a **consequence, the** outer spiral pattern has three major **arms.**

The redshift is v_0 = 3364 km s^{-1}. No stars **or** HI I regions **are individually resolved.**

NGC **3181** **Sc(r)II.2** **panel S5**
PH-7993-S
Feb2/3, 1981
103aO
12 **niin**

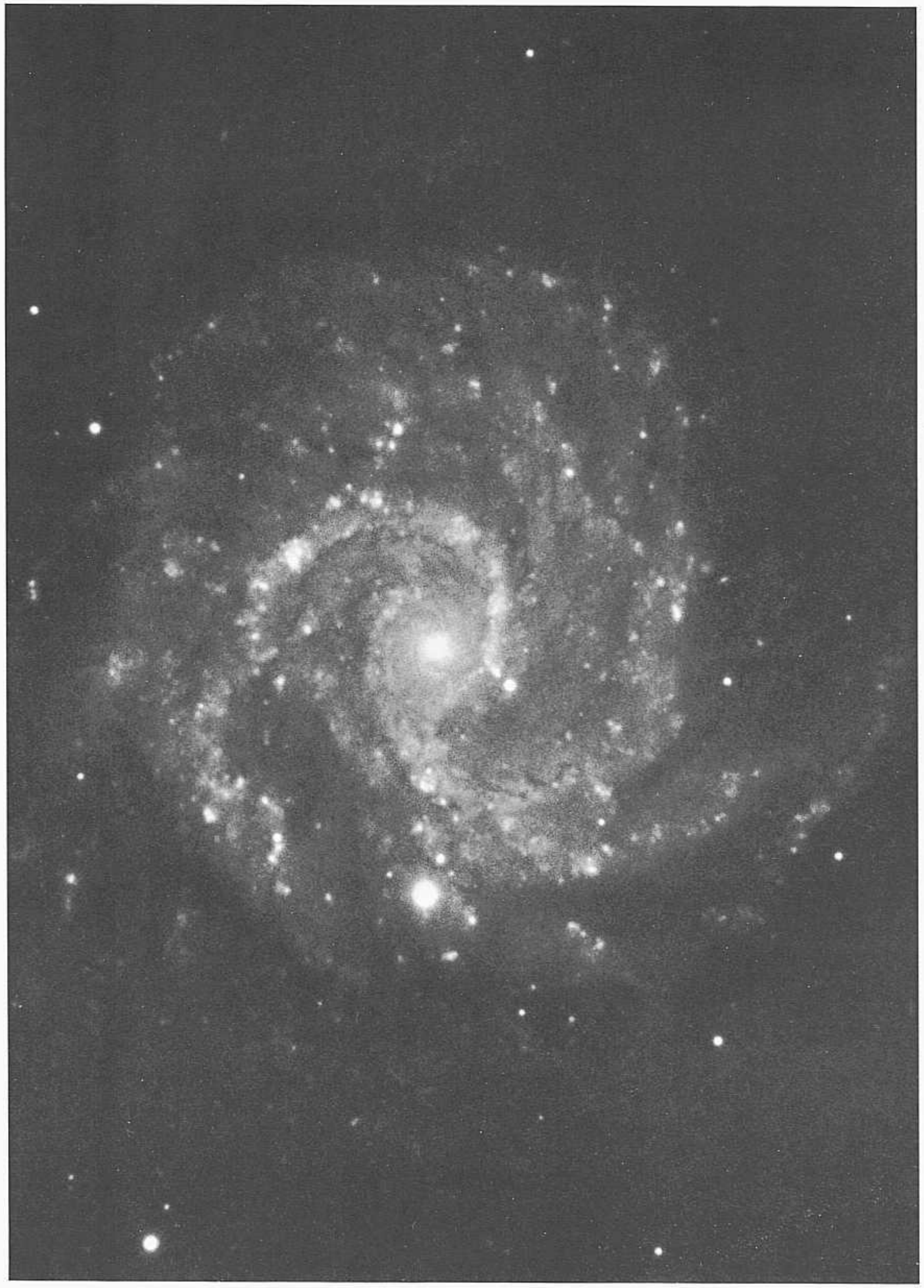
NGC 3184 is **near** enough that individual stars **begin to** resolve **out of** the **background** of the arms **at** about B = 22. hut **the** separation of **the** stars from **the** many **H**11 regions will **require** the standard identification procedures comparing Met and yellow images. The redshift of NGC 3184 is v_0 = 60 7 km s"'.

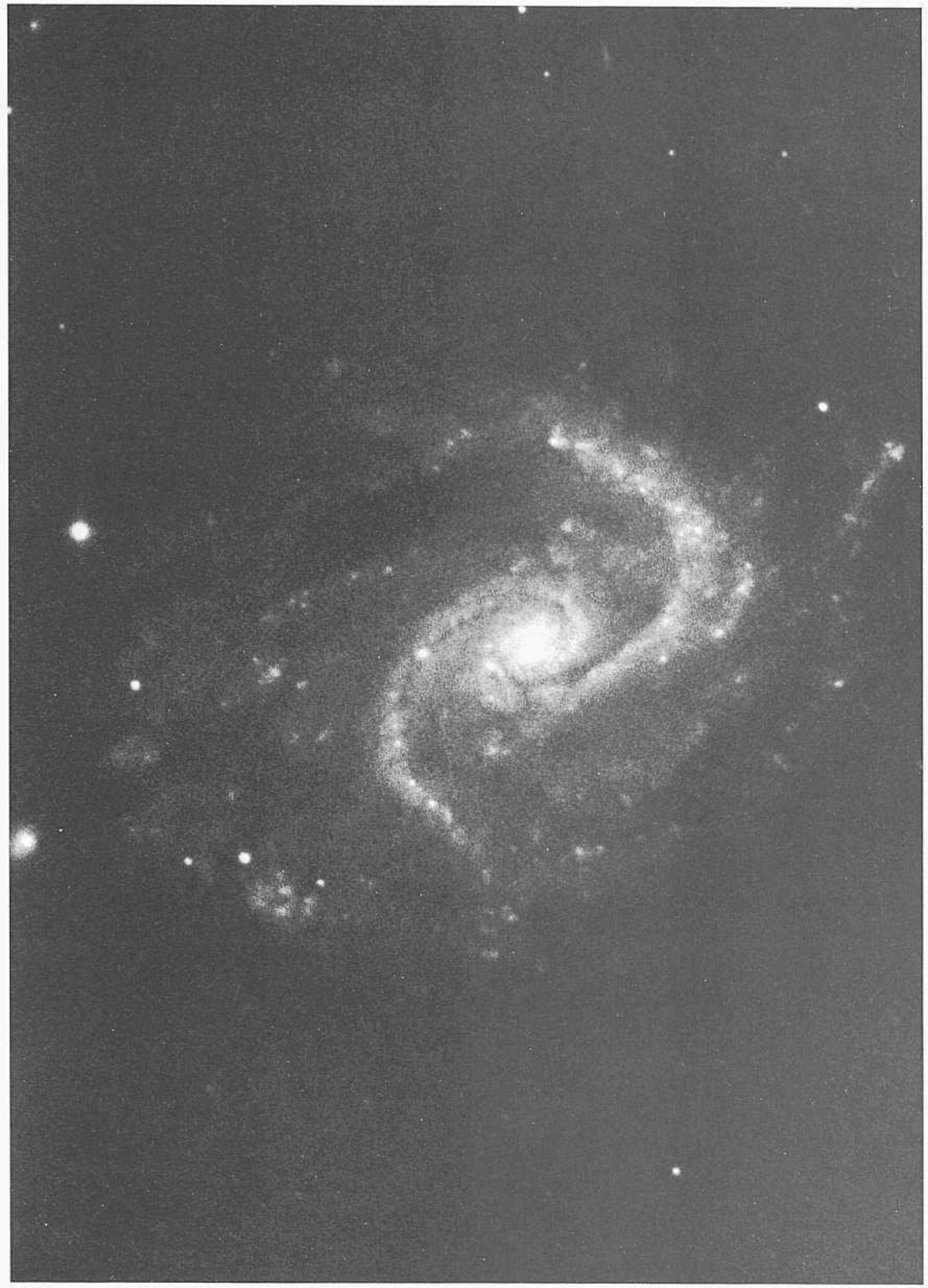
The arms begin tangent to the rim of a small, smooth inner disk, within which two faint spiral dust lanes start at **the** center and connect with the beginnings of the two main luminous arms. The luminous arms branch into several thick **fragments** that spread to cover much of the area of the outer disk. Dust lanes exist throughout the pattern.

NGC 895 Sc(s)II
CD-1589-S/Br
Aug 11/12, 1980
103aO + GG385
45 niin

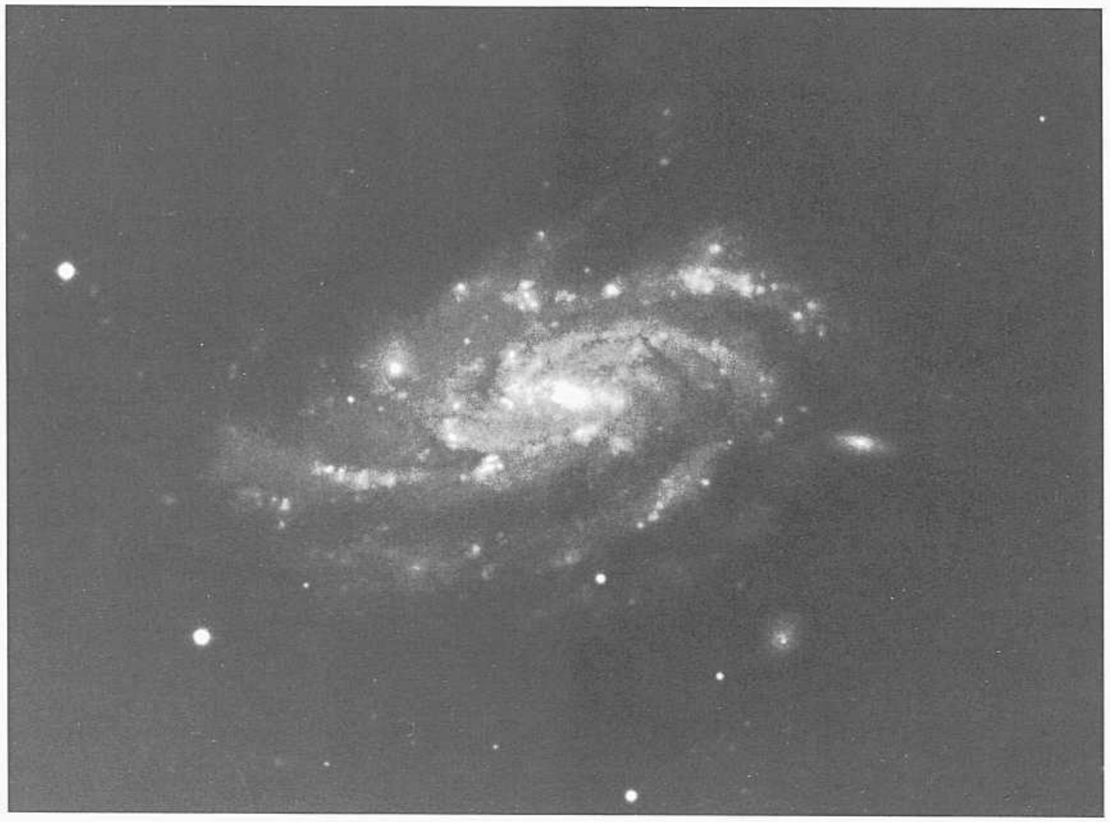
The two principal arms can be traced into the center. Well-defined (opaque) dust lanes exist inside these high-surface-brightness dominant arms throughout the region where their surface brightness remains high. **Low-surface-brightness** spiral arm fragments exist over the outer area of the disk on the outside of the principal arms.

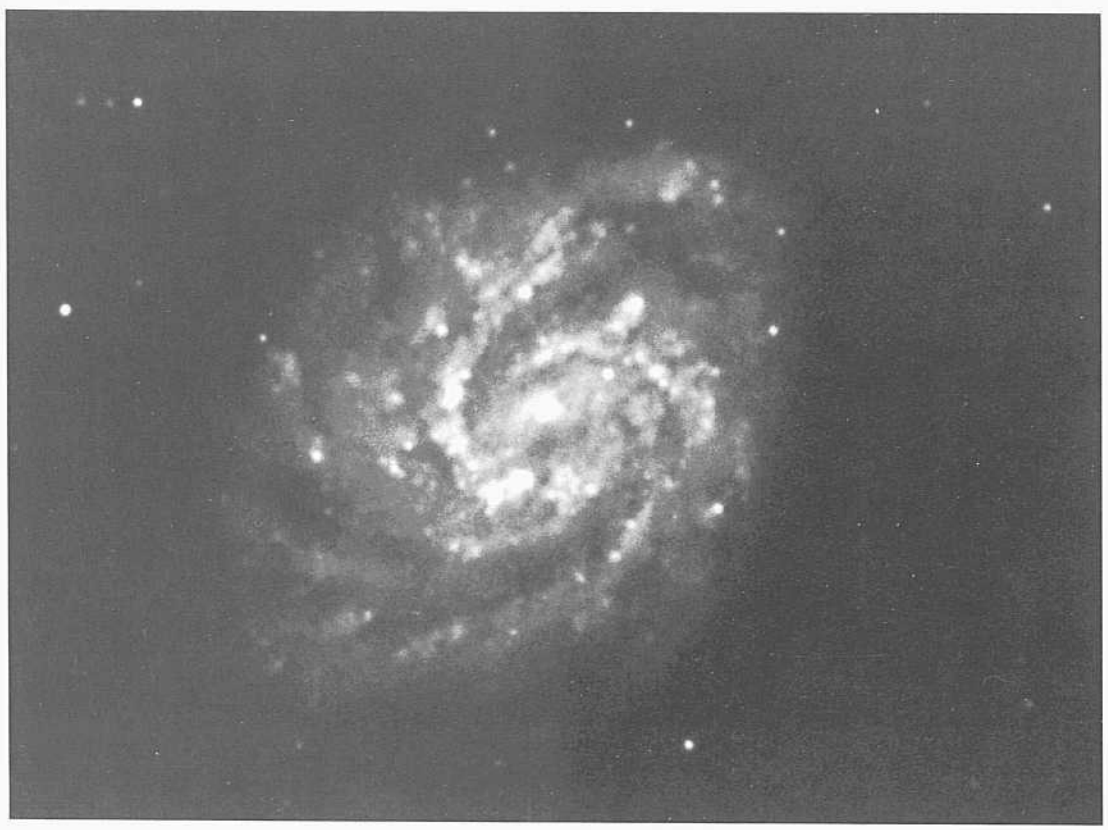
The redshift **is** v_n = **2383** km s^{-1}.





PANEL
238





The separate arms in each of the galaxies on this panel are easy to trace. Their geometrical entropies are low; hence the moderately early luminosity classes near II for each is required.

NGC 578 Sc(s)H
CD-1523-S/Br
Aug 5/6, 1980
103uO + GG385
15 niin

Like NGC 3052 two panels back, NGC 578 is a three-armed spiral. The third arm is not well defined near the center. It becomes prominent, having the highest density of II11 regions of the three arms, only in its outside segment.

The two largest HII regions are complex, probably composed of overlapping separate centers. They appear to resolve (core + halo) at about 1.5". The redshift of NGC 578 is $v_{t)}$ = 1675 km s"'.

NGC 7418 Sc(rs)1.8 Gins Gr?
CD-1161-Br
Aug 22/23, 1979
103aO + GG385
45 niin

NGC 7418 may be a member of the loose Grus Group, of wide extent and mixed morphology (de Vaucouleurs 1956a; Shobbrook 1966; Sandage 1975b, 1978). The mean v_o redshift of the group is about 1580 km s^{-1}. The redshift of NGC 7418 is v_0 = 145 1 km s"'.

Four principal arms exist, yet the galaxy is of the grand design type.

IC L954 Sc(s)II.2
CD-672-Br
Jail 24/25, 1979
103aO + GG385
15 mill

The arms in IC 1954 are massive in the sense of Reynolds (I927a.b). As in NGC 578 to thi' left and NGC 3 0 52 on panel 236, there are three principal arms, two of which start together OIl one side of the center; the other starts on the opposite side and remains single for the two-thirds of a revolution that can be traced. Opaque dust lanes exist on the Inside of each of the three major arms.

The redshift of IC 1954 is $i>_o$ =905 km s~'.

NGC 1084 Se(s)II.2 HA, p. *29*
PH-7915-S
Nov 7/8, 1980
103aO
2 min

The surface brightness of the arm pattern in NGC 1084 is exceptionally high. The well-exposed image here was obtained in only a two-minute exposure with the Paiomar 200-inch Hale Telescope; it is nearly overexposed even so.

The arms are massive in the sense of Reynolds (1927a.b). There are three arms, as in IC. 1954 and NGC 578 on this panel and NGC. 3052 on panel 23d. The best-developed oi' the arms is on one side alone. The other two arms on the opposite side in the outer region start as two thin, luminous threads that themselves begin on opposite sides of the center but overlap after unwinding by half a turn, after which the spiral pattern on that side is conluscd.

The redshift of NGC 1084 is ,<„ = 147!! km s^{-1}.

The four galaxies on this panel all have spiral patterns of the grand design rather than filamentary (floccular) type, examples of which follow on panels 241-258.

NGC 5861 Sc(s)II
CD-1381-S/Br
March 20/21, 1980
103aO + GG385
55 miii

The spiral pattern in **the inner** part **of** NGC 5 861 is one of the most regular in the sky.

One **of** the two main arms can he traced from its beginning at the center for nearly 11/2 revolutions without **branching.** The other can be traced for one revolution, at which point it breaks into an outer fragment and a **moderately** chaotic pattern begins. If this outer **pattern** were absent, the luminosity class would be I rather than 11.

The redshift is v_0 =1725 km s^{-1}.

NGC 6946 Sc(s)II
PH-3832-S
Aug6/7, 1961
103aE + RG2
120 min

NGC 6946 is among the closest galaxies to the Local Group as judged by the large angular extent (D95 = 18'). the moderately easy resolution into brightest stars beginning at about B = 21 . and the large angular size of the several largest HII regions at a core + halo diameter of I 0". The resolution into stars is not as easy as in Ml 01 . whose **distance** modulus is 29.3. **or** in members of the NGC **4395/NGC** 4214 Group al $m - M$ **of** about 28.5. but **the** Galactic latitude of NGC 6946 is **low** at b = 12°. opening the **possibility of** appreciable Galactic absorption.

Note that **the** plate used here is red sensitive, **favoring the** detection of **HII** regions **rather** than **individual** brightest blue stars.

The redshift of NGC 6946 is low **at** u_0 =3 36 km s^{-1}.

NGC 5899 **Sc(s)II**
PH-7648-S
April 28/29, 1979
103aO
12 min

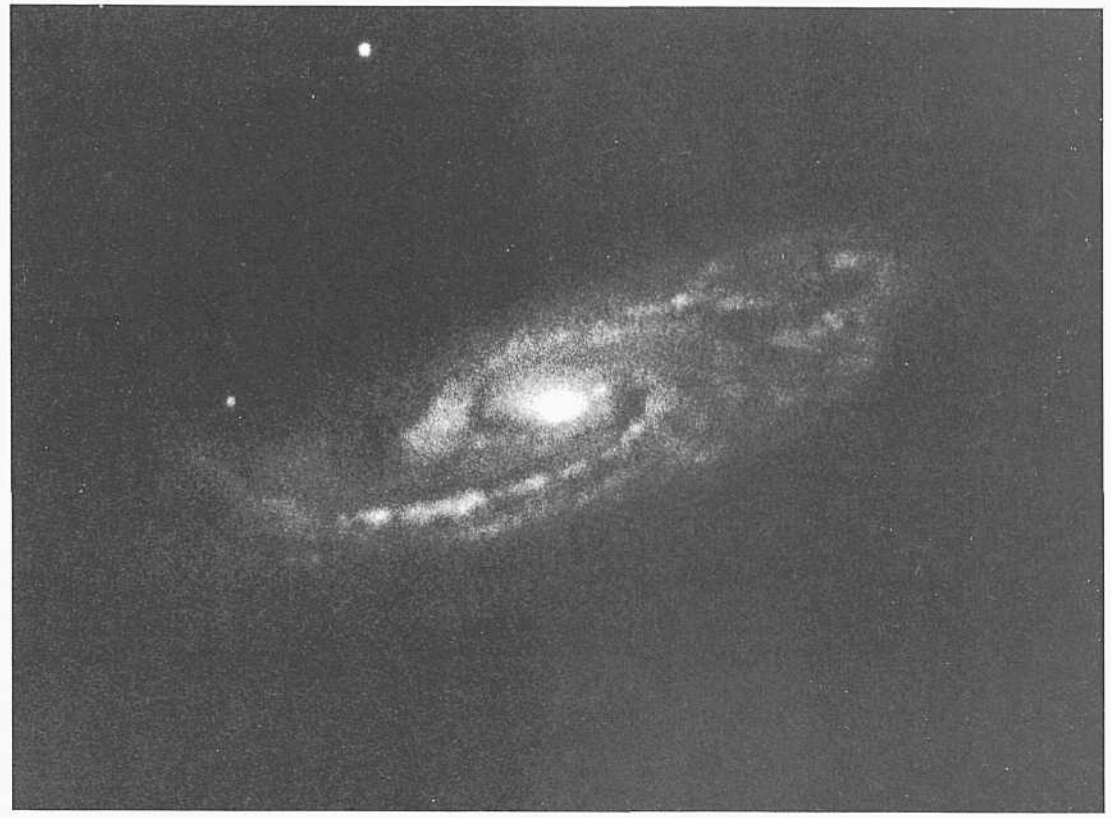
The pattern **defined** by the two **principal** arms of this **grand design** spiral is highly regular. The arms are of high surface brightness, they are thin, and they can each be traced for three-quarters **of** a turn without branching. Beyond that point, one of the arms branches **in** a way similar to **the** pattern in NGC 5861 at the left.

The redshift of NGC 5899 is v_n = 2657 **km** s^{-1}.

NGC 5756 Sc(s)II panel 257
CD-1471-S/Br
May 10/11, 1980
103aO + GG385
45 niin

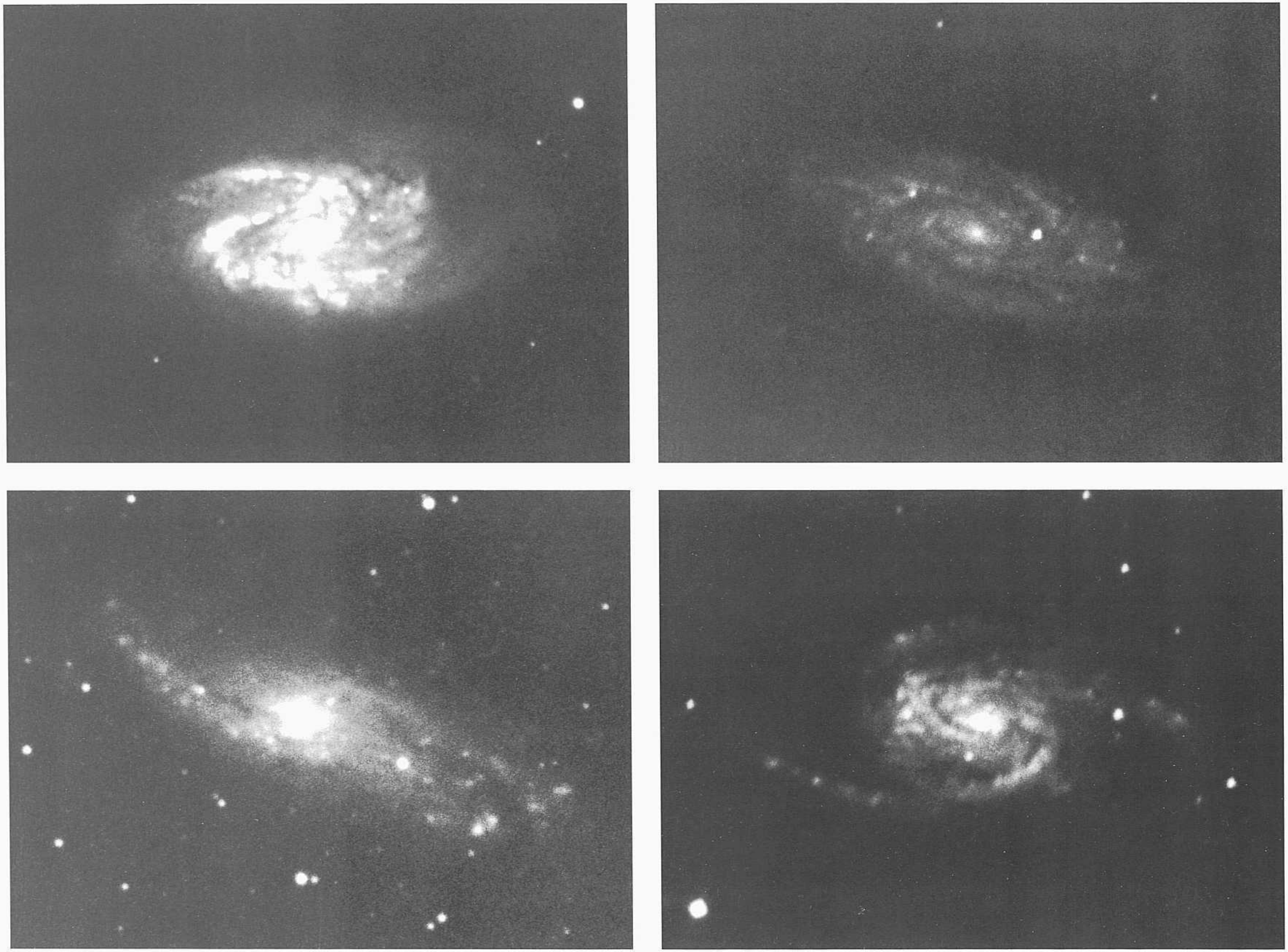
This galaxy, shown also in a deeper print on panel 25 7. has a very faint set of regular, smooth outer arms which resemble the outer pattern in the Sa galaxy NGC 1350 (panels 71, 88, S3). These outer arms of exceedingly low surface brightness are extensions of the two principal **(s)-type** inner arms shown in the low-contrast print here.

The **redshift of** NGC 575**6** is v_0 **= 202 5 km** s^{-1}.

PANEL
239


PANEL
240



The four galaxies on this panel finish the SII section of galaxies where the spiral pattern is Formed by two principal arms.

NGC 2964 Sc(s)II.2 pair?
PH-7603-S panel 251
April 3/4, 1979
HlaJ + GG385
30 min

NGC 2964 may form a physical pair with NGC 2968 (Amorphous or S0:i pec; panels 49. 337). at an angular separation of 6.2'. The redshifts are $u_o(2964)$ = 1292 km s⁻' and $u_o(2968)$ = 1576 km s~ʲ . If they are associated at a mean redshift distance of 29 Mpc (/•/ = 50), the projected linear separation of the pair is small at 52 kpc. which is the distance of the Large Magellanic Cloud from the Sun.

The arms in NGC 2964 are massive in the sense of Reynolds (1927a,b). The pattern is principally that of two arms, although a third, ill-defined broad arm pattern exists on one side. Opaque dust lanes exist on the insides of the two best-defined luminous arms.

NGC 406 Se(s)II.8
CD-2015-Bedke/Gregory
Oct 25/26, 1981
103aO + GG385
4-5 min

The spiral pattern in NGC 406 is not well defined. Although the luminosity class assigned in the RSA2 is II, the diffuseness of the pattern suggests the later luminosity class of II.8 given here.

The redshift is v_0 = 1326 km s~'.

NGC 4712 Sc(s)II
H-2286-H
May 30/31, 1946
103aO
40 mill

Although NGC 17 12 is in the same field as NGC 4 725 (Sb/SHIi: panel I 68), with an angular separation of 12'. the pair is an optical superposition and not a physical association. The redshifts are $u_o(4712)$ = 4332 knis'[1] and r,,(IT25) = 1167 km s"'.

The print here is made Irom a 100-inch plate taken with the Mount Wilson Hooker reflector before the mirror had regained thermal equilibrium from an earlier thermal shock due to rapid temperature change. On such occasions the plate glass mirror is warped and the star images are distorted.

NGC 6181 Se(s)II HA, p. *29*
H-1851-II
Aug3/4, 1937
Imp. Eel.
60 min

The spiral pattern of NGC 6181 is dominated by two principal arms having moderate geometrical entropy. The redshifl is v_o = 243 8 km s~'.

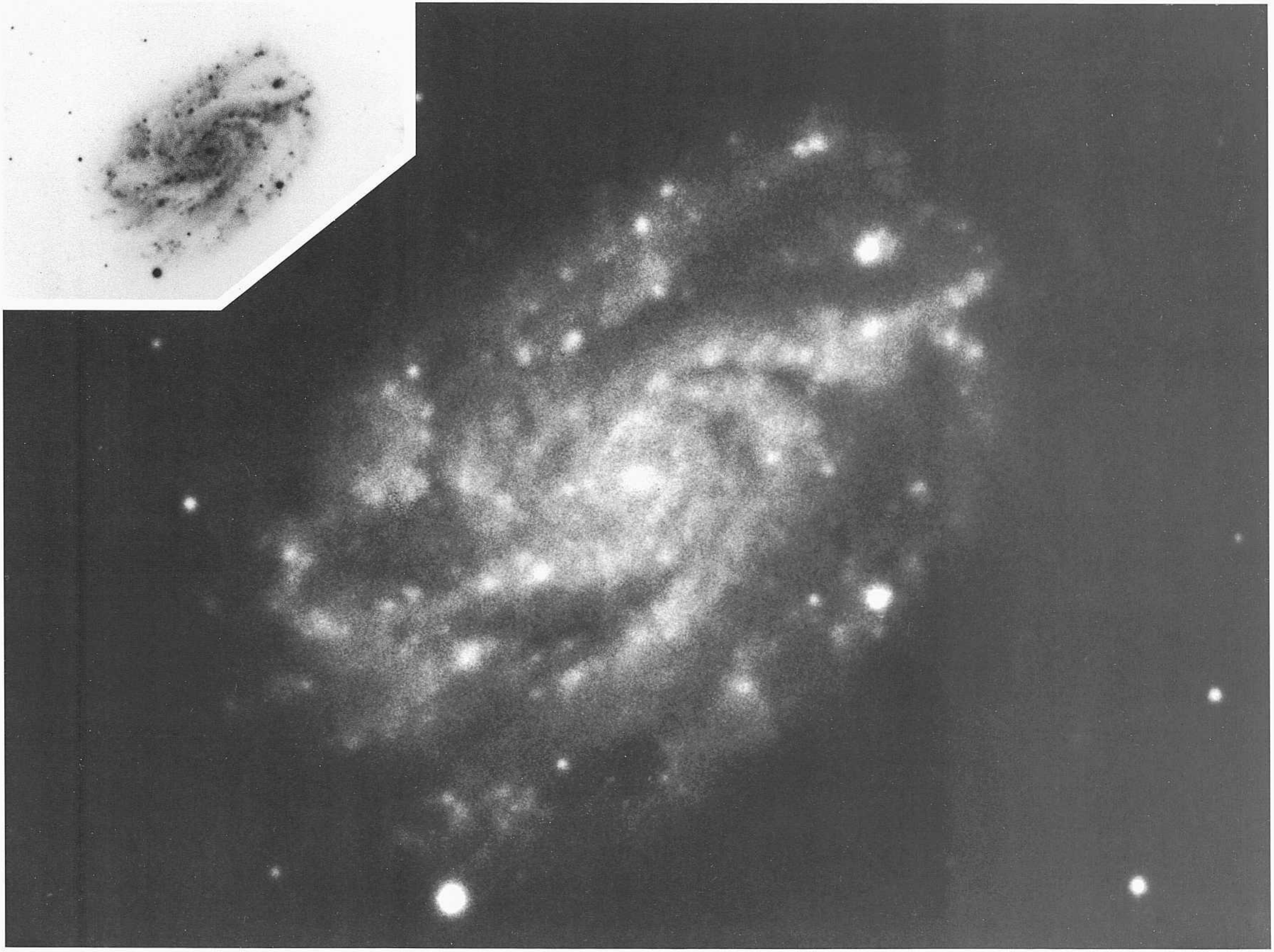
This page begins the section of the Sell galaxies having a primarily multiple-armed pattern. Some have arms of the grand design type; others have a flocculent design of the NGC 2841 (panels 142, S4, S12) type. Galaxies with multiple arms that are thin are on panels 241-247. Galaxies with thicker arms are on panels 248—253.

NGC 7689 Sc(sr)II
CD-503-S
Scp 27/28, 1978
103aO + GG385
45 mill

Each of the many arms in NGC 7689 begins tangent to a thin luminous inner ring close to the nucleus. The three arms on one side begin near one another on the ring, within about 1 5° in their position angles. The three arms wind outward and remain moderately well defined over half the outer disk, although one arm abruptly changes direction by about 120° and continues unwrapping. The arm pattern on the other side is more chaotic, becoming more difficult to trace. This may be an aspect effect where the far side is less visible than the near because of silhouetting effects against the background disk.

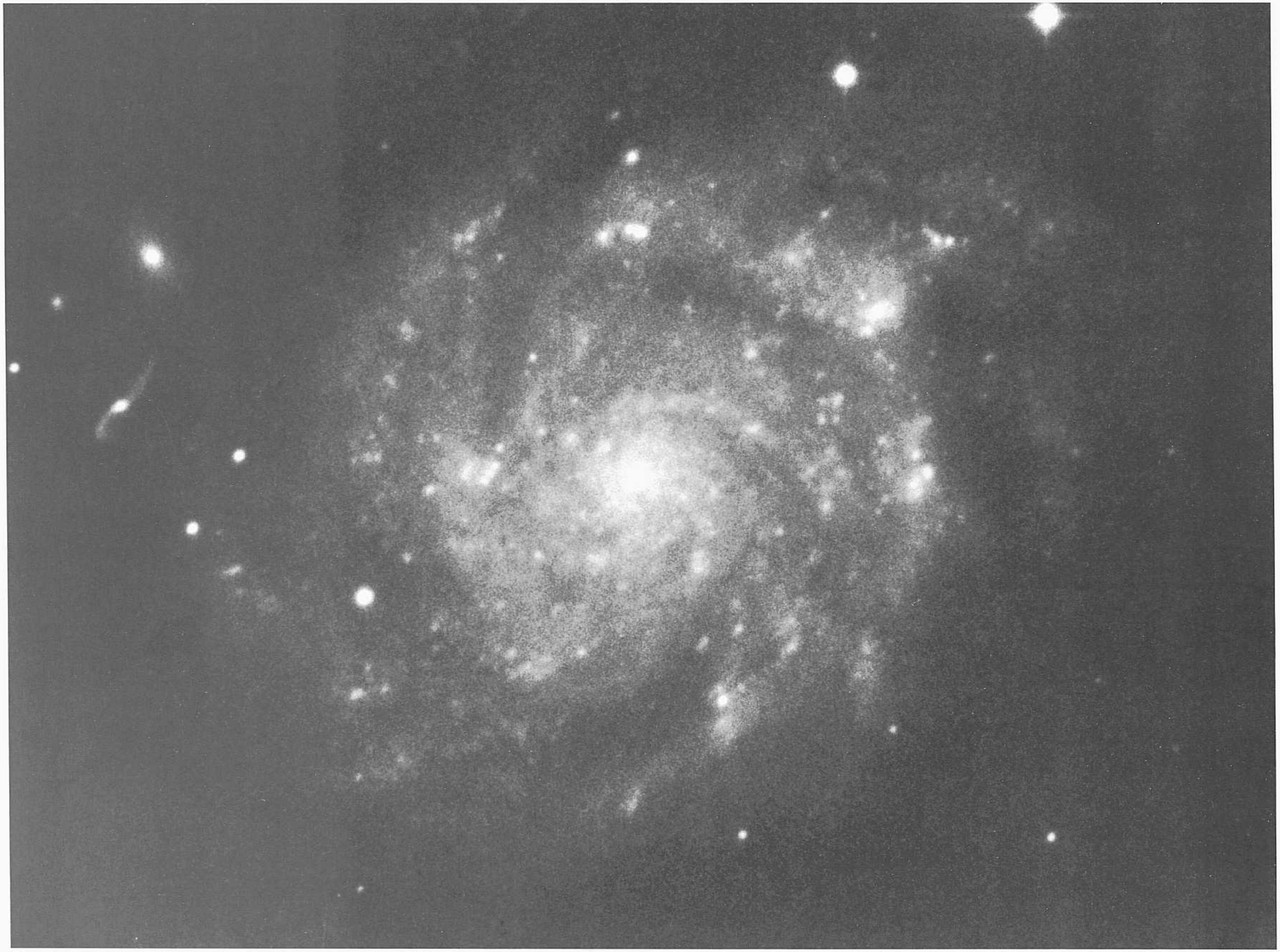
The arms are massive, covering an appreciable fraction of the disk area.

The redshift is $v_o = 1681$ km s^{-1}.



PANEL
241

PANEL
242



NGC 3423 **SC(B)IL2**
CD-1684-S
Jan 2/3. 1981
!03aO + GG385
15 mill

The multiple-armed Bpiral pattern in IN(»(! 3423 is similar **to thai in NGC 5457 (M101; Hubble** Alias, **pp.** *27.* ***31;*** **panel 218 here). There are no grand design major** arms; rather al least six arms can **IK* identified starting** nl **the** center, **existing over all** position **angles around the** image.

Brightest individual stars may **be beginning to resolve at about** ***B*** **= 2 1 . luil** they are **confused on this blue plate** with the **numerous 1111** regions. The largest **of these** regions have **core** + halo diameters **of about 2".**

The **redshift of** NGC 3423 is v_0 = **845 km** s^{-1}.

NGC 2763 **Sc(s)II**
CD-789-S
Feb 23/24, 1979
103aO + GG385
15 niin

The two galaxies on this panel have spiral patterns highly similar to that of M10] (Scl; panel 2 18).

Two principal arms in NGC 2 763 start near the center. After unwinding for about half a revolution, each arm branches into several segments, which themselves branch again until the outer region is filled with spiral fragments, most of which are of moderately high surface brightness. Many HI1 regions exist throughout the multiple arms, but individuals must be identified by the usual methods before the brightest stars can be isolated.

The redshift of NGC 2763 is v_n = 1 658 km s^{-1}.

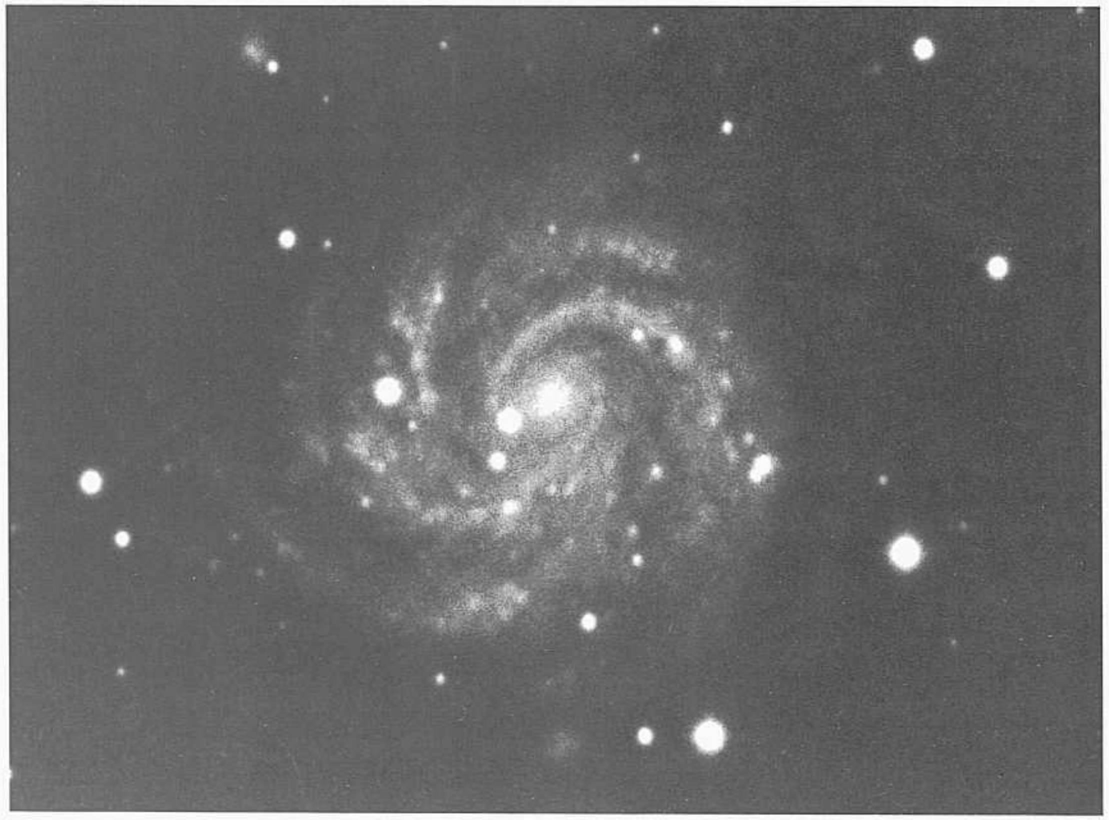
NGC 5085 Sc(r)II
CD-1849-HB
April 3/4, 1981
103aO + GG385
45 mill

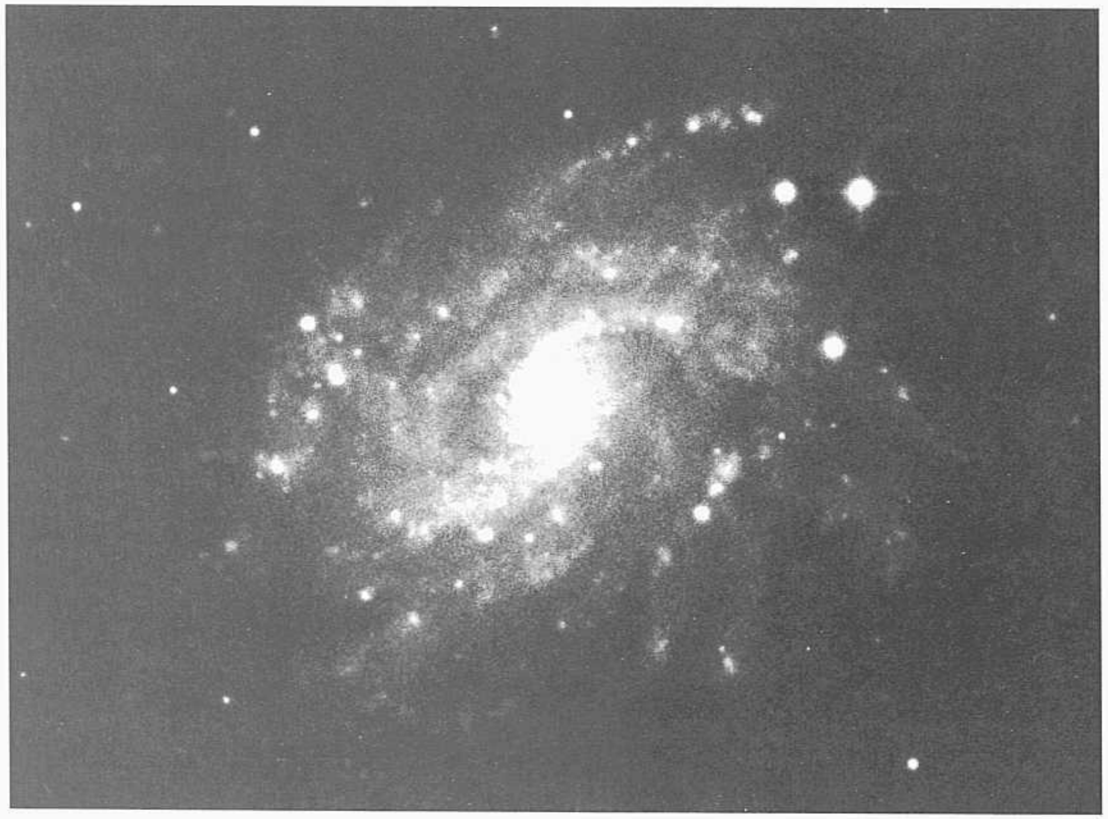
Two principal well-defined arms of low surface brightness begin near the center, tangent to the edge of a small central bulge. Prominent, regular dust lanes exist inside each of the two main arms over about half a revolution from their beginnings.

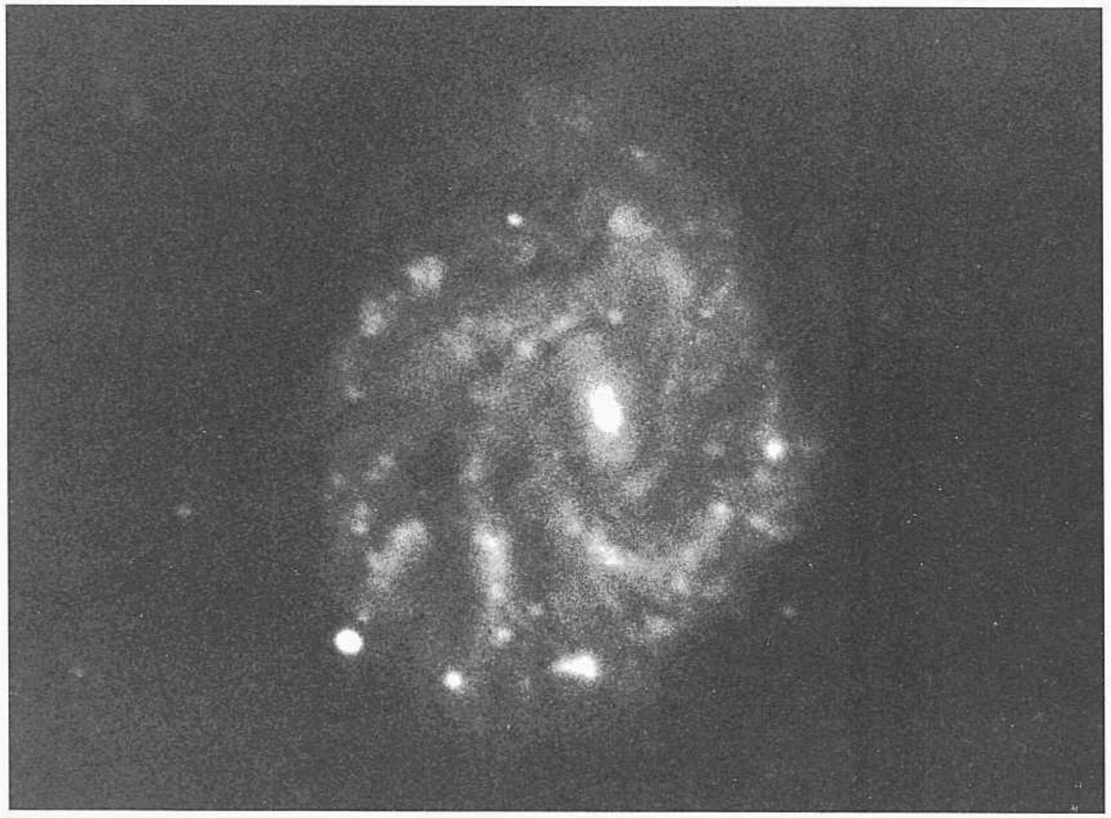
The outer disk is filled with spiral fragments, which originate not as branches of the two main arms but rather as dust lanes covering the disk, as in the NGC 2841 floeculent pattern. These lanes in the outer disk either turn luminous in short segments or are defined by a pattern of HII regions. The pattern is not chaotic, but, aside from the inner parts of the two principal grand design arms, the outer spiral fragments are difficult to trace.

The redshift is !;„ = 1720 km s"^{1}.

PANEL
244







The galaxies on this and the following panel continue the pattern of spiral arms that are thin and multiple.

NGC 5494 Sc(s)II
CD-1549-S/Br
Aug8/9, 1980
103aO + GG385
45 min

Two principal arms begin in NGC 5494 near the center on the rim of a small, relatively high surface brightness, smooth disk. They branch almost immediately into secondary arms, which remain of moderately high surface brightness.

The redshift is v_0 = 2461 km s^{-1}. The numerous H1I regions arc not resolved at the 1″ level.

NGC 2848 Sc(s)II triplet
CD-799-S
Feb 24/25, 1979
103aO + GG385
45 nùn

NGC 2848 forms an apparent triplet with NGC 2851 ($S0_3$ or very early Sa. not in the RSA) at an anguiar separation of 5.1', and with an ImlV dwarf irregular at 3.6' from NGC 2848.

The brightest of the HH-region-eandidate knots in NGC 2848 and in the ImlV candidate companion are about the same brightness. The same is true of candidates for the brightest individual stars in each galaxy, strengthening the case for a common distance: the redshifts of NGC 2851 and the ImlV dwarf are not yet known (c. 1990). If the triplet is at a common distance of 36 Mpc, based on v_o = 1795 km s'" of NGC 2848, the projected linear separations of the companions from NGC 2848 would be small, at 53 kpc and 38 kpc.

The two principal well-defined arms in NGC 2848 begin at the center [(s)-type pattern] and branch to form most of the multiple arms over the face of the disk.

NGC 5584 SC(B)L8
CD-1836-HB
April 1/2, 1981
103aO + GG385
45 min

Tin' spiral pattern is highly regular although of the multiple-armed type. Some of the arms ran be traced for more than half a revolution as Individual fragments. Three arms ran be said to begin near the center. The two principal ones emerge from the center in an (s)-type connection; the third begins near the center and can be traced for half a revolution outward. Other fragments branch from these main arms farther oul in the disk.

The redshift is r,, = 15 18 km s '.

NGC 4189 SBc(sr)II VCC 89
CD-2118-S
March 20/21, 1982
103aO
50 mill

INGC 4189, listed in the Virgo Cluster Catalog, is located 4.2° west of subcluster A associated with NGC 4486 (M87). The morphological type listed in the VCC is SBc(sr)IL2. The evidence for the bar is well seen in the reproduction here. (The galaxy was placed in the Sc section here during an early formatting of the present atlas, based on the RSA classifications. That formatting became fixed early, preventing moving the illustration into the more appropriate SBe section.)

Three principal arms begin near the ends of the bar. Two start at the ends of the short bar in the manner of arms in NGC 1300 (panels L54, S8). The third begins close to but slightly beyond one of the ends of the bar. Branching of all the segments fills the disk with the multiple-arm spiral pattern.

NGC 5676 Sc(s)II
S-1999-H
April 12/13, 1948
103aO
30 niin

The print here of NGC 5676 is from a plate taken with the Mount Wilson 60-inch telescope. The galaxy is unreachable with the Mount Wilson 100-inch because of the high declination.

The spiral pattern is not symmetric on opposite sides of the major axis; the faint and chaotic outer spiral pattern on one side extends over the outer disk to twice the distance from the center, as do the well-defined inner arms on the opposite side, where there are no corresponding outer arms. This pattern is rare but not unknown. NGC 5678 (ScII-III: panel 278) shows the same asymmetry.

The inner arms are thin and well defined. They start from the center in the (s)-subtype configuration.

The redshift of NGC 5676 is «„ - 2239 km s^{-1}.

NGC 3810 Sc(s)II HA, p. *30*
H-15-S
Jan 5/6, 1951
103aO
20 min

The spiral pattern of IVGC 3810 resembles that of NGC 1068 (Sb: panel 138). The central disk is filled with very-high-surface-brightness, tightly wound spiral fragments. Lower-surface-brightness arms with more-open pitch angles exist outside the break in the surface-brightness distribution over the inner half of the image.

The largest Mil regions may just resolve at the 1" level. Candidates for **individual** brightest stars exist, but they must be verified by standard techniques that separate the stars from HII regions.

The redshift is $i\text{-}_o$ = 860 km s '.

NGC 991 Sc(rs)H
PH-7844-S
Sep 3/4, 1980
103aO
12 **min**

The extremely low surface brightness arms begin at the rim of a central smooth disk that may be an oval; if so, an alternate classification would be SBc.

An unresolved nucleus exists at the center of the oval. The central pattern closely resembles dE,N nucleated dwarf elliptical galaxies (Sandage and Binggeli, 1984, give an atlas of dE,N Virgo Cluster galaxies). Such bright, unresolved nuclei embedded in a smooth disk are characteristic of this type.

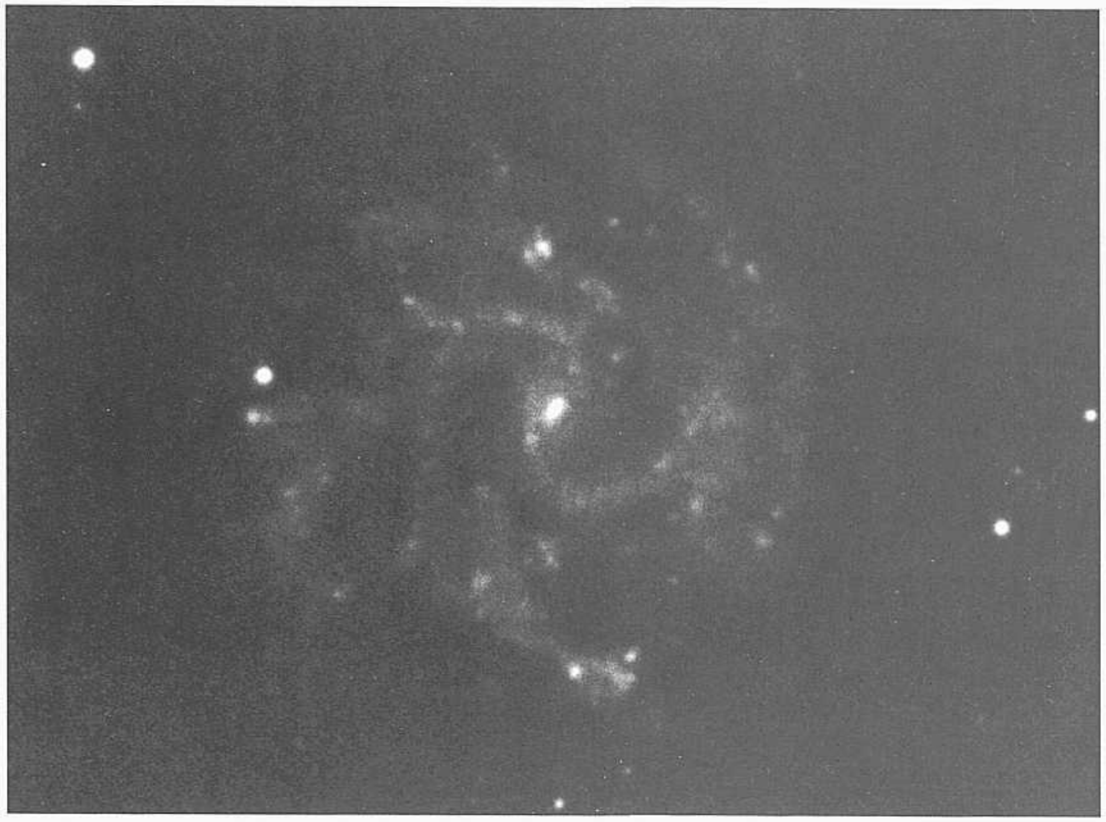
The redshift is v_a = 1607 km s^{-1}.

NGC 5468 Sc(s)1.8
CD-1856-HB
April 4/5, **1981**
103aO + GG385
45 min

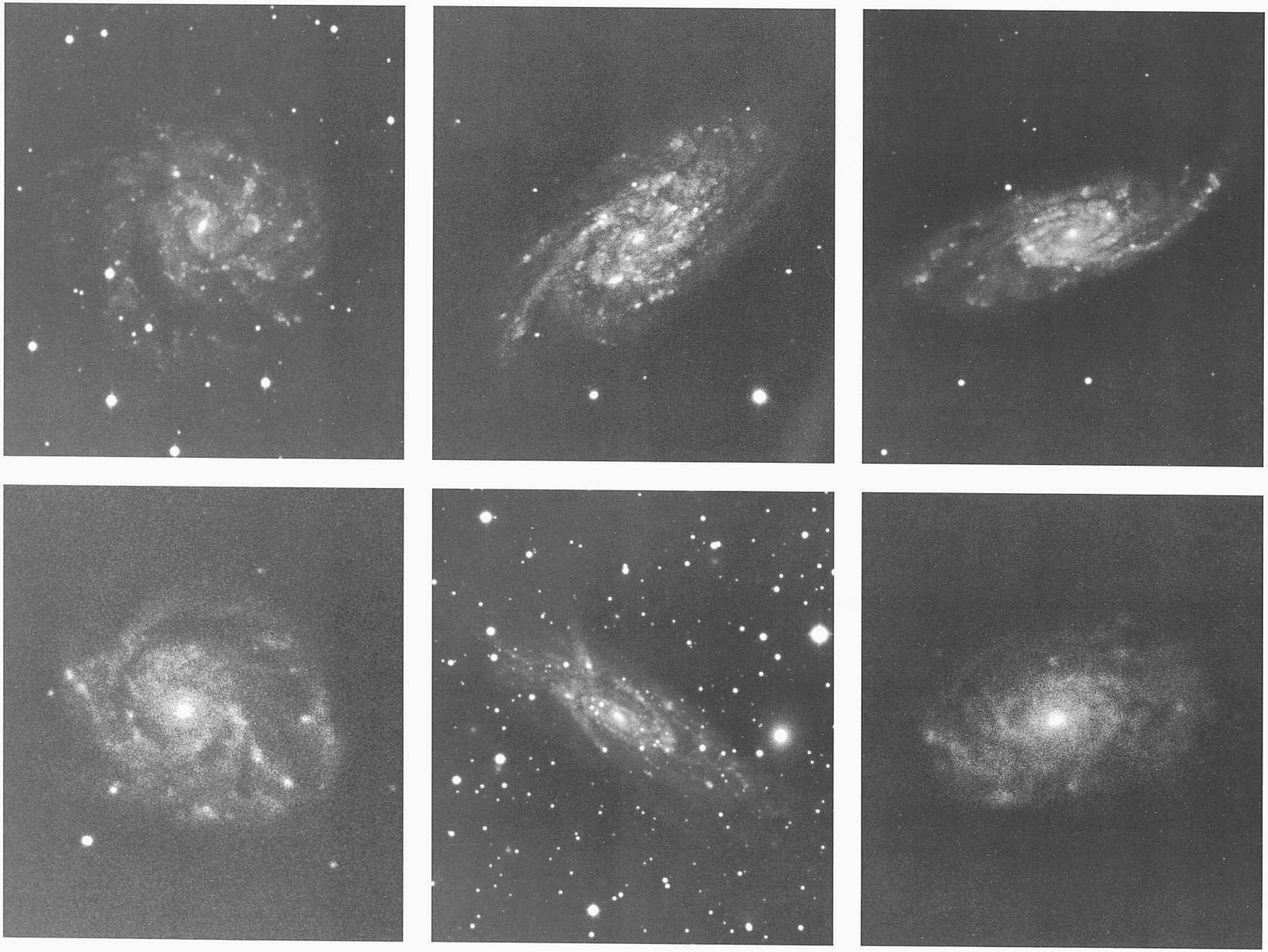
Two thin principal arms can be followed from the center outward, one for half a revolution and the other for a quarter revolution, before they branch into several thin fragments winding through the outer disk. The resulting arm pattern is open. Although the arms are multiple, they remain thin and do not cover a large area of the outer disk because they are so thin.

Three high-surface-brightness HII regions and a number of fainter HII regions exist in the arms but are unresolved at the 1" level. The redshift of NGC 5468 is v_n = 2696 km s"'.

PANEL
245



PANEL
246



Galaxies on this panel continue the illustration of well-organized spiral structure where the arms are moderately thin and the pattern is multiple rather than dominated by two arms of the grand design type.

F-703 =A1511-15 Sc(s)II.2 pair?
CD-1420-S/Br
March 24/25, 1980
103aO
75 min

F-703 forms a possible wide physical pair with NGC 5878 (Sb: panel 128) at an angular separation of 1.2°. The rcdshifts are v_o(703) = 2128 km s''' and v_o(58 78) = 1974 km s'''. If the two galaxies are at the same redshift distance of 41 Mpc, the projected linear separation would be 8 60 kpc (which is the separation of our Galaxy from M3 1 in the Local Group).

NGC 5605 Sc(rs)II
CD-1580-S/Br
Aug 11/12, 1980
103aO + GG385
45 min

Three arms begin near the center of NGC 5605, tangent to the rim of a small, high-surface-brightness, smooth inner disk. These arms branch to form the arm fragments that cover the outer disk.

The redshift is v_n = 3196 km s'''.

NGC 6643 Sc(s)II HA, p. *35*
PII-60-H panel 247
April 27/28, 1949
103aO
40 min

The surface brightness of the inner part of the multiple-arm pattern in NGC 6643 is high. Many bright III I regions largely define these inner arms. The arm fragments, together with their associated fragmented dust lanes, cover the disk.

A print from a yellow Palomar plate is on the next panel.

The redshift is v_n = 1743 km s^{-1}.

IC 4721 Sc(s)II paii-
CD-1480-S/Br
May 11/12, 1980
103aO + GG385
27 min

IC 472 1 forms a physical pair with IC 4720 (Sc) at an angular separation of 8.5'. The red-shifts are u_o(4720) = 2 104 km s~' and u_o(4721) = 2405 km s^{-1} . At the mean redshift distance of 45 Mpc the projected linear separation of the pair is 111 kpc. An E0 galaxy of unknown red-shift exists at the small angular separation of 2 .2 ' from IC 472 1 . It can be seen on the print here. If it is associated with the pair, its projected linear separation from IC 4721 is small, at 29 kpc.

NGC 2715 Hc(s)II
PH-7709-S
Fell 1 1/12. 1979
I03a0
12 miu

The arm pattern in NGC 2 7 15 is multiple in the sense of NGC 28 11 and NGC 488. It is nol formed by two principal inner arms that start at the center and then fragment into an outer multiple pattern. Ratlin-, the MAS pattern in NGC 2715 is present from the beginning of the spiral pattern at the center.

The redshift of NGC 27 15 is v_o = 1 540 km s^{-1}.

NGC 4237 Sc(r)I1.2 VCC 226
H-1970-H HA, p. *20*
April 21/22, 1938
E40
60 min

The spiral pattern of NGC 42 3 7 is similar to that of NGC 27 15. above. The reproduction in the Hubble Atlas was made from the same Mount Wilson 100-inch plate shown here.

The redshift of NGC 4237 is v_o = 8 14 km s^{-1}. The galaxy is in the region surveyed for the Virgo Cluster Catalog. It is located 4.5° northwest of NGC 4186. associated with Virgo subcluster A.

NGC 6643 **Sc(s)H** **HA, p. 35**
PH-5372-S **panel 246**
Sep 11/12, 1969
103aD + GG11
40 inin

The image here of NGC 6643 is from a 200-inch Palomar **103aD** yellow plate rather than from the blue Palomar plate used for **the** image on the preceding panel.

The description of the **spiral pattern** is given there for this galaxy. The image on this panel shows a high-surface-brightness continuum disk upon which young spiral arms are superposed. The continuum yellow light shown in this print is from the old stellar component rather than from the young stellar content detected in either blue light or in Ha light, on red-sensitive plates.

NGC **4504** **Sc(s)II** **pair**
CD-1859-HB
April 6/7, 1981
103aO
75 min

NGC 4504 forms an **apparent** physical pair **with** NGC 4487 (Sc; panel 250) at an angular separation of 35'. The redshifts of **the** pair are u_o(4487) = 831 km s~' and u_o(4504) = 794 km s~[1]. At the mean redshift distance of 16 Mpc, the projected linear separation is 165 kpc. The resolution into HII regions and brightest stars is about the same for both galaxies. The largest several **HII** regions in each galaxy resolve into disks (core + halo) at about the 3" level.

Another nearby spiral exists (UGCA 282: SBbI) at an angular separation from NGC 4487 **of** 25' at **redshift** v_o = 5460 km s^{-1}. It is clearly in **the** background **for** reasons other than the large redshift difference: its resolution into 1111 regions is **nil,** contrary to the case of NGC 4487 and NGC 4504.

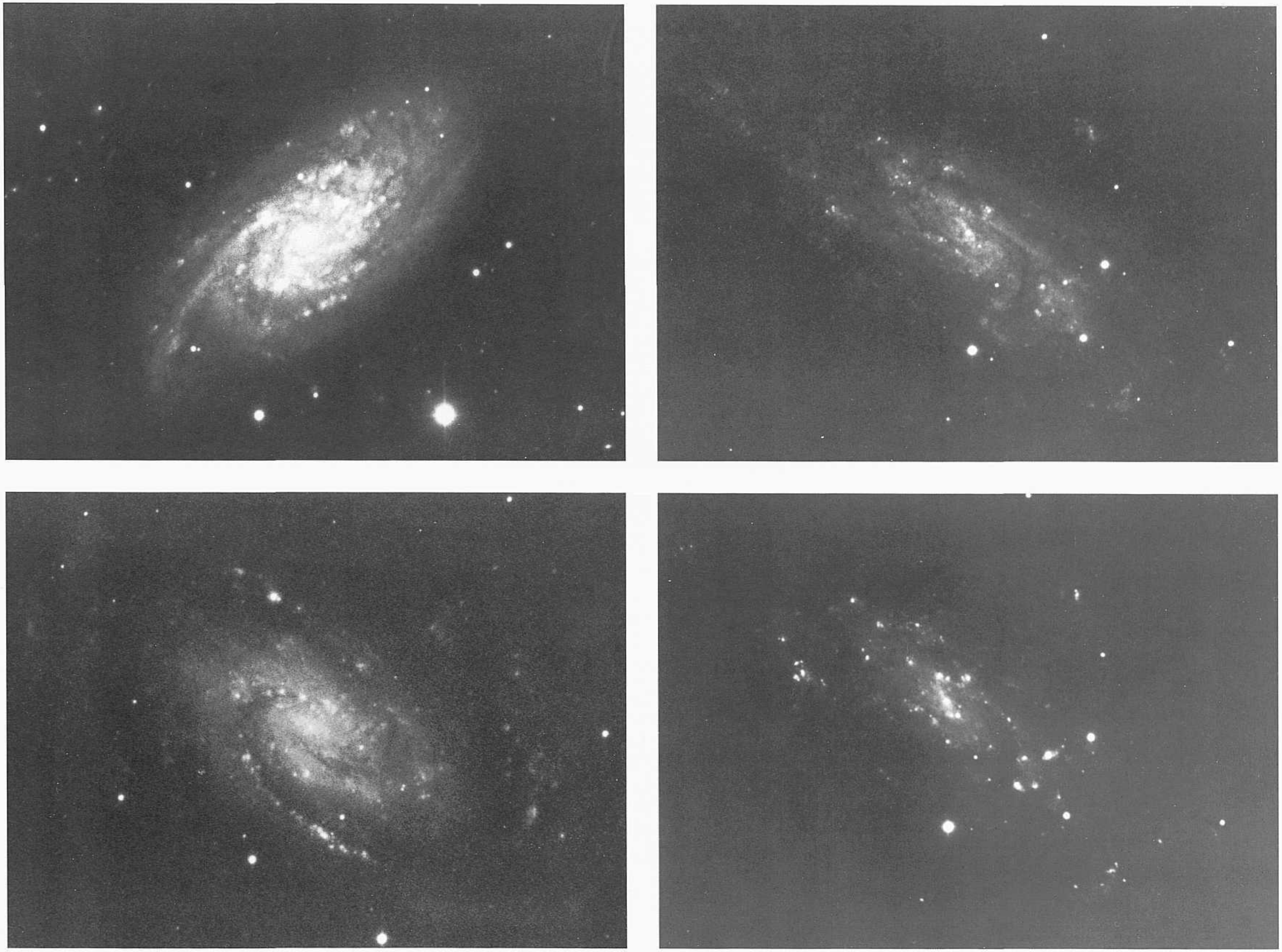
NGC 4559 Sc(s)II
PH-8003-S
Feb 2/3, 1981
103aO
12 nUn

NGC 4559 is nearby, judged by the ease of resolution of the **HII** regions at about the 3" level and the existence of what appear to be individual stars starting at about B = 22 mag. The blue image is given in the upper print here. The **Ha** interference filter image is below.

The redshift is v_o = 771 km s~'.

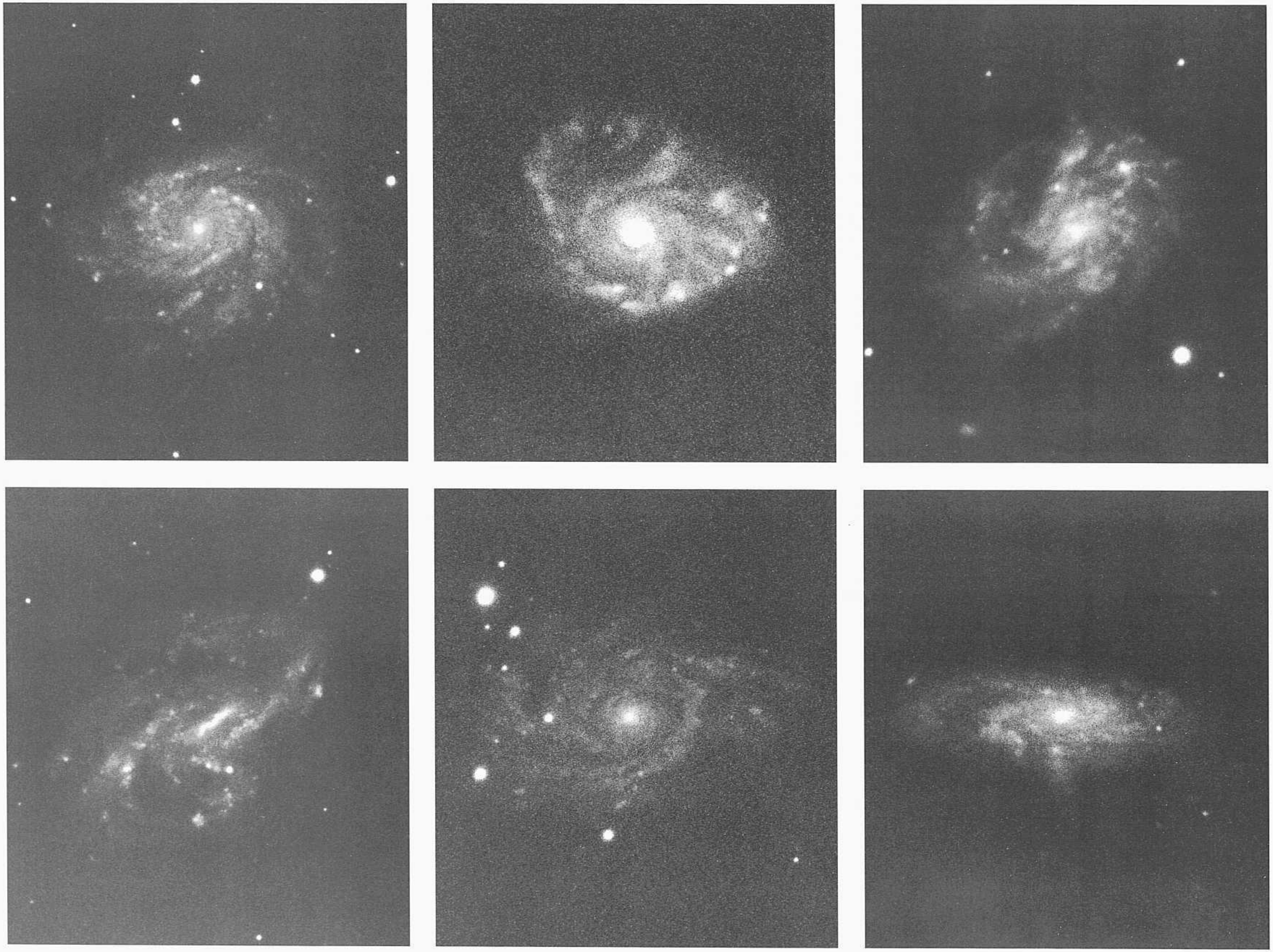
NGC 4559 **Sc(s)II**
PH-4516-S
April 14/15, 1964
Ha interference **filter**
120 min

The largest of the individual HII regions in NGC 4559 resolve at about the 3" level. The arms are not as well defined as in the continuum blue image in the print above.



PANEL
247

PANEL
248



The six galaxies on this panel continue the Sell morphology among galaxies whose spiral arms are thin and easily traced as individual fragments 1>•11 which are multiple and cover much of the underlying disk.

NGC 514 Sc(s)II Racine wedge
PH-7698-S
Sep 26/27, 1979
103aO
12 inin

The multiple pattern in NGC 514 begins at the small nuclear region, starting as dust lanes closer to the center than where the luminous segments start, after which the dust lanes are generally on the insides of the best-defined arm fragments.

The bright stars show secondary images made by the Racine wedge.

The redshift is v_o = 2675 km s~'.

NGC 5112 Sc(rs)II Racine wedge
PH-8063-S
Feb 4/5, 1981
103aO
12 min

An apparent short bar exists at the center of NGC 5112. The bar is strong enough for the type to be SBc in the RC2, based on a Mount Wilson 60-inch plate.

Four arms begin in the vicinity of the ends of the bar. They remain thin but branch into several segments over the outer disk.

The redshift is v_o = 998 km s~'.

NGC 95 Sc(s)1.8 Racine wedge
PH-7694-S
Sep 26/27, 1979
103aO
12 min

Five arm segments begin at the center and end abruptly at a bright edge, which at lower resolution would appear to be a luminous outer rim.

The redshift is large for RSA galaxies, at v_o = 5104. Because NGC 95 has an apparent magnitude that is bright enough to be in the RSA, the absolute magnitude of NGC 95 is among the brightest in that catalog, at M_B = -22.2.

There are evident HI1 regions, especially along the outer edge of the spiral pattern. These are unresolved at the great distance of the galaxy.

NGC 3041 Sc(s)II Racine wedge
PH-7962-S
Nov 8/9, 1980
103aO
12 min

Two faint stubs of luminous spiral arcs begin at the center but fade into the inner disk after a quarter revolution. The larger fragments of arms composing the outer spiral pattern begin farther from the center and have no clear connection with the two inner spiral stubs.

The bright stars show the secondary images made by the Racine wedge, separated from the primary by 18" with an intensity that is 5 mag fainter.

The redshift is v_o = 1296 km s'" .

NGC 3629 Se(s)II.2 Racine wedge
PH-8053-S
Fcb4/5, 1981
103aO
12 min

The spiral pattern of NGC 3629 is of the MAS type, similar to that of NGC 2 HI 1 and NGC 488 where many arms on the outside extend I" the center.

The bright stars show the secondary images made by the Racine wedge, separated by 18" from the primary and fainter by 5 mag.

The redshift of NGC 3629 is v_o = 145 I km s^{-1}.

NGC 5362 Sc(s)II Racine wedge
PH-8098-S
Feb 6/7, 1981
103aO
12 min

Although the viewing angle for NGC 5362 is high, it appears that four main arms exist in a grand design pattern starting from the rente]- in an (s)-type central connection.

The most unusual feature is the spike of luminosity on one side of the image, beginning at an unresolved knot on the minor axis. From the direct image alone one cannot locate it in three dimensions: it is not evident if it is in the plane or is above the nucleus in the halo.

Such features arc rare elsewhere but not unknown. Evidence exists for a fountain into tin; halo in NGC 1808 (Shi- pec; panel 193). Evidence both from direct imaging and speetroscopy exists for matter being ejected from the plane in NGC 3034 (MK2: panels 333. 334).

The redshift of NGC 5362 is u_0 = 232 1 km s^{-1}.

NGC 5967 Sc(rs)II.2 pair
CD-923-HB
May 3/4, 1979
103aO + GG385
45 mill

NGC 5967 forms a physical pair with NGC 5967A at an angular separation of 8.3′. The v_o redshifts are 2657 km s^{-1} and 2714 km s^{-1}, respectively. At the mean redshift distance of 54 Mpc (// = 50) the projected linear separation is 130 kpc.

The inclination of NGC 5967 to the sight line is sufficiently high that the central region appears to be oval. However, the major axis of the central image has the same position angle as that of the outer spiral arms. By viewing the image obliquely by holding this page at an angle and rotating for the proper position angle of the major axis, a decision can be made that the morphological type is Sc rather than SBc.

NGC 1292 Sc(s)II
CD-577-S
Oct 8/9, 1978
103aO + GG385
40 min

Four arm crossings of the major axis occur on one side of the image of this MAS-type spiral; three crossings occur on the other side. The arms and their associated spiral dust lanes in the inter-arm regions cover much of the area of the disk.

The redshift is v_o = 1390 km s'.

NGC 7059 Sc(r)II
CD-508-S/Br
Sep 28/29, 1978
103aO + GG385
45 min

The spiral pattern is not regular in NGC 7059. The arm pattern is difficult to trace both in the center and on the outside. Two thin segments of separate arms cross on one side of the major axis: they either have very different pitch angles or one is out of the main plane. As with other galaxies on this panel, the disk is covered with star-forming regions. The numerous HII regions are unresolved.

The redshift is v_o = 1660 km s"'.

NGC 3021 Sc(s)II Racine wedge
PH-7932-S
Nov 7/8, 1980
103aO
7 min

The set of (s)-type multiple arms is of high surface brightness. Note the secondary images of the bright stars made by the Racine wedge.

The redshift is v_o = 1520 km s^{-1}.

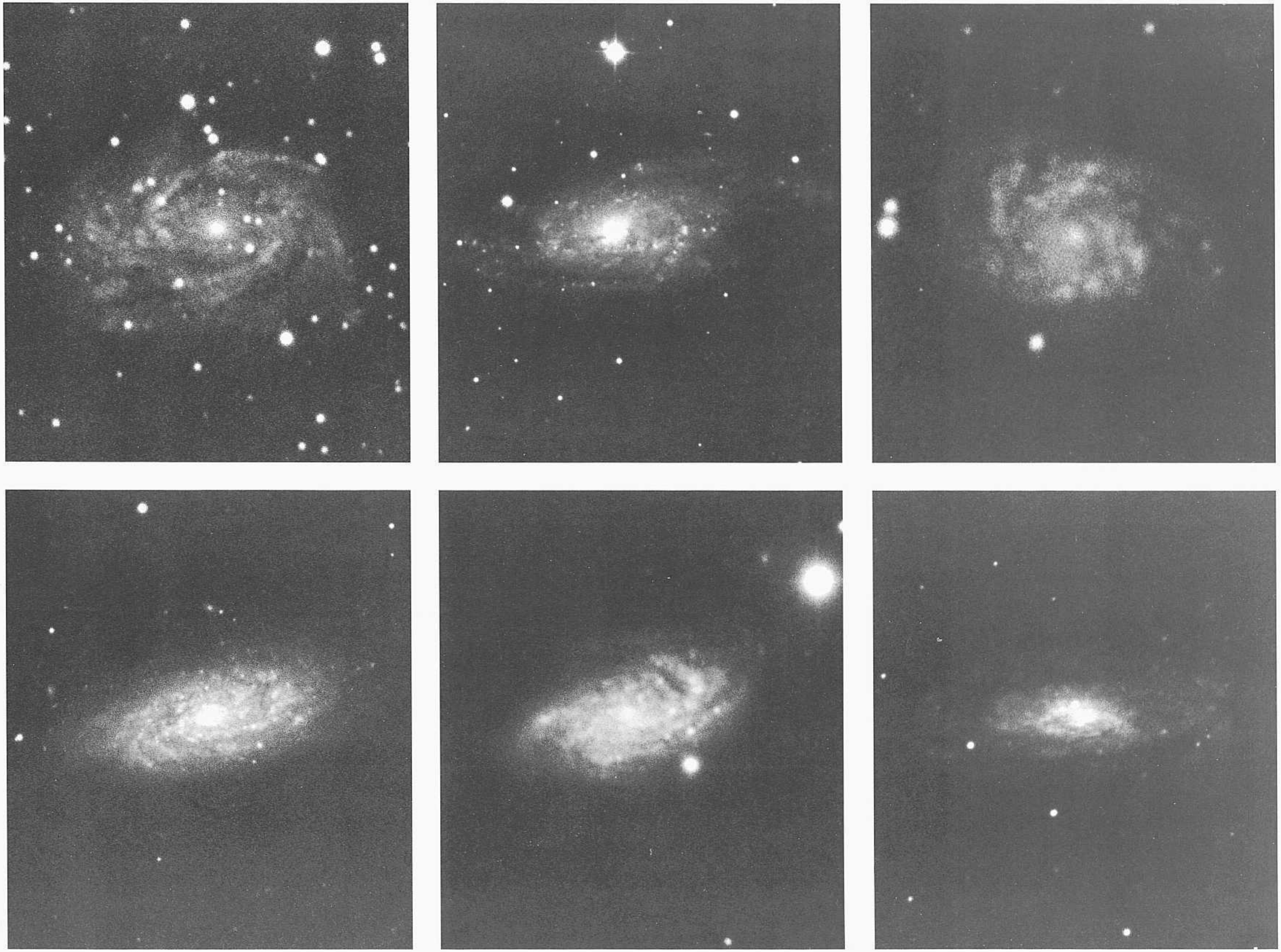
NGC 6574 Sc(s)II
H-1403-H
July 31/Aug 1, 1932
Imp. Eel.
60 min

Three principal arms exist in this more-or-less grand design spiral. Two of the principal arms are themselves double. Counting these as separate arms yields four arm crossings of the major axis on one side.

The redshift is v_o = 2415 km s^{-1}.

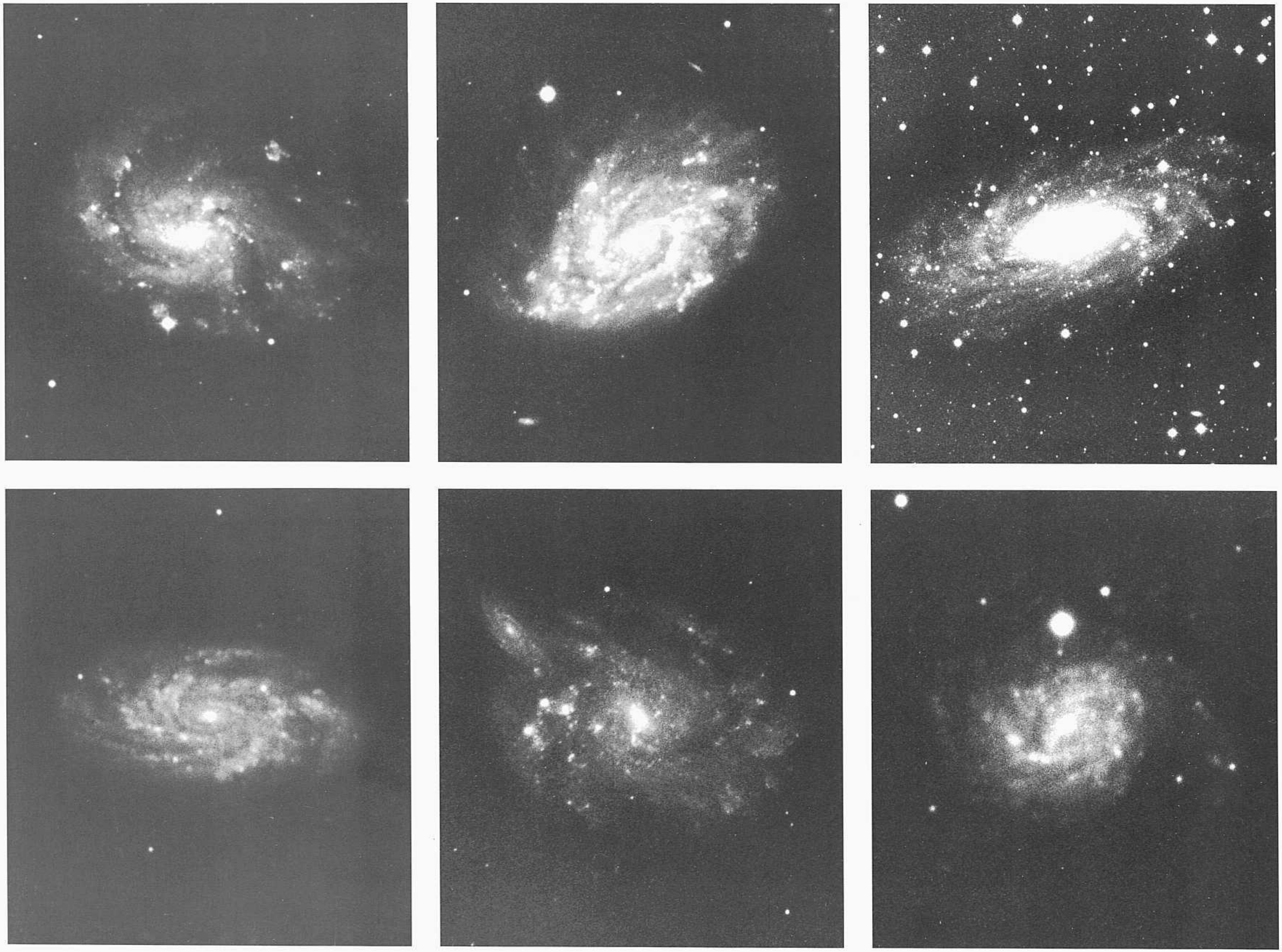
NGC 4951 Sc(s)II pair:
CD-2189-S
March 29/30, 1982
103aO + GG385
45 min

NGC 4951, with v_o = 993 km s~'. may form a physical pair with NGC 4941 (Sab: panel 117), whose redshift is v_0 = 878 km s^{-1}. The angular separation of the pair is 60'. At a redshift distance of 19 Mpc the projected linear separation is 332 kpc, or about one-third the diameter of the Local Group.



PANEL
249

PANEL
250



Galaxies on this and the next three panels are of morphological class Sell and often have the MAS arm pattern. Most have massive arms in the sense of Reynolds (1 927a,b); such arms cover much of the disk.

NGC 4487 **Sc(s)II.2** **pair**
CD-1859-HB
April 6/7, 1981
103aO
75 niin

NGC 4487 forms an **apparent** physical pair **with** NGC 4504 (Sc; panel 247). The redshifl of NGC 4487 isi;$_o$ = 831 km s"[1]; that of NGC 4504 is v_o = 794 km s^{-1}. The latter has an **angular** separation of 35' from NGC 4487. At the mean redshift **distance** of 16 Mpc the projected linear separation is 165 kpc.

Two principal arms of the grand design type exist in NGC 448 7. Dust lanes accompany these arms on the inside of the arm segments. One of the **principal** arms is less well defined than the other; it branches into several, perhaps four, broad segments which cover one side of the disk.

The largest of the many Hll-region candidates resolve into disks (core + halo) at the 3" level.

NGC 2742 **Sc(rs)II** Racine wedge
PH-7710-S
Feb 11/12, 1980
103aO
12 nün

The spiral pattern in NGC 2 742 is beautifully regular. It is multi-armed: five crossings of the major axis can be traced on one side and three or four on the other (depending on whether one counts satellite arm fragments as separate arms).

The original **plate** was taken with a Racine wedge which makes secondary images of the bright stars.

The redshift is v_o= 1422 **km** s^{-1}.

NGC 1255 **Sc(s)H**
CD-2000-Bedke/Gregory
Oct 22/23, 1981
103aO + GG385
45 min

The arm pattern in NGC 1255 is massive in the sense of Reynolds (1927a,b), covering **the** disk. Four arm crossings of the major axis can be counted on each side of the image.

The largest of the several **Hll-region** candidates **probably** resolve into disks (core + halo) at about the 1.5" level.

The redshift is v_o = 1656 km s^{-1}.

NGC 450 **Sc(s)II.3** **Racine wedge**
PH-7835-S
Sep 3/4, 1980
103aO
12 **rain**

The surface brightness of the multiple-arm pattern in NGC 450 is low. The **brightest of** the many Hll-region candidates in **the** arms may be **complex.** The largest two regions appear to resolve (core + halo) at about the 2" level. The redshift of NGC 450 is 191 1 km s~[!].

Note the small Sc galaxy nestled in the outer arm pattern of NGC 450. There is no evidence for a strong gradient of absorption across the disk of this galaxy. The point is important because the small galaxy is evidently in the background; yet dust absorption, as would be caused by the disk of NGC 450 if it were **optically thick,** is **not** evident. This is taken as evidence **that the** disks of at least some Sc galaxies are optically **thin** at blue (optical) wavelengths, **contrary to** some current (c. 1990) views.

NGC 2090 **Sc(s)Il** **panel** 257
CD-663-Br
Jan 22/23, 1979
103aO + GG385
45 min

The distance to NGC **2090** is evidently **smaller than the distance to the** Virgo **Cluster (adopted** here **to** be m — M = **.SI** .7) **because the outer-** arms are **well resolved into individual** brightest-star **candidates and Ill1 regions. The** largest **of the 1111** regions **are resolved into** disks (core + **halo) at the** 4" level.

Although **the resolution into** individual **brightest** stars is better **than** in Virgo **Cluster** spirals, the galaxy is **not** as easily **resolved** as **Ml** 0 **1** , whose distance modulus, **determined** from Cepheids, is m - M = 29.3. An **estimate of the** distance modulus of NGC 2090 at **about** m - M = 31 comes from the ease of **resolution into stars. The redshift** is v_a = 755 km s^{-1}.

The arm pattern in NGC 2090 **is multiple.** The inner region of **the** disk is **covered with** spiral arms **that** have very high surface brightness. The outer-arm **pattern is** composed **of arm fragments of low surface brightness;** the resolution **into** stars and III! regions is easiest here.

NGC 5768 **S<-(s)II**
CD-1844-HB
April 2/3, 1981
103aO + GG385
45 min

The small **angular size of NGC** 576 **8** (D_{25} = **2')** and **the faint apparent magnitude of** Sf = 12.9. combined **with the** fairly small **redshift of** v_0 = 1960 km s^{-1} gives **the** faint absolute magnitude M_{Hj} = -20.4.

The **HI I regions and individual brightest** stars arc unresolved.

The spiral arms in the six galaxies on this panel are massive in the sense of Reynolds (1927a,b). The arm pattern in each is regular enough for assignment of luminosity class II.

NGC 7448 **Sc(r)II.2**
PH-7689-S
Sep 26/27, 1979
103aO
12 **min**

As in NGC 2090 on the preceding panel, the spiral pattern in NGC 7448 is composed of two regions of quite different surface brightness. The inner region of **the** disk has tightly wound, **high-surface-brightness** spiral fragments. Individual arms are **not** easily identified. The surface brightness decreases abruptly at the edge of this inner zone. Outer individual arm fragments and a general inter-arm spiral pattern in weak dust lanes can be traced over the outer disk.

A cluster of unresolved **HII** regions exist in one of the most conspicuous of the outer arms.

The **redshift** is v_0 = 2485 km s^{-1}.

NGC 3055 **Sc(s)II**
CD-1698-S
Jan 4/5, 1981
103aO + **GG385**
45 min

NGC 3055 has weak features of a barred spiral. Two high-surface-brightness inner arms start from the ends of the bar and. by branching, give rise to the luminous, massive arm fragments that cover the outer disk.

The redshift is v_0 = 1747 km s^{-1}.

NGC 3089 **Sc(s)II**
CD-1315-S/Br
March 12/13, 1980
103aO + GG385
45 min

The two principal arms of this (s)-type spiral begin as low-surface-brightness features with associated dust lanes near the center. These features, moderately ill-defined, connect with the **very-high-surface-brightness,** massive, well-defined principal outer luminous arms at a distance of about half a disk length from the center.

A third, lower-surface-brightness arm begins also at the place that one of the two principal **high-surface-brightness** arms starts. The pitch angle of this third arm is different from the others.

The redshift is v_o = 2375 km s^{-1}.

NGC 2964 **Sc(s)II.2** **Karachentsev 210**
PH-7603-S **panel 240**
April 3/4, 1979
IIIaJ + **GG385**
30 **min**

NGC 2964 forms a close physical pair with **NGC** 2968 ($S0_8$ or Amorphous: panels 49, 337) at a separation of 5.8'. The redshifts are **v_o(2964)** = 1292 km s^{-1} and v_o(2968) = 1576 km s^{-1}. At the mean redshift distance of 29 Mpc (*H* = 50) the projected linear **separation** is small, at 49 kpc.

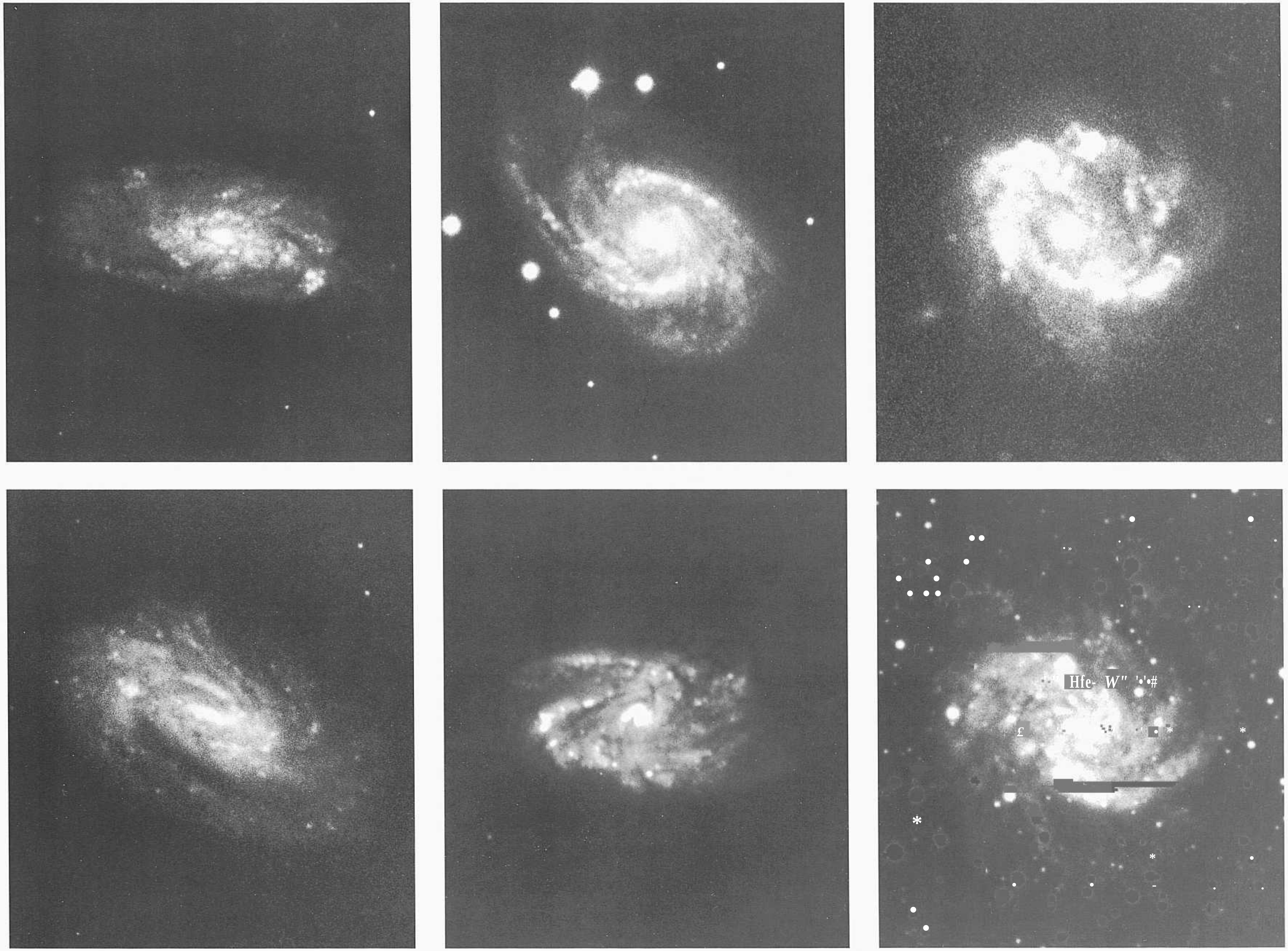
NGC 245 **Sc(s)II pec**
PH-7834-S
Sep 3/4, 1980
103aO
12 min

There are three main arm connections with the center in NGC 245, but, as in NGC 3089 to the left, the surface brightness of these connections is low. The central structures become the bright principal arms at about a third of a disk radius from the center. Four main bright arms are evident near the outside of the pattern.

The redshift is v_0 - **4275** km s^{-1}.

NGC 6215 **Sc(s)II** **pair**
CD-1582-S/Br
Aug 11/12, 1980
103aO + GG385
45 min

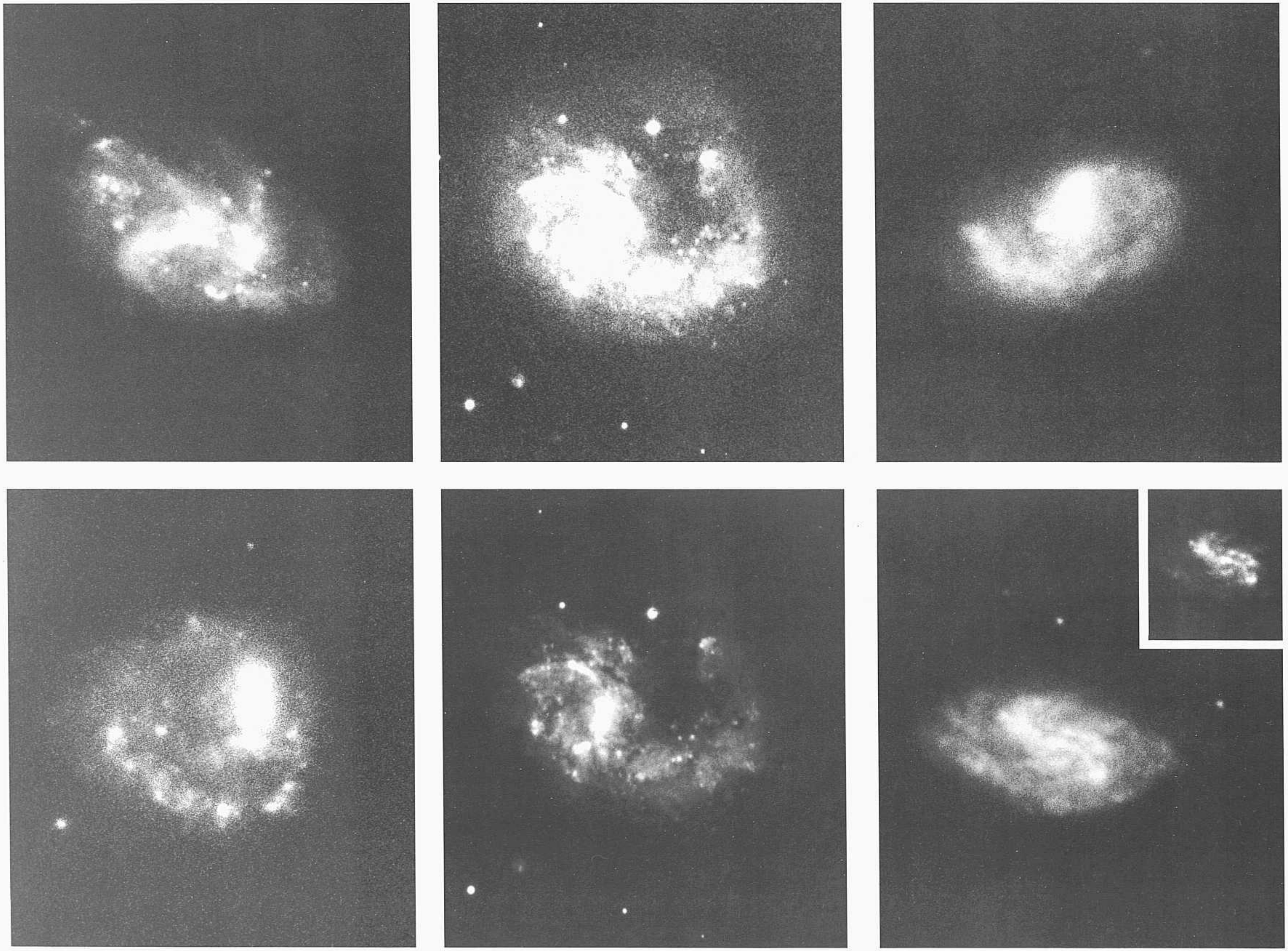
NGC 6215 forms a physical pair with NGC 6221 (Sbc: panel 189) at an angular separation of 18.3'. The redshifts are v_o(6215) = 1355 km s^{-1} and v_o(6221) = 1270 km s^{-1}. At the mean redshift distance of 26 Mpc (*H* = 50), the projected linear separation of the **pair** is 140 kpc. There are several candidate low-surface-brightness **companion dwarfs** in the field.



PANEL

251

PANEL
252



T he five galaxies on this panel continue the examples of spiral patterns that cover the disk because of their massive nature in the sense of Reynolds (1927a,b).

NGC 337 Sc(s)II.2 pec merger?
PH-7672-S
Sep 25/26, 1979
103aO
12 min

The arms in NGC 337 cannot be well traced from the nucleus. Perhaps part of the central pattern is a bar, from whose opposite ends originate two of the arm fragments, but the pattern is not regular. The association of the other segments with any overall spiral pattern as a whole is even less obvious.

The irregular morphology of the arm segments may be clue to a close encounter: this might be established if the small structure with a central knot (a nucleus?) and associated bar with its associated stubby (s)-type arms can be identified as a companion. But it is not certain that this galaxy is in fact a companion, or even if so-il' it is ready to merge.

The comment in the RC1 on the morphology of NGC 337 that NGC 337 "resembles NGC 1313" may be appropriate; NGC 1313 (SBiIIi-IV; panel 309) has been suggested to be in a close encounter.

NGC 2793 Sell pec
PH-7931-S
Nov 7/8, 1980
103aO
12 min

The unusual morphology of NGC 2793 is similar to NGC 337 above and NGC 4027 to the right. The partial-ring morphology is also similar to the ring galaxies attributed by Theys and Spiegel (1976, 1977) and Lynds and Toomre (1976) as due to plunging encounters, as discussed on earlier pages of this atlas. A small, undisturbed galaxy exists at the close separation of 90", but its redshift is unknown and it may be in the background. If so, the unusual morphology of NGC 2793 would be endemic to the system, not due to an encounter.

NGC 4027 Sc(s)II.2 group
CD-1679-S
Jail 1/2, 1981
103aO
60 min

NGC 4027 is in an apparent small group of galaxies contained within a 2°-diameter circle, all having similar redshifts within 1 10 km s^{-1} of the mean redshift. $<v_u>$ = 1382 km s^{-1}, of the five brightest group members. These five brightest members, all in the RSA. are NGC 4024 (SO,; panel 31), NGC 4027 here (Sc), NGC 4033 (SOj: panel 35), and the famous interacting pair NGC 4038/4039 (Sc/Sc tides: panel 280). If the angular radius of the group is 1°, its linear radius is 480 kpe, based on a mean redshift distance of 28 Mpc. Therefore the group is a field example of the Local Group. It contains late-type spirals, early-type galaxies, and Magellanic Cloud-type Im galaxies. Two of these are close to NGC 4027, here. A well-resolved Imlll exists at an angular separation (south) of 4.0' (projected linear separation of only 33 kpc): a BCD exists at an angular separation (northwest) of 16.4' (projected linear separation of 133 kpc).

Although NGC 4027, shown here and below, has a peculiar morphology because of the nonsyiumetry due to its one bright, massive arm, there is no evidence of an encounter or a merger; there is no perturbing galaxy nearby.

It must be considered a coincidence that NGC 4038/4039, the galaxies that provide the most direct evidence anywhere in the sky of a close encounter, are in this group and are separated from NGC 4027 by only 41'. The projected linear separation of the NGC 4038/4039 pair from NGC 4027 is 334 kpc.

NGC 4027 Se(s)II.2 group
CD-1679-S
Jim 1/2, 1981
103aO
60 min

The resolution of NGC 4027 into 1111-region candidates and perhaps a few brightest stars is visible in this short-exposure print from the same original plate used for the heavy print above.

NGC 3985 Sc(s)Il pee Racine wedge
PH-8055-S Ursa Major Cluster
Feb 4/5, 1983
103aO
12 min

Us position and redshift, v_0 = 1004 km s '. suggest thai NGC 3985 is a member of the Ursa Major Cluster.

In a way similar to NGC 44)27 shown at the left, the spiral structure in NGC. 3985 is unusual because of its one-armed pattern.

NGC 2990 Sc(s)II.2
CD-1692-S
Jan 3/4, 1981
103aO + GG385
45 min

NGC 2990 insert
CD-1691-S
Jim 3/4, 1981
103aO + GG385
7 min

The inner spiral pattern in NGC 2990 has an unusually high surface brightness, as seen ill the insert. The arms are massive, covering much of the area of the disk.

The redshift is v_0 = 3006 km s~' .

The six galaxies on this panel complete the illustration of Sell objects having massive arms in the sense of Reynolds (192 7a,b). Most are of the two-armed variety with the arms beginning at the center [the (s) subtype].

IC 4444 Sc(s)II pec
CD-1875-HB
April 10/11, 1981
103aO + GG385
45 mill

The surface brightness of the central region and the two inner spiral fragments beginning therein is very high. The arm pattern is not symmetrical, yet the spiral feature of the three (perhaps four) arm segments is definite.

The redshift is u_0 = 17 60 km s̄ \ Only a very few (if any) HH-region candidates have been identified.

NGC 5595 Sc(s)II pair
CD-1569-S/Br
Aug 10/11, 1980
103aO + GG385
45 nún

NGC 5 595 forms a close physical pair with NGC 5597 (SBe: panels 298. S10) at an angular separation of 4.0'. The redshifts are i_0(5595) = 2501 krns"' and i_o(5597) = 2444 km s"'. At the mean redshift distance of 59 Mpc, the projected linear separation of the pair is small, at 58 kpc.

The surface brightness of the arms in NGC 5595 is unusually high.

NGC 3389 Sc(s)II.2 Leo Gr #28
PH-270-S
Dec 10/11, 1952
103aD + GGll
25 nún

NGC 3389 is listed as a member of the Leo Group in the catalog of Ferguson and Sandage (1990). where the morphological type is given as Scd(s)II.

NGC 3389 is in a triplet of the brightest Leo Group galaxies, which form the center of the aggregate. The other two galaxies are NGC 3379 (E0: panel 1) at a separation of 9.8', and NGC 3384 (SBO j: panels 54, S7) at a separation of 6.4'. The mean redshift of the group listed in the Leo Cluster Catalog is $<v_o>$ = 909 km s^{-1}. At a redshift distance of 1 8 Mpc, the projected linear separations of NGC 3379 and NGC 3384 from NGC 3389 are small, at 51 kpc and 34 kpc, respectively. The redshift of NGC 3389 itself is v_o = 1] 27 km s^{-1}.

NGC 6970 Sc(s)II
CD-1532-S/Br
Aug 6/7, 1980
103aO + GG385
15 inin

NGC 6970 insert
CD-1110-Br
Aug 19/20, 1979
103aO + GG385
15 nún

The angular size of this remote galaxy is small, at 35". The redshift is v_0 = 5207 km s~'.

The two major spiral arms have very high surface brightness. The arm pattern is of the grand design, the arms being of the massive type.

IC 2056 Sc(s)II
CD-135-S
Jan 31/Feb 1, 1978
103aO + GG385
60 inin

IC 2056 insert
CD-172-S
Feb 6/7, 1978
098-04 + GG385
10 min

The inner disk of IC 2056. filled with spiral segments, has a very high surface brightness and surrounds a nearly pointlike nucleus. The spiral arms are tightly wound.

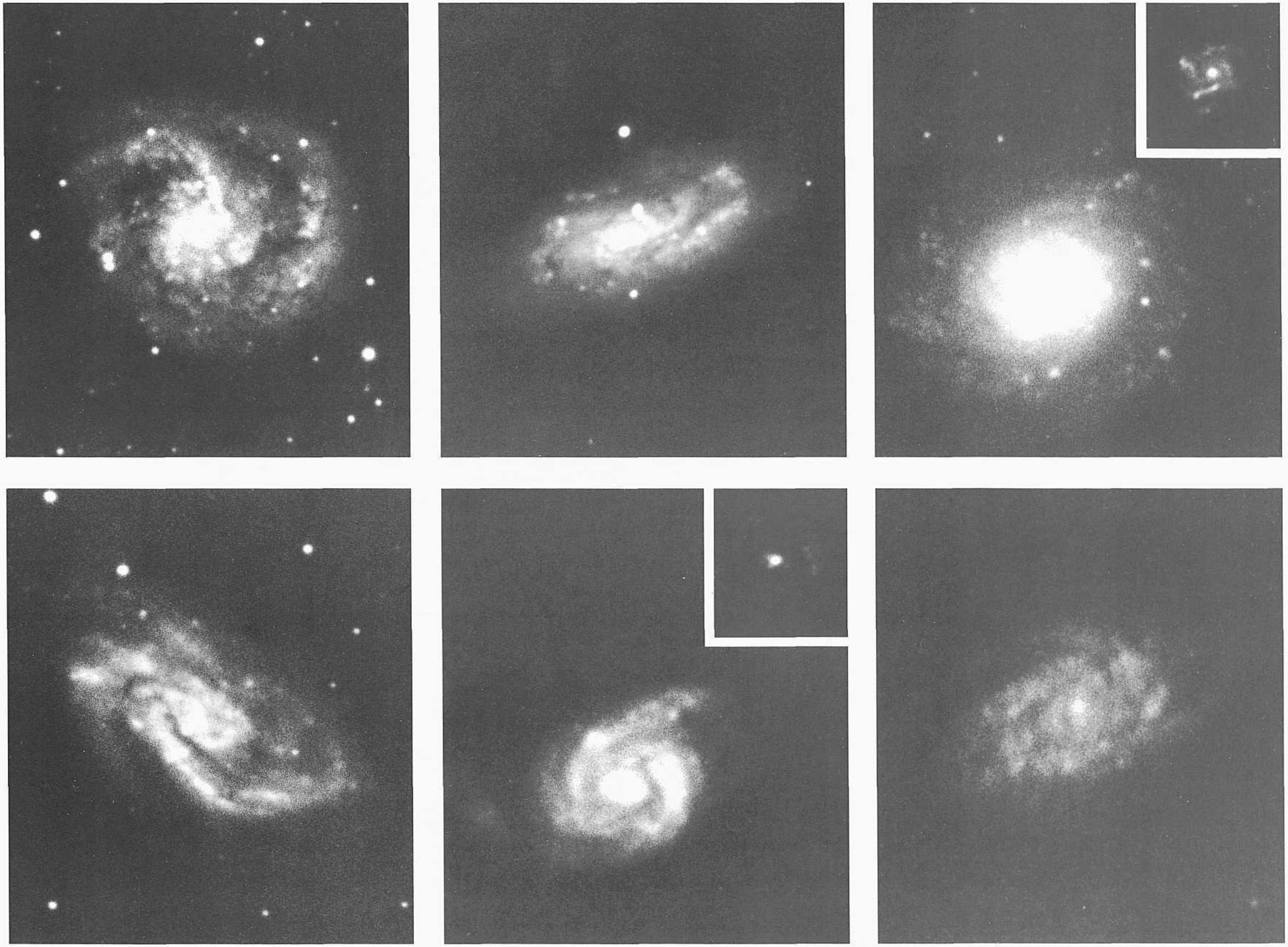
Lower-surface-brightness segments of a spiral pattern exist in the outer disk, shown in the heavy main print. Many knots in these outer arms are candidates for Mil regions. The redshift of IC 2056 is $v_{,,}$ = 934 km $s^{"1}$.

The high-surface-brightness inner arms and the small, intense nucleus are well seen in the insert print made from a red-sensitive plate and a wide-bandwidth filter.

NGC 5633 Sc(s)II
PH-7862-S
Sep 5/6, 1980
103aO
2 min

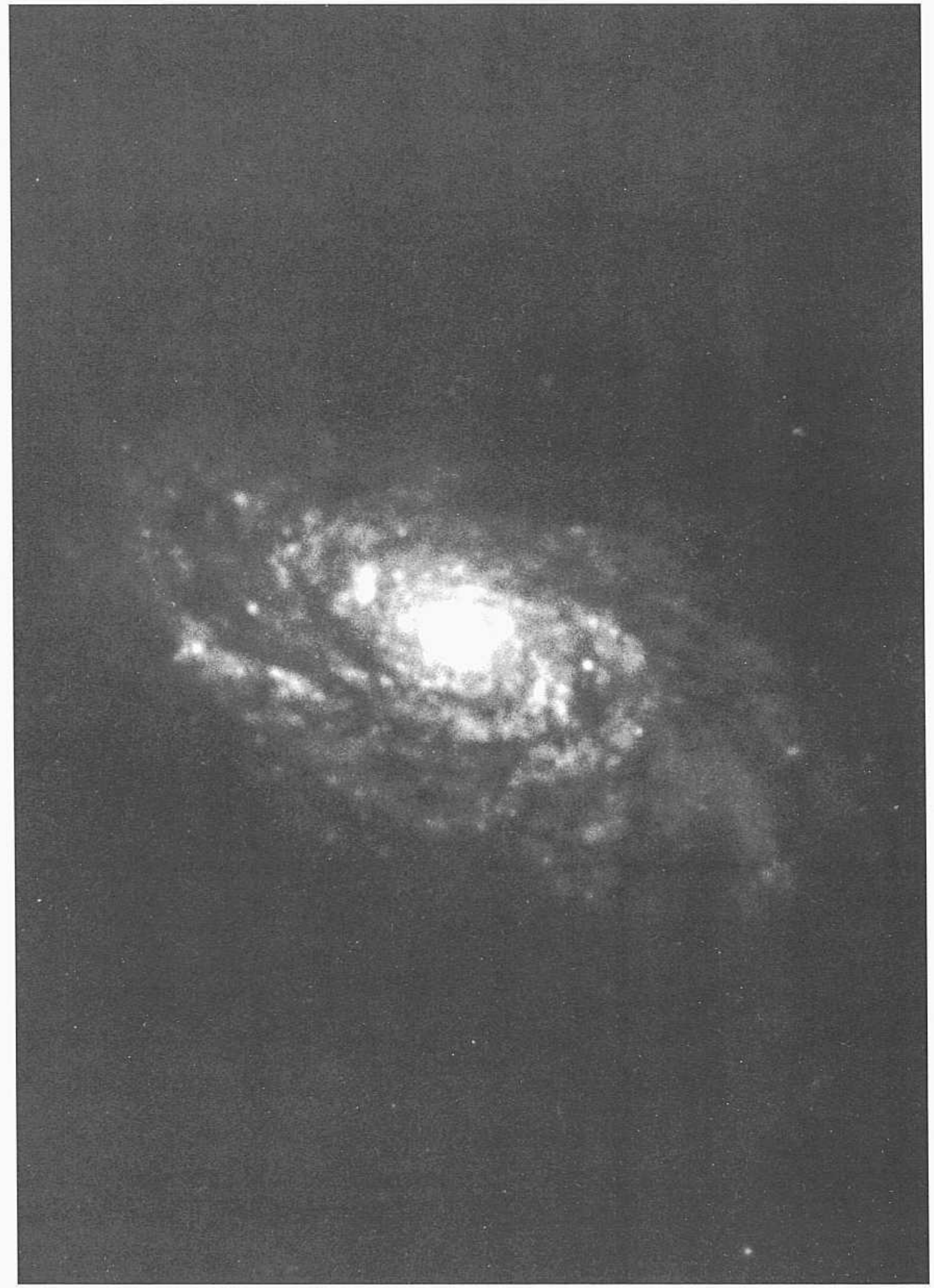
Two sets of arms exist in NGC 5633. The inner set, of extremely high surface brightness, is shown in the print here, made from a very-short-exposure Palomar plate. The outer set of much-fainter-surface-brightness arms is not seen here.

The redshift is v_{n} = 2437 km $s^{"1}$.



PANEL
253

PANEL
254



Galixios on this and the next panel arc grouped together as Sell galaxies with multiple-arm morphologies similar to the arm patterns of NGC 488 (Sal>; panels L15, S3, SI 2) and NGC 2841 (Sb; panels 142, S4, SI 2).

NGC 1437 Sc(s)II FCC 290
CD-192-S
Fel>8/9, 1978
103aO + GG385
45 mill

NGC 1437 is listed as a member in the Fornax Cluster Catalog (Ferguson 1989). It is located about 1° southeast of the center (nominally at the position of NGC 1399). Us redshift is v_0 = 1067 km s^{-1}. The adopted mean redshift of the Fornax Cluster is <v_o> = 1366 km s"[1] (Ferguson and Sandage 1990).

The Fornax Cluster is 0.2 mag more distant than the Virgo Cluster (Ferguson and Sandage 1988, Sandage and Tammann 1990) and therefore has a distance modulus near $m — M$ = 32. Resolution of NGC 1437 into individual stars occurs about half a magnitude above the plate limit of this image (B = 23) made with the Las Campanas du Pont 100-inch reflector; therefore the absolute magnitude of these brightest stars is about *MB* = —9.5. The several IUI-region candidates are unresolved at the 1" level.

NGC 441-1 Sc(sr)H.2
[-1-2384-11
Fcb 21/22, 1917
IlaO
10 iiiin

The multiple-armed spiral structure is well developed in NGC 4414. Dust accompanies the luminous arm fragments and is well silhouetted against the near side of the underlying disk. The Illl regions are unresolved, as are the brightest stars on this plate taken with the Mount Wilson LOO-inch Hooker reflector. The redshift of NGC 4414 is v_B = 702 km s^{-1}.

NGC 1792 Sc(s)II
CD-129-HB
Jaii 6/7, 1978
103aO + GG385
60 niin

Tlie surface brightness of the spiral fragments covering the disk is exceptionally high. The arms are massive in the sense ol Reynolds (1927a.b). and the spiral pattern is multiple, as in NGC 488, but NGC. 1792 here is of later morphology; the arms are not thin or as easily traced as they are in NGC 488.

The redshift is o_o = 1 055 km s^{-1}.

NGC 1792 Sc(s)II
CD-1347-S/Br
March 15/16, 1980
103aO + GG385
7 niin

This print from the short-exposure plate shows the high-surface-brightness ridge positions of multiple arms. Hll-region candidates are numerous along the ridge lines. Note the small nucleus.

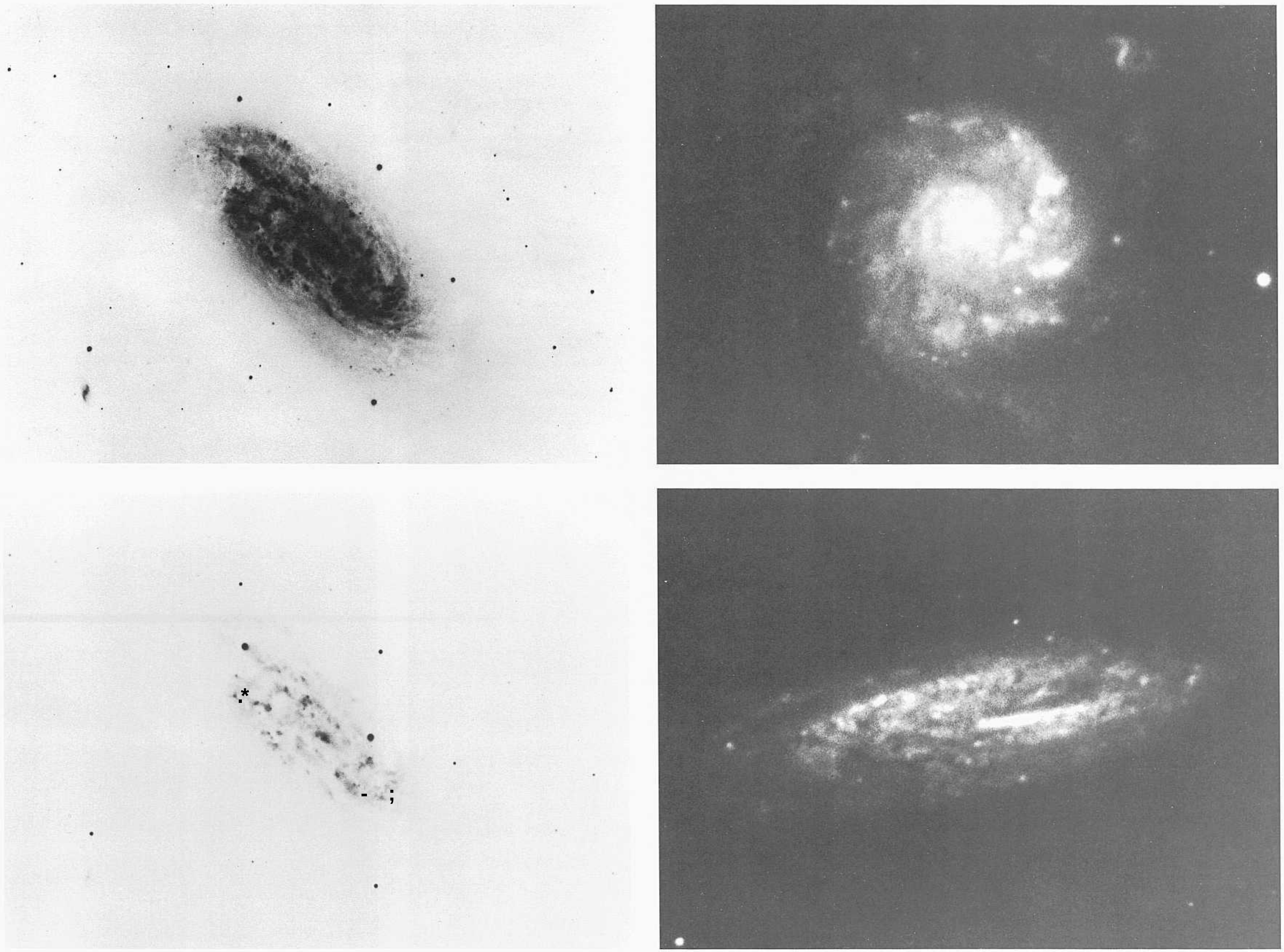
NGC 1309 Sc(s)II Racine wedge
PH-7918-S
Nov 7/8, 1980
103aO
12 niin

The spiral arms are regular and are very tightly wound. The inner-arm pattern is of high surface brightness. One of the principal arms is brighter than the other. Both begin at the edge of the inner disk, which itself is filled with luminous arm segments that begin at the center.

Hll-region candidates exist. A few candidates for individual brightest stars also exist in the low-surface-brightness parts of the outer arm system, but identification as stars must yet be done by the standard methods that separate stars and HII regions. The redshift is v_o = 2143 km s~'. At the redshift distance of m - M = 33.2 a star of absolute magnitude Mg = -10 has a blue magnitude of B = 23.2, which is fainter than the candidate stars: the starlike candidates are therefore interesting, as they may be HII regions.

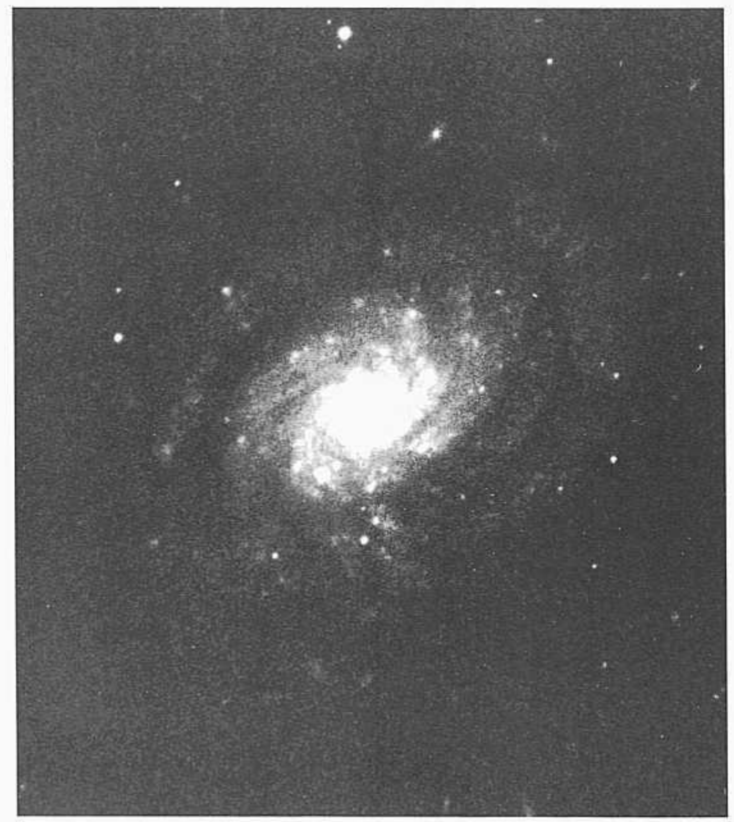
NGC 754-1 Se(s)II Karachentsev 578
H-945-Dunean panel 282
Sep 2/3, 1945
103aO
60 niin

NGC 7541 forms a physical pair with NGC 7537 [Sc(s)] at an angular separation of 2.7'. Karachentsev (1987) gives redshifts of i'_o(7537) = 2834 km s~' and u_o(7 541) = 2793 km s"'. At the mean redshift distance of 5 6 Mpc the projected linear separation is small, at 44 kpc. There is no evidence for morphological distortion in either galaxy, despite this apparent closeness.



PANEL
255

PANEL
256



NGC3684 **Sc(s)Il** group
CD-1811-**IIK**
April 2/3, 1981
I03a0
7ƀ mill

NGC 3684 is IIK- center <>f ;i small group of seven confirmed members (based on similarity ol redshifts). The number of candidate group members is ;is lii^h us 15, Many of the fainter candidates are dwarf Sin and Im morphological types.

The confirmed group members listed in llie RSA are NGC 3681 (SBb; panel L64;u_o-1135 kms"[1]), NGC 3686 (SBbc; panel 20*): v_o~ 1034 km a"[1]), and NGC 3693 (Scd; panel 317; v_0 = 947 km s~[l]). Other members lhal have 21-cm redshifts are listed in Hoffman *et til. (* 1 987). The mean redshifl of the seven confirmed group members is <v_u> =1021 km s~[l].

The group is more compact than the Local Group. The members are within I ° of each other, a linear diameter of 35 6 kpc (about one-third the size of the Local Group).

The three images of NGC 3684 on the opposite page have been made from a single original tlu Pont 100-inch plate taken at Las Campanas hut printed to different densities to show the inside spiral pattern [(s) type] and the very-low-surface brightness outer-arm struelure, which has at times been called a fossil-arm pattern.

The four galaxies on this panel continue the pattern of two sets of arms seen on the preceding panel. An inner set has very high surface brightness; an outer set of very faint outer arms exhibits the form of what is often called a fossil-arm pattern, common in many galaxies. Earlier-type galaxies having this pattern include NGC 1068 (Sb; panel 138) and NGC 3981 (Sbc; panel 178).

NGC 4793 **Sc(s)II.2** **HA,** p. *35*
H-2273-H
May 5/6, **1946**
103aO
40 min

A possible dwarf companion (type Sm?) to NGC 4793 exists at an angular separation of 1.3'. The **redshift** of NGC 4793 is $v_o = 2460$ km s^{-1}. If the satellite is a companion, the projected linear separation from NGC 4793 is small at 19 kpc, based on a redshift distance of 49 Mpc *(H* = 50). One of the outer low-surface-brightness fossil **arms appears** to connect with the satellite.

NGC 3403 **Sc(s)II** **Racine** wedge
PH-8015-S
Feb 3/4, 1981
103aO
12 min

There is an **abrupt** change of surface brightness between the inner and outer sets **of multiple** arms in **NGC** 3403.

The redshift is $v_o = 1422$ km s^{-1}.

NGC 5756 Sc(s)II panel 239
CD-1471-S/Br
May 10/11, 1980
103aO + GG385
45 min

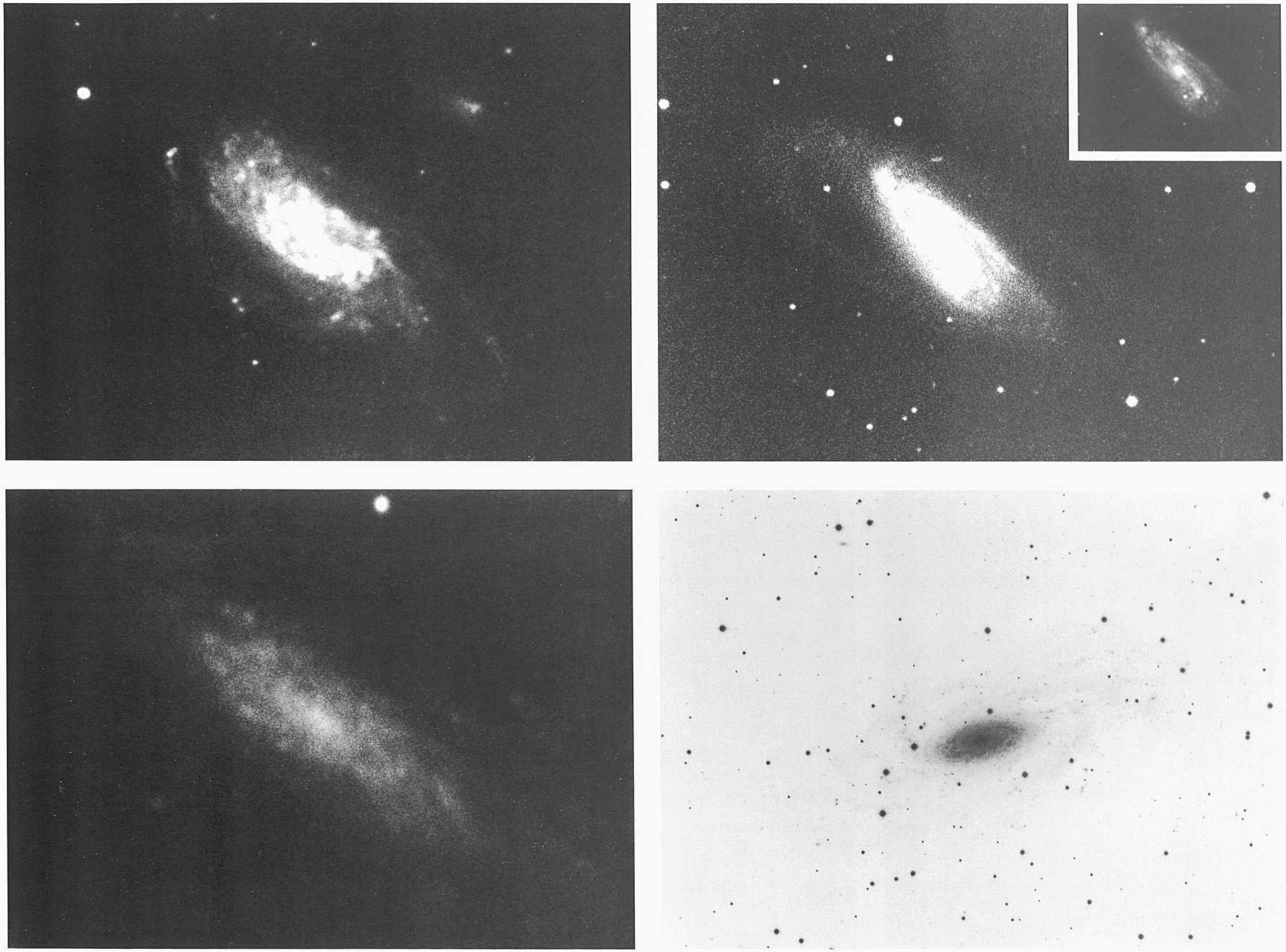
The **very-faint-surface-brightness** outer arms in NGC 5756 are smooth, showing no evidence of recent star formation. The two main **high-surface-brightness** inner arms start at **the** small nucleus in a prototype (s) pattern.

The redshift is $v_0 = 2025$ km s^{-1}.

NGC 2090 **Sc(s)II** panel 250
CD-663-Br
Jan 22/23, 1979
103aO + **GG385**
45 min

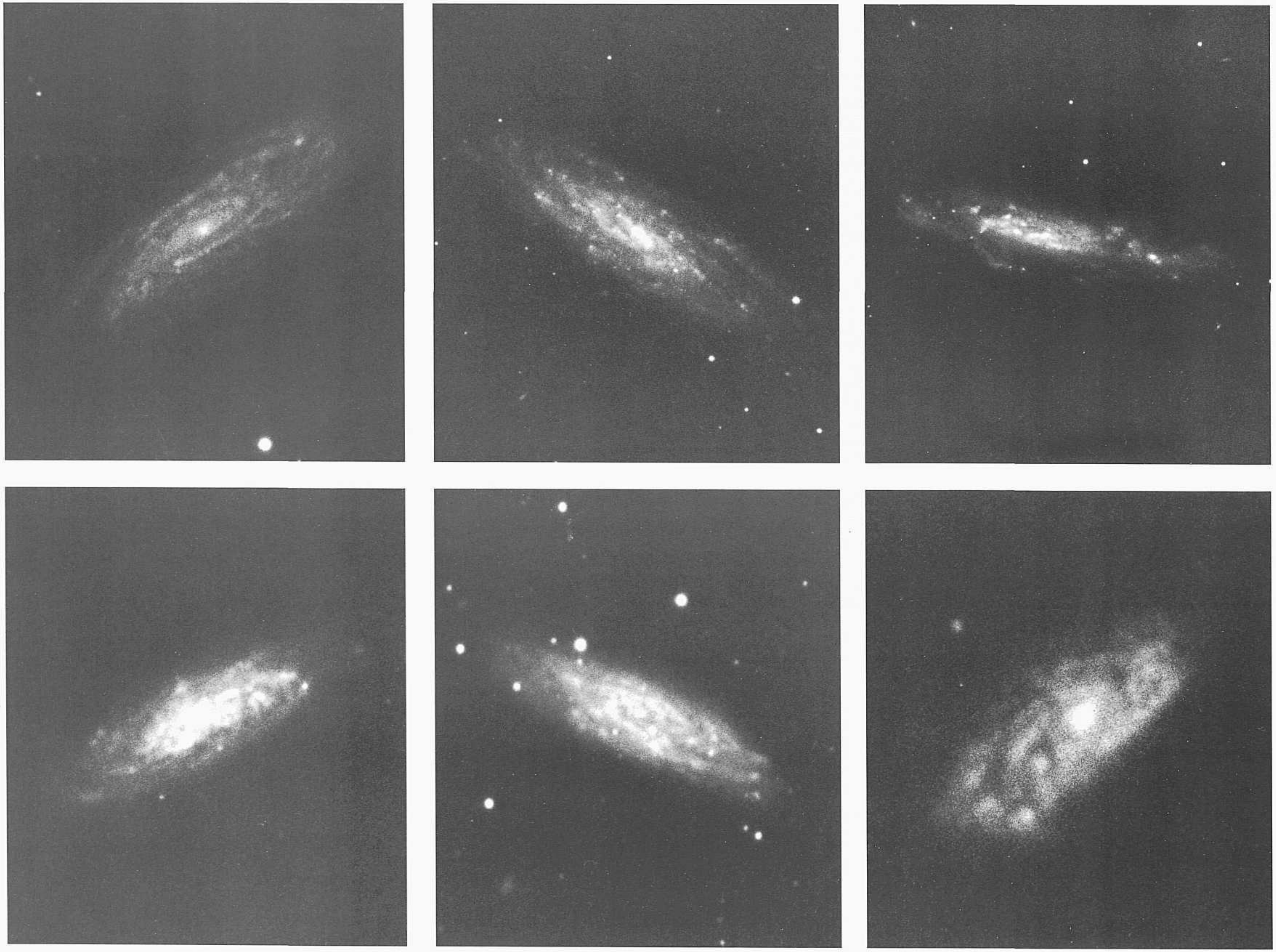
NGC 2090 is repeated here from panel 250 to illustrate and compare the pattern of high-surface-brightness inner arms and low-surface-brightness outer arms with the similar pattern shown by other galaxies on this page. The pattern is similar to that in such prototype cases as NGC 1068 (Sb; panel 138) and NGC 3981 (Sbc; panel 178).

The redshift is $v_o = 755$ km s^{-1}.



PANEL
257

PAXEL
258



The six galaxies on this panel complete the Sell morphological bin of RSA galaxies whose arm pattern is generally filamentary, often similar to the pattern in NGC. 488 but later in the classification sequence. All six galaxies here are highly inclined to the line of sight, showing well the absence of a central bulge and the presence of only a small nucleus.

NGC 3549 Sc(rs)II
PH-8073-S
Feb 5/6, 1981
103aO
12 niin

The multiple arms in NGC 3549 are thin, regular, and multiple. The redsbift is v_0 = 2921 km s~J.

NGC 3437 Sc(s)II Racine wedge
PH-8021-S
Feb 3/4, 1981
103aD
2 ruin

The image of NGC 3437 here is from a yellow plate (no filter) with a very short exposure, designed to see the semi-chaotic spiral pattern over the high-surface-brightness inner disk. The redshift of NGC 3437 is u„ = 1201 km s^{-1}.

NGC 3956 Sc(s)II group
CD-1672-S
Dec 31/Jan 1, 1980/1981
103aO
60 niin

NGC 3956 is in a rich field that includes the RSA galaxies NGC 3957 ($S0_3$: panel 44), at a separation from NGC 3956 of 59.2' with a redshift of v_0 = 1583 km s~' . and NGC 3981 (Sbc: panel 178), at a separation of 50.0' with a redshift of $v_{()}$ = 15 54 km s^{-1}. The redshift of NGC 3956 itself is v_o = 1.394 km s"[1]. If the three galaxies are physically related with mean redsbift of <f_o> = 1510 km s^{-1} at a redshift distance of 30 Mpc (/7 = 50), the projected linear separations from NGC 3956 are 516 kpc and 436 kpc from NGC 3957 and NGC 3981, respectively. These dimensions are similar to the size of the Local Group.

The field around and between these three bright galaxies contains many (IE, Im, and Sm dwarf galaxy candidate members of the group.

IC 5039 Sc(s)II pair
CD-1529-S/Br
Aug 6/7, 1980
103aO + GG385
45 niin

IC 5039 forms a physical pair with IC 5041 [SBbc(s)II; not in the RSA] al a separation of 9.8'. The redshifts are i>$_o$(5039) = 2723 km s~\ and y,,(5041) = 2 739 km ī[1]. At the redshift distance of 55 Mpe (// = 50), the projected linear separation is 157 kpc.

NGC 3003 S.-(s)H
PH-7958-S
Nov 8/9, 1980
103aO
12 mill

NGC 3003 is seen nearly on edge, making its spiral pattern difficult to trace. The absence of a halo and (he smallness of the central nucleus is evident.

The redshift of is v_a = 116 1 km s"'.

NGC 6808 Sc(s)II
CD-480-S
Sep 23/24, 1978
103aO + GG385
60 mill

Three principal arms can he traced in NGC 6808, two on one side and one on the other. The arms are intermediate in width between narrow and massive in the sense of Reynolds (1927a,b).

The redshift is i'$_o$ = 3281 km s"'.

Galaxies on the next 16 panels are of the late-luminosity classes II-III and III. Many are nearby and are highly resolved into individual stars and HII regions, making them especially useful for calibration of the extragalactic distance scale. Many of the disks are of low surface brightness; hence photometry of the resolved stars will be relatively straightforward.

IC 5332 **Sc(s)H-III** **pair**
CD-539-S
Oct 1/2, 1978
103aO + **GG385**
45 niin

IC 5332 forms a wide pair with NGC 7713 (Sc; panel 267) at a separation of 1.9° and at redshifts of 713 km s~[1] and 684 km s~[1]. At a mean redshift distance of 14 Mpe *(H* = 50), the projected linear separation of the pair is 464 kpc, similar to the distances within the Local Group.

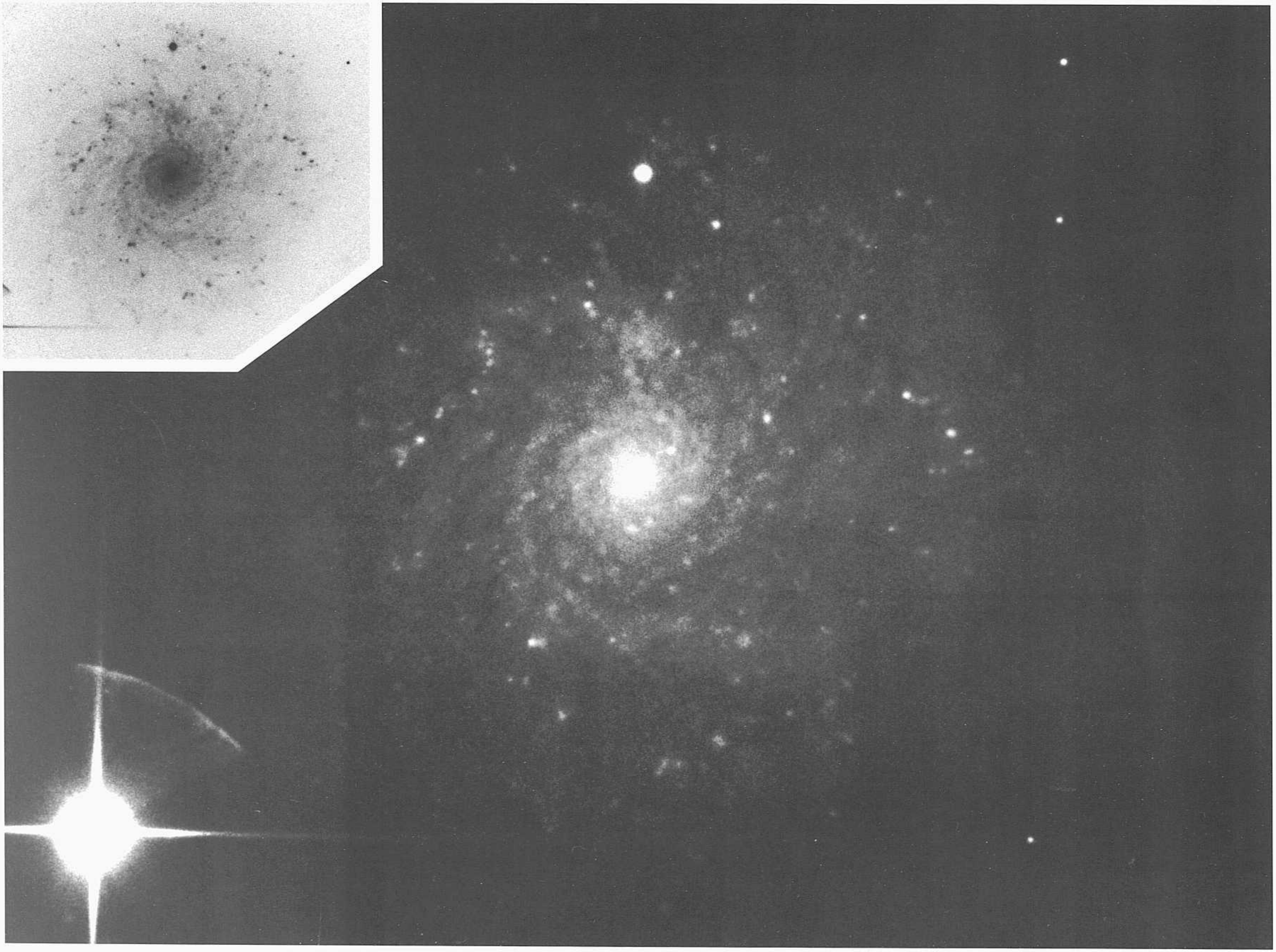
IC 5 3 32 resolves easily into individual stars starting at about *B* = 19. The surface brightness of the disk is low. making IC 53 32 a prime candidate for detailed photometric study.

The largest **HII** region in a faint outer arm has a disk diameter (core + halo) of 6". If it conforms to the linear halo diameter of 500 pc from the calibration of first-ranked **HII** regions in **ScII-III** galaxies (Sandage and Tammann 1974a), the **inferred** HH-region-based distance is 1 7 Mpc, similar to the adopted redshift distance given above. A similar distance is obtained from the ratio of the halo diameter 6" here to that of NGC 604 (the first-ranked HII region in M33. with a halo diameter of 100").

Because of the very low disk **surface** brightness and the easy resolution into individual stars, a detailed study of the stellar content would be of great importance.

PANEL
259

PANEL
260



NGC4571 SC(B)II-IU VCC 1696
CD-756-S
Feb4/5, 1979
103aO + Wr2c
50 inin

NCC **45 7 1 is an Sc galaxy in the Virgo Cluster whose potential for significant resolution** into individual stars and **1111 regions** from **tin* ground** is good, owing to **the low** surface **brightness of the disk** and **the** openness **of tin* spiral** arms.

The arm pattern **resembles** M 1 0 1 hut is **of** lower **surface** brightness. It is similar to hut later than thai in the **prototype multiple-armed** spiral NGC 488 (Sab; panels **L15, 116,** S3, S12).

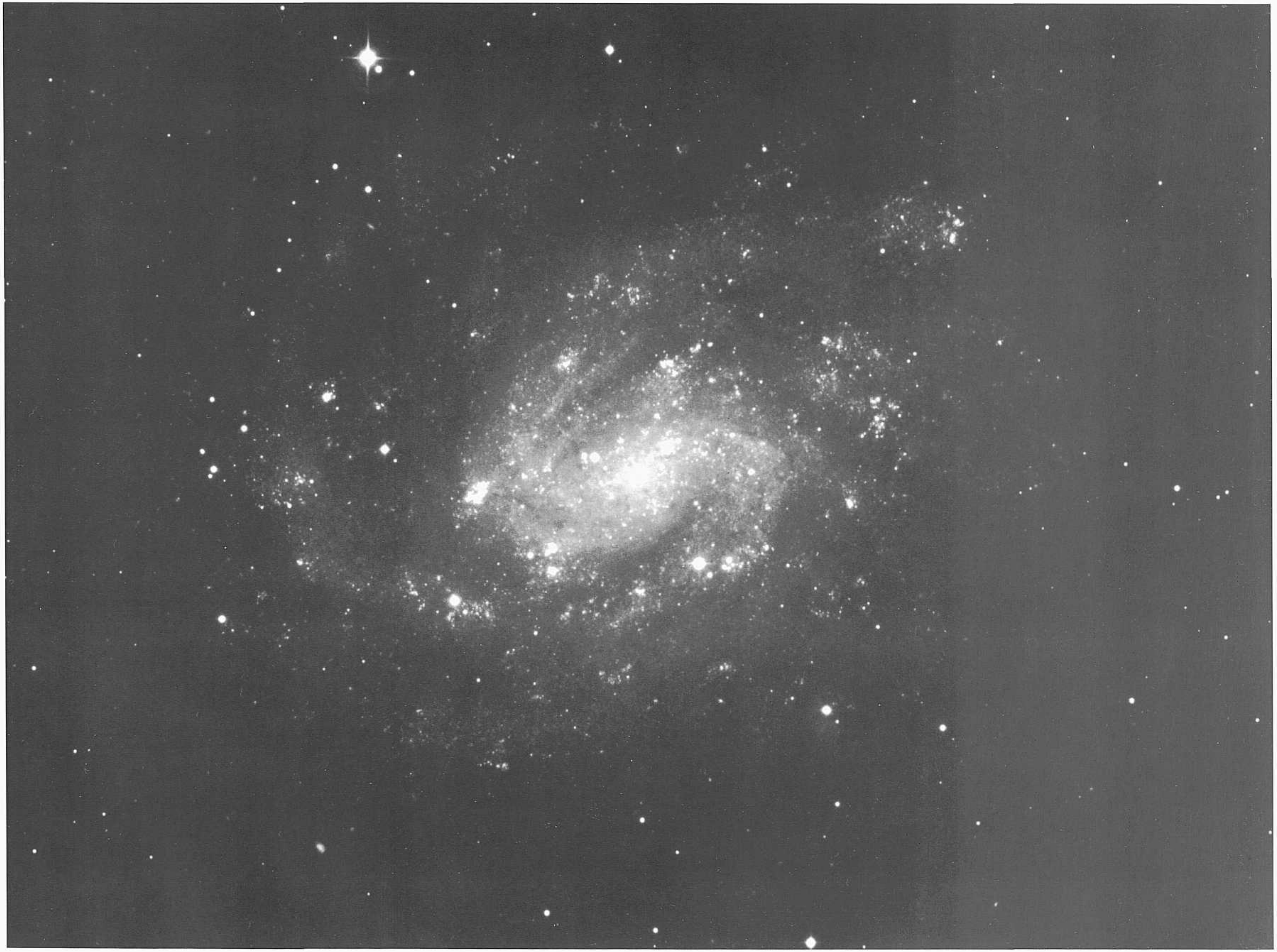
NGC 45 7 1 is in the northeastern **part of the** Virgo Cluster region, about 2.5° **from the core of** Virgo **subcluster** A assoeiated **with** [NGC 4486. Its redshift is v_0 = 342 km s^{-1} . **which differs from** the cluster mean of <v_o> = 976 km s^{-1}. **presumably** because of the large internal velocity dispersion of the Cluster and/or the streaming motions of the system of Virgo spirals relative to the Virgo core ellipticals. **Spirals** may **be falling into** the older cluster core, composed of ellipticals and dE dwarfs.

NGC 300 **Sc(s)II.8** **South Polar Gr**
CD-2044-Bedke/Gregory **panel S6**
Nov2/3, 1981
103aO
90rain

NGC 300 is a member of the South Polar Group **(de Vaucouleurs** 1959a), **which** also contains the well-resolved galaxies NGC 55, NGC 147, NGC 253, and NGC 7793. The distance modulus of NGC 300 is small, at $m - M = 26.5$ ($D = 2.9$ Mpc), determined from **Cepheids** (Graham 1984). Because the distance is so small, resolution into individual brightest stars in many well-defined associations is exceptionally easy, **beginning** at about $B = 18$ (estimated).

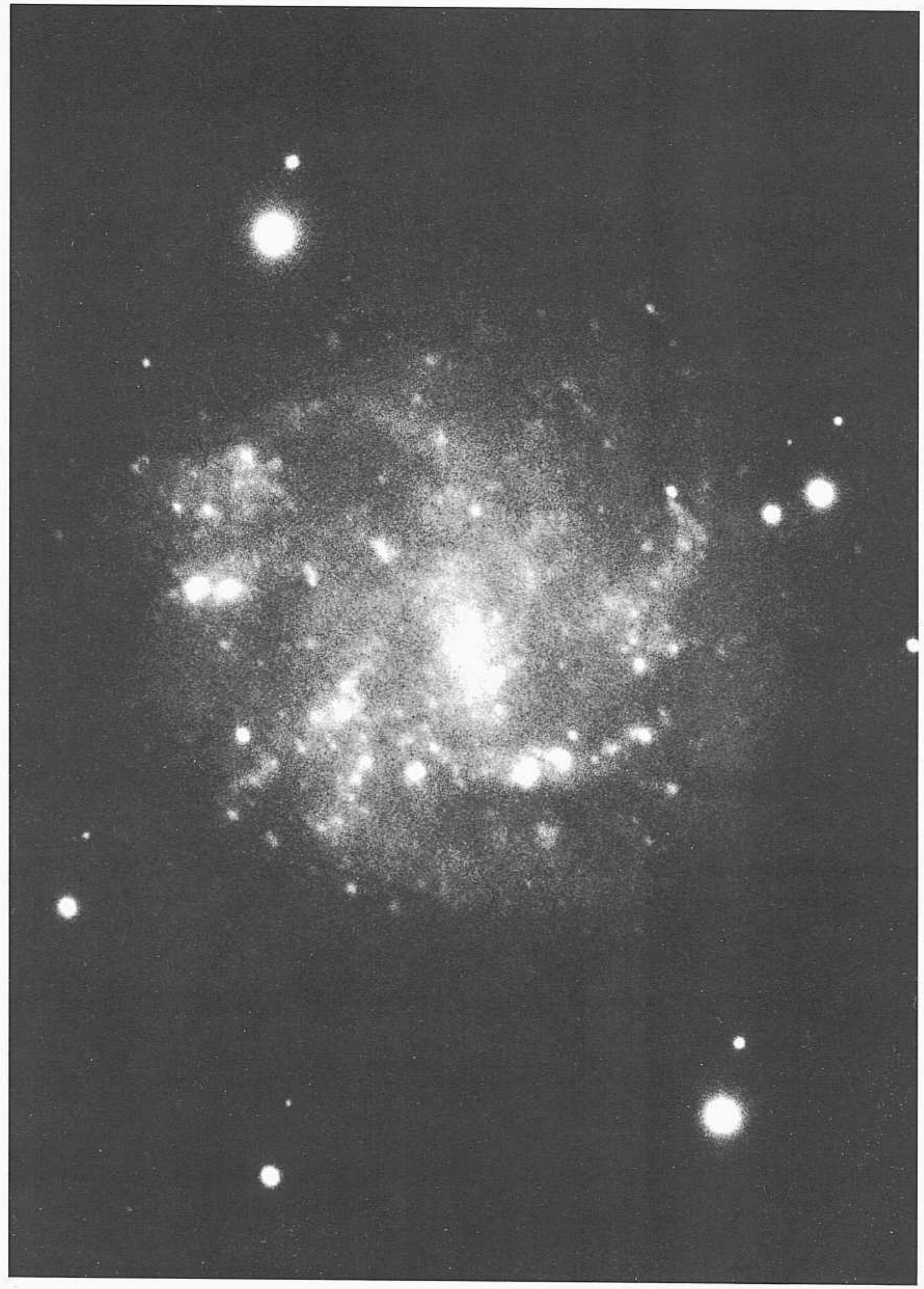
The brightest stars are contained in the associations. \et, only slightly fainter stars that are also young are spread throughout the interarm region.

The spiral-arm pattern is massive in the sense of Reynolds (1927a,b). At least two major arms exist on each side of the minor axis. Three arm crossings of the major axis can be traced on each side of the image.



PANEL
261

PANEL
262



NGC 598 **Sc(s)II-III** **HA, p.** *36*
PR-243-Schweizer **M33**
Aug 23/24, 1974
103aO + GG13
120 inin

The wide-field image **of** M3 3 **here** was **taken** with **the Palomar 60-inch** reflector by **Schweizer.** The telescoped remarkable **field of** more than 1 ° (diameter) with its large plate scale of 16 **arc** seconds per mm is the optical **design** of I. S. Bowcn. **His** design **of the** 60-inch Palomar reflector was the **prototype for the even-wider-field** Las Campanas 40-inch Swope **Telescope** and the remarkable Las Campanas 100-inch du Pont reflector, both of whose optics were also **designed** by Bowen.

The stellar content of M33 has been discussed in detail by Humphreys and **Sandage** (1980). They addressed the spiral pattern, the associations, the dust patterns, and the brightest resolved red and blue stars. The brightest blue stars begin to resolve at B = 15: the brightest red supergiants begin to resolve at V = 16.5.

Ten spiral arms were identified and mapped in that study. The two main inner arms have a different projected geometry than the outer eight arms. This was interpreted (Sandage and Humphreys 1980) as a warp of the spiral-arm plane, as in the tilted angular ring model of Rogstad, Wright, and Lockhart (1976).

The surface brightness of the disk is **moderate-to-light.** M33, the prototype for ScII-**III** galaxies, is the template by which other galaxies of this type and luminosity class are compared. Its near-twin is NGC 300, shown on the previous panel.

NGC **2500** **Sc(s)11.8** **quadruple**
PH-7704-S
Feb 11/12, 1980
103aO
12 min

Individual stars arc **n<I** as easily **resolved oul** of the **high** surface background of **the** disk in NGC. 2500 as in IC 5332 (panel 259). which has nearly the same **redshifl.** The **Illl** regions **are** numerous and are of high **individual surface** brightness. The largest of **these** has a disk diameter of about 3".

NGC 2500. with redshifl v_0 = 713 km s~'. forms a wide **quadruple** with NGC 2537 (Sc pec; panel 275: v_0 = 5 13 km s"'), **NGC** 254] (Sc; panel 264: $v_{,,}$ = 646 km s"[1]). and **NGC 2552** (Sd; **pane]** 322; v_0 = 607 km s^{-1}). **The** separations of the members of this nearby **group** are discussed in the description paragraph for iNGC 2541 (panel 264).

NGC 3780 Sc(r)II.3
PH-7634-S
April 28/29, 1979
103aO
12 niin

The spiral pattern in NGC 3780 is similar to the multiple arms in the prototype multiple-armed galaxy M101 (Sc; Hubble Atlas, pp. 27, 37; panel 218 here). Both galaxies are later versions of the multiple-armed pattern of NGC 488 (Sab: panels 115.1 16. S3. S12).

The arms in NGC 3 780 are thin but highly branched. Most can be traced as individual fragments for only about a half-rotation.

The many individual HII regions are unresolved at the 1" level. The redshift of NGC 3780 is v_o = 2481 km s"'.

NGC 2276 Sc(r)II-III Karachentsev 127
S-1879-H
Dec 4/5, 1939
103aO
60 min

NGC 22 76 forms a pair with NGC 2300 (E3: panel 6). The redshifts measured by Karachentsev are u_o(22 76) =2 598 km s^{-1} and i;$_o$(2 3 00) =2332 km s^{-1}. The separation of 6.3' corresponds to a projected linear separation of 90 kpc at the mean redshift distance of 49 Mpc.

The difference in morphological type of the pair is particularly to be noted (Sc and E3) if the two galaxies form a bound system. Other listed nearby Dreyer galaxies are IC 455 (SO) and IC 469. Many fainter early-type galaxies and several candidates for dwarf dE galaxies also exist in the field.

The image here of this field near the celestial pole is from a plate taken with the Mount Wilson 60-inch telescope. For comparison, an image from a plate taken with the Palomar 200-inch Hale reflector is shown at the right.

NGC 1659 Sc(s)II-III
H-44-S
Feb 8/9, 1951
103aO
25 min

The multiple spiral arms form an asymmetrical pattern over the outer disk. The asymmetry is similar to that in NGC 22 76, below, but unlike in that galaxy there is no evidence in NGC 1659 for a close (tidal) encounter. NGC 1659 appears to be isolated.

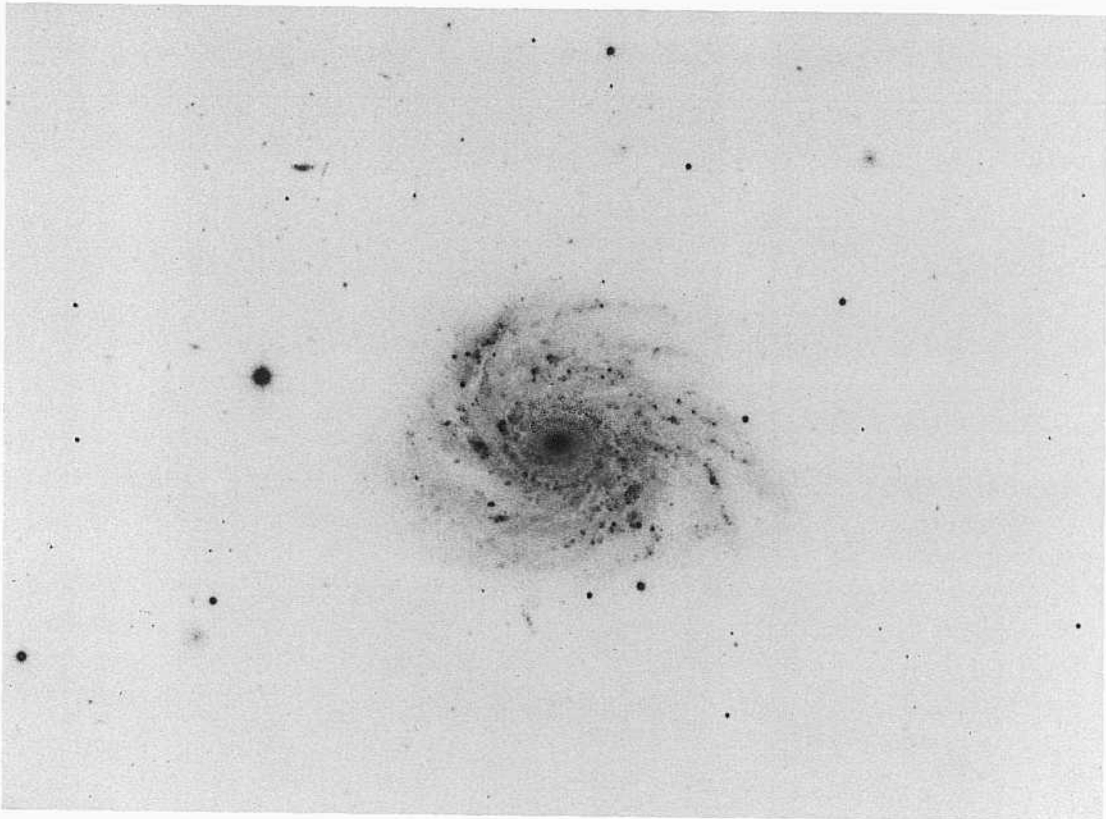
The multiple-arm pattern, which is asymmetric in the region where the arms end abruptly at an outer edge, is nearly identical with that of NGC 95 (Sc: panel 248). The pattern is also similar to that in NGC 5605 (Sc; panel 246).

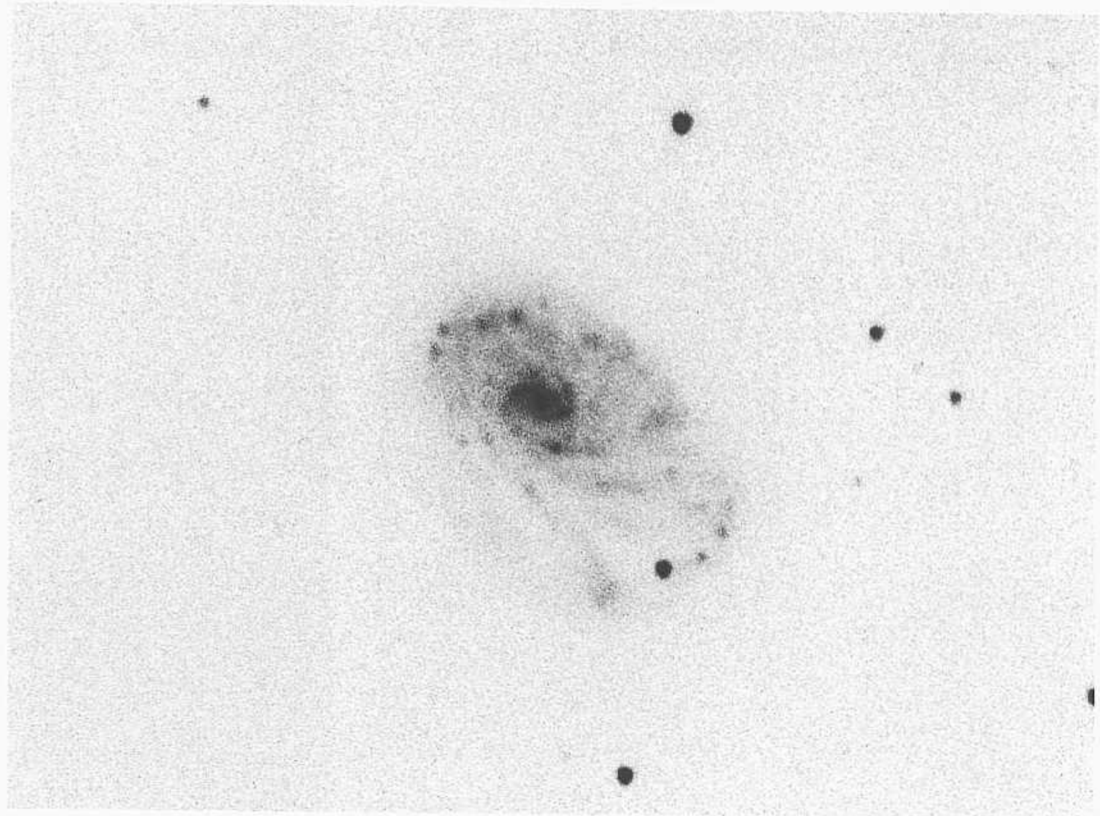
The redshift of NGC 1659 is v_n =4522 km s^{-1}.

NGC 2276 Sc(r)II-III Karachentsev 127
PH-7566-S
Nov 7/8, 1978
103aO
12 min

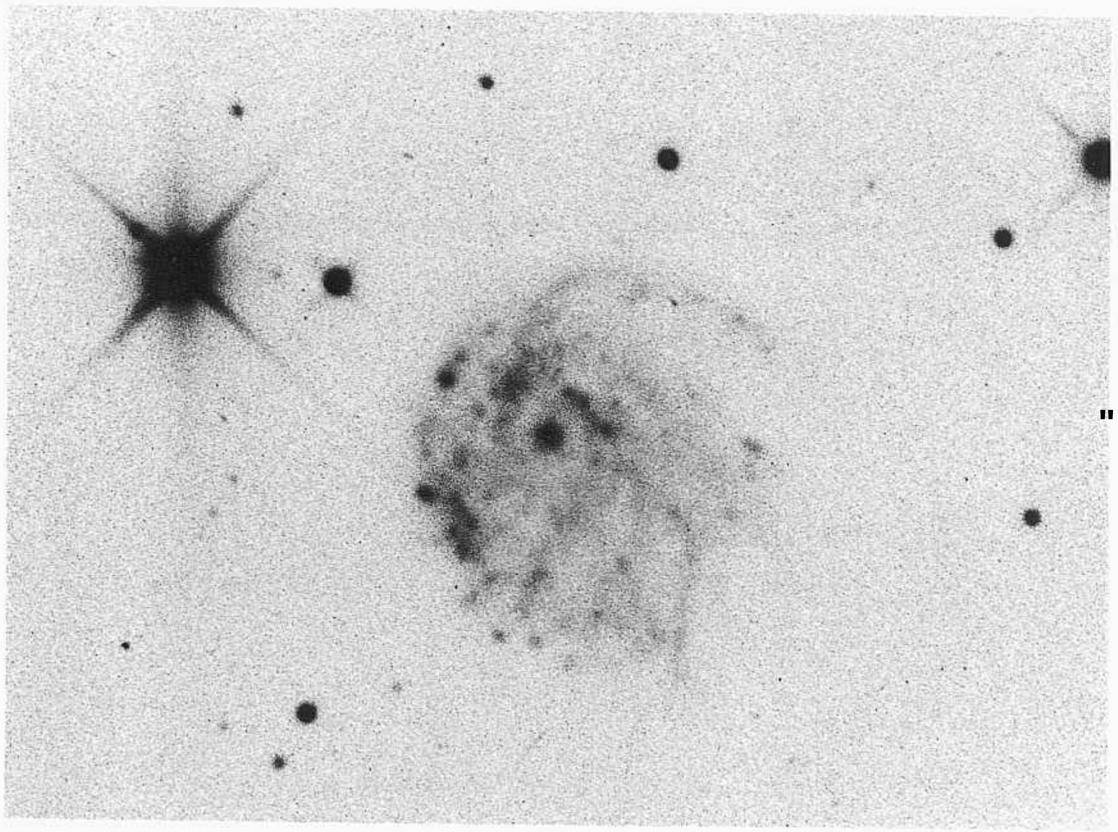
Compare the image of NGC 22 76 taken with the Palomar Hale 200-inch telescope in the print here with that taken with the Mount Wilson 60-inch reflector in the print to the left.

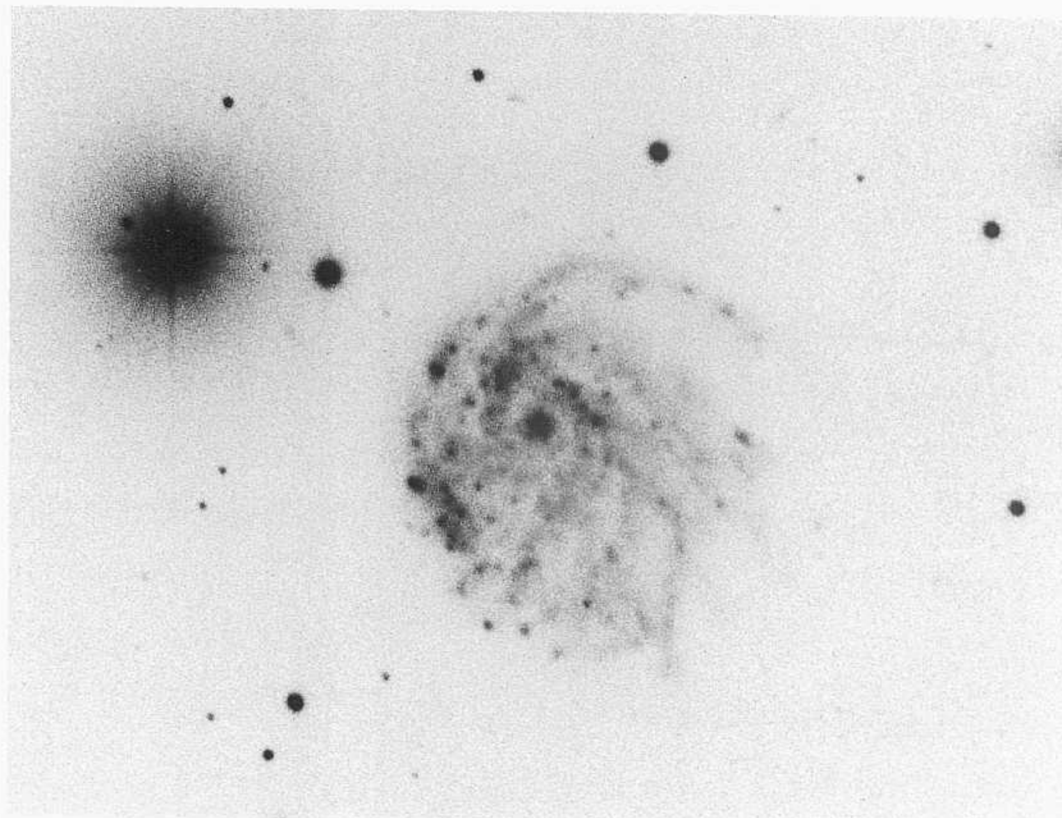
The spiral pattern is unusual, perhaps because of a tidal encounter with the probable companion NGC 2300 (E3; panel 6), whose projected linear separation is small at 90 kpc.



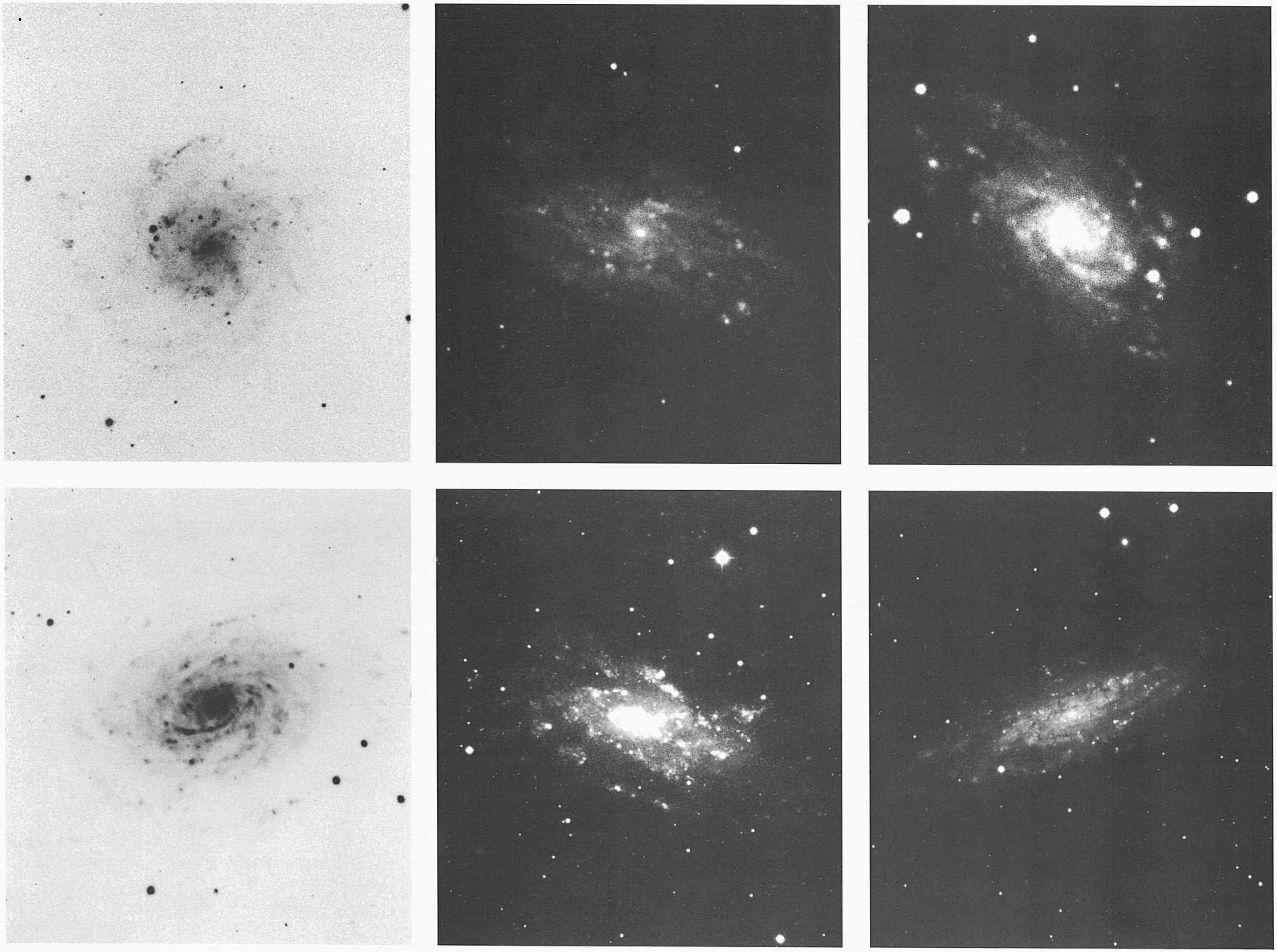


PANEL
263





PANEL
264



The six galaxies on this panel continue the late-luminosity class, Sc morphological type, where the arm pattern is multiple and where the arm fragments are thin. The arm pattern in each galaxy has similarities to the spiral pattern in M10 1 (Se; panel 2 18) lint the geometrical entropy is higher (mure chaotic) here; hence the later-luminosity class is required.

NGC 5668 Sc(s)II-III panel 268
CD-2114-S
March 19/20, 1982
103aO + GG385
35 min

The brightest HII region in NGC 5668 is double, apparently resolving at about the 2″ level. The numerous other Mil regions are unresolved at 1". The redshift of NGC 5668 is v_o = 1491 km s~'.

NGC 5962 Sc(rs)II.3 HA, p. *30*
II-2295-H
July 2/3, 1946
ItaO
30 mil)

The HII-region candidates are unresolved at the 1" level. The redshift of NGC 5962 is v_0 = 1972 km s~\

New 4 = A 1252+00 S«(s)II-Ill
CD-2167-S
March 27/28, 1982
103aO + GG385
45 min

The largest of the several II11 regions appears to be a composite of several separate but overlapping regions, presenting a disk of about 2" diameter. The other regions are unresolved. The redshift of New 4 is v_0 = I I 60 km s"'.

NGC 2541 Sc(s)III group
PH-93-MH
March 16/17, 1950
103aO
10 min

NGC 2541 is highly resolved into individual HII regions. The largest three of the more than 50 such regions identifiable on this short-exposure Palomar 200-inch plate have resolved disks at the 3"-diameter level.

NGC 2541 is near the middle of a loose group of at least four highly resolved late-type galaxies, all in the HSA. already mentioned in the description of NGC 2500 (Sc; panel 262). The mean redshift of the group is $<v_0>$ = 595 km s^{-1}. The individual redshifts are u_o(2500) = 615 km s~\ u_o(2 5 3 7) = 513 km s~\ tf_o(2541) = 646 km a^1, and u,,(2552) = 607 km s⁻'. The angular separations and corresponding projected lineal-separations from .NGC 2541, based on a mean redshift distance of 1 1 .9 Mpc (/•/ = 50), are 2 .6° and therefore 540 kpe for NGC 2500. 3.1° and 644 kpc for NGC 2537, and 1 .2° and 2 19 kpc for NGC 2552. These projected linear separations are similar to distances within the Local Group.

Note the similarity of the HII-region brightness distribution and the spiral pattern in all members of the group, seen on panels 2 62, 275, and 322 in addition to the pane! here.

NGC 6106 **Sc(rs)II.3**
CD-910-HB
April 29/30, 1979
103aO + GG385
40 min

The redshil'i of NGC 6 1 06 is r,, = 1459 km s^{-1}. The IIII regions are unresolved at the I" level.

NGC 7456 Sc(s)II-III
CD-549-S
Ocl 2/3, 1978
103aO + GG385
15 min

The surface brightness of the disk is low. There is no central bulge: as in all Sc galaxies on this and previous pages, the nucleus is either small or often unresolved al the 1-2" level, as here. The redshift of this galaxy is v_o = 1199 km s^{-1}.

The six galaxies on this panel complete the late-luminosity class (II-III/III) of the Sc classification section for galaxies with thin arms. The ScII-III and ScIII galaxies with intermediate or massive arms follow on panels 266-272.

NGC 4062 Sc(s)II-III HA, p. *20*
H-2246-H
March 7/8, 1946
103aO
60 rain

The multiple-armed structure of the NGC 488 type begins at the small nucleus of NGC 4062 and. together with associated spiral dust lanes, spreads throughout the moderately low surface brightness disk. A few HH-region candidates exist, which, despite the low redshift of v_0 = 745 km s^{-1} , are unresolved at the I" level.

The plate used for the image here was taken with the Mount Wilson 100-inch Hooker reflector.

NGC 3949 Sc(s)III
S-476-H
June 16/17, 1925
E40
40 inin

NGC 3949 is in the highly complex Ursa Major region, within which at least four separate kinematic groups can be identified. The lowest-redshift group contains the highly resolved late-type spirals NGC 4144, 4214, 4244. 4449, 4736. and IC 4182. The mean redshift of this group is<t'$_o$> = 28 5 km s^{-1} . The second kinematic group at <v_o> = 59 5 km s^{-1} is associated with M51, and contains also NGC 42 5 8, 4490 , 461 6, and others. A group with <v_o> near 750 km s~^{1} contains NGC 3675, 3769. 3782, IC 750, NGC 4051. 4242. and NGC 3949 shown here. The fourth group is the great Ursa Major Cluster, with <u$_o$> about 980 km s^{-1}.

The image here of NGC 3 949 is from a Mount Wilson 60-inch plate. The surface brightness of the disk is high. Useful resolution into stars from the ground seems unlikely.

The redshift is u„ = 85 7 km s~^{1}.

NGC 6015 Sc(s)II-III
PH-5543-S
June 6/7, 1970
103aO + GG385
20 nún

The multiple-arm pattern of NGC 6015 starts at the center in a prototype (s)-type configuration. There is no evidence of a central bulge. The nucleus is small, characteristic of the Sc morphology. The redshift of NGC 6015 is v_o = 1018 km s"'.

NGC 4428 Sc(s)II.3
H-2263-S
May 4/5, 1946
103aO
40 min

NGC 442 8 forms a physical pair with NGC 4433 (She; panel 194) at an angular separation of 7.2'and v_o redshifts of 2 828 km s~' and 2 771 km s^{-1} , respectively, giving a mean redshift distance of 56 Mpc. The projected linear separation is 117 kpc.

The print here is from a Mount Wilson 100-inch plate. The print of NGC 443 3 on panel 194 is from a Palomar 200-inch plate. Note the similar morphology of the two galaxies of this pail*.

NGC 4595 Sc(s)II-IH VCC 1811
H-1729-H
Dec 25/26, 1935
Imp. Eel.
60 min

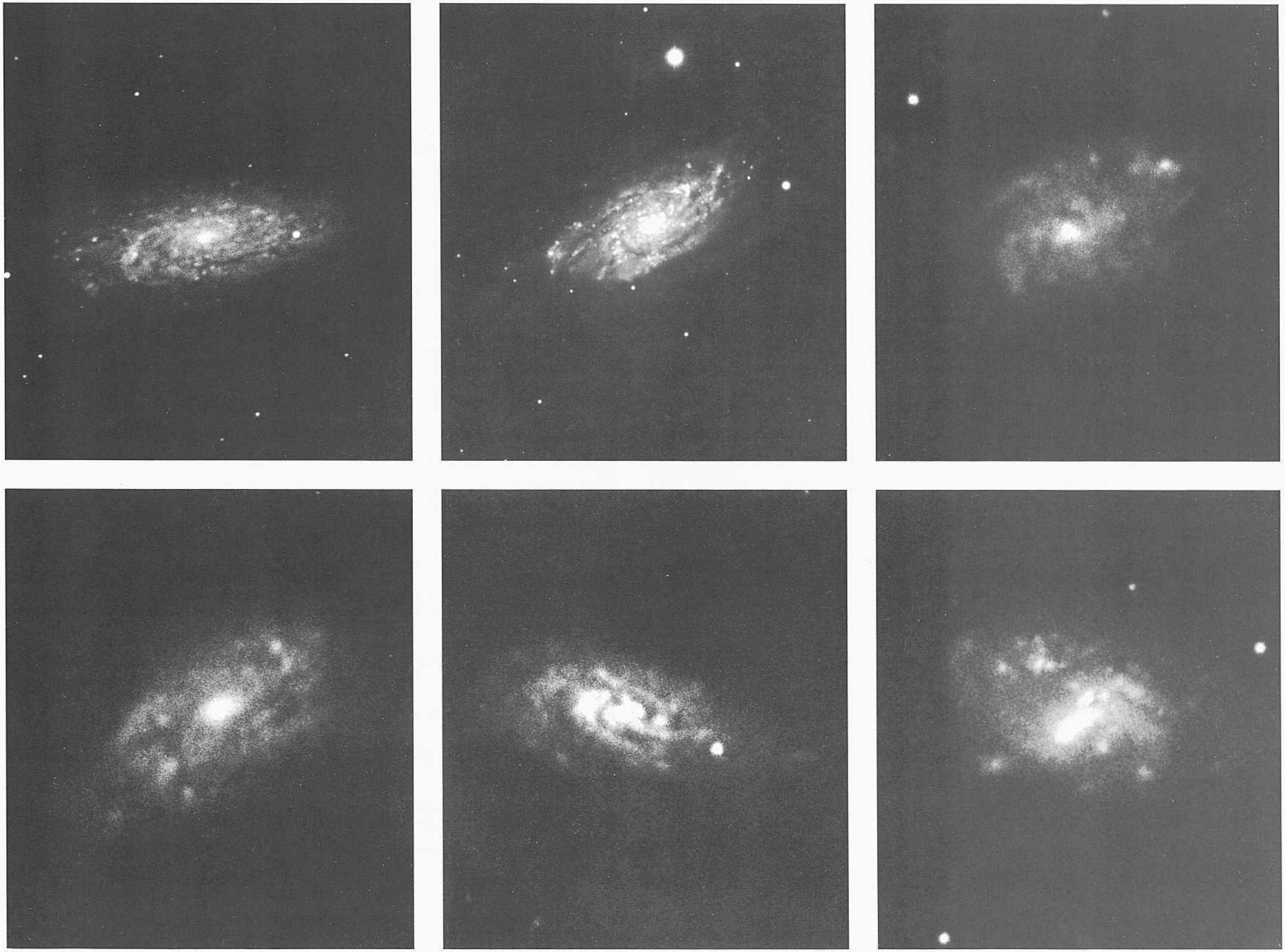
NGC 4595 is a small galaxy located 3.7° northeast of NGC 4486, which is the brightest galaxy associated with the Virgo subcluster A. A comparison of the angular size of NGC 4595 with other Virgo Cluster galaxies is made in the atlas of such galaxies printed to a common scale (Sandage, Binggeli, and Tammann 1985a).

The redshift of NGC 4595 is v_B = 559 km s^{-1}.

NGC 5645 Sc(s)II-III
CD-1868-HB
April 9/10, 1981
103aO
75 min

The spiral pattern in NGC 5645 is less regular than in other galaxies of luminosity class II-III on this panel. The pattern has a similar geometrical entropy to that in NGC 42 8 (ScIII) on the next panel, and hence the luminosity classification might have been placed at III. Note, however, that the arms are still moderately thin in contrast to the massive arms in, say, NGC 2427 (Sc: panel 269).

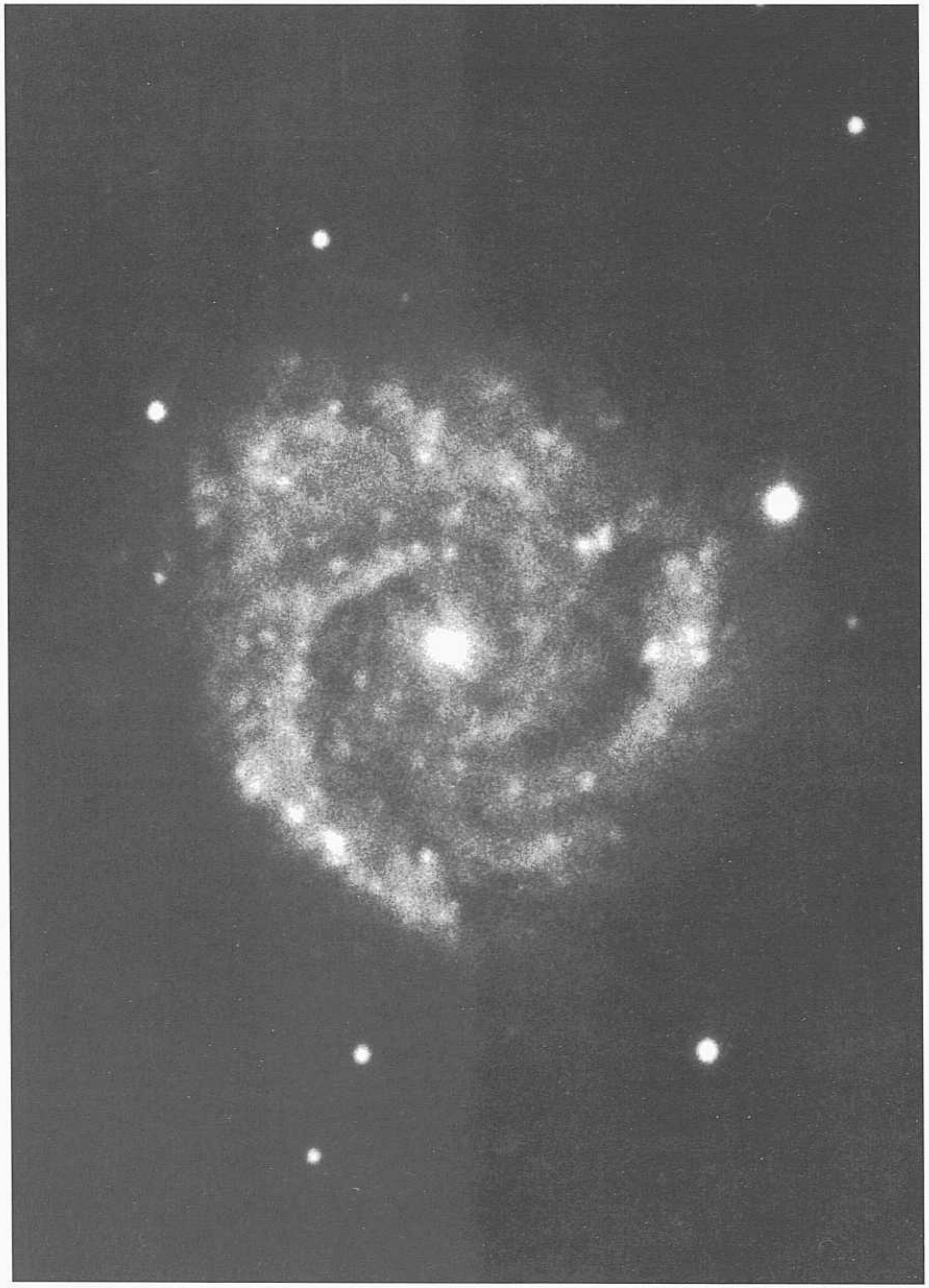
The redshift of NGC 5645 is v_0 = 1375 km s^{-1}.

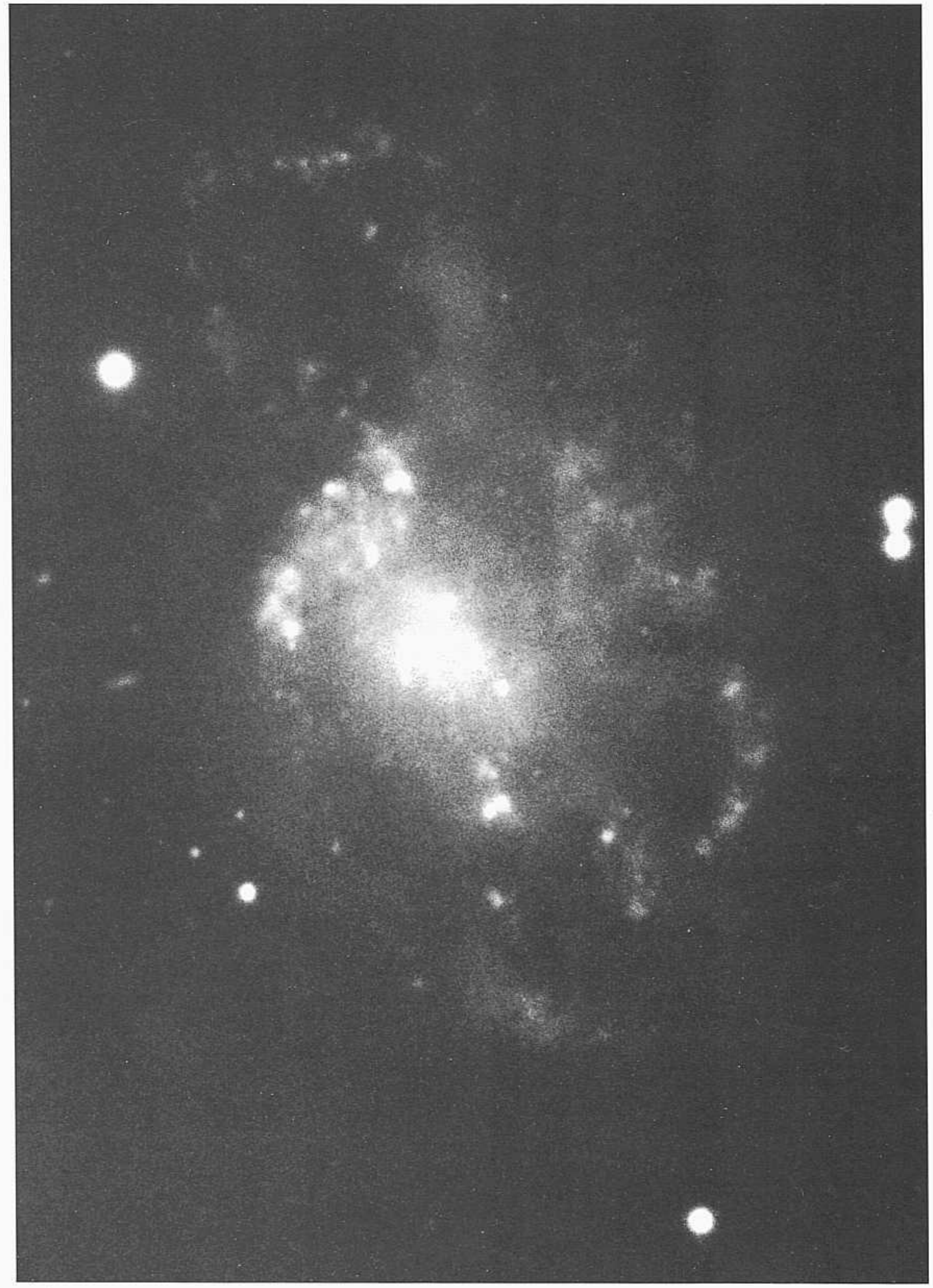


PANEL
265

PANEL

266





The spiral arms of the 12 galaxies on this and the next two panels are intermediate in thickness between the thin arms shown on the preceding seven panels of .Sell-Ill types, and the massive arms in the sense of Reynolds (1927a,b) in galaxies on panels 269-272.

NGC 7137 Sc(rs)II.8
PH-5-S
Sep 24/25, 1951
103aO
30 min

For its relatively small redshift, v_0 = 1951 km s^{-1}. the angular diameter to the edge of the spiral pattern in NGC 7137 is very small, at D = 0.9'. At a redshift distance of 39 Mpc (II = 50). this corresponds to a linear diameter of only 10 kpe. Despite the small size (and the consequent relatively faint absolute magnitude, ($V/_B$ = -20.4), the arm pattern is well formed and indeed almost exquisite.

The disk is filled with arms which on one side break into six separate fragments; in contrast there is but one major arm on the opposite side.

NGC 428 Sc(s)III
PH-7562-S
Nov 7/8, 1978
103aO
12 min

The semi-chaotic pattern seen here is similar to that in NGC 5645 on the preceding panel. The surface brightness of the inner disk is high. Many Mil regions exist in the bright part of one ol the major arms on one side of the image. Useful resolution into individual stars from the ground seems difficult.

The redshift of .NGC 428 is ,„, = 13 11 km s^{-1}.

NGC **3320** **Sc(s)II-III** **Racine wedge**
PH-7713-S
Feb 11/12, 1979
103aO
12 min

The **arm pattern is multiple,** beginning at the center in a characteristic (s) mode. The disk is covered **with arm** fragments. **The few individual** HH-region candidates are unresolved at **the** 1" level. The redshift of NGC 3320 is v_o = 23 80 km s"[1].

The original plate was made with a Racine wedge, making **multiple** images of the bright stars whose secondary component is 5 mag fainter **than the primary.**

NGC 7713 **Sc(s)II-HI** **pair**
CD-1522-S/Br
Aug 5/6, 1980
103aO + **GG385**
4-5 min

NGC 7713 forms a wide pair with IC 5332 (Sc: panel 2 59) at an angular separation of 1.9°. The redshifts are u_o(5332) = 713 km s'" and **u_o(7713)** = 684 km s~'. At the mean redshift distance of 14 Mpc (// =50) the projected linear separation is 464 kpc.

The resolution of NGC 7713 into individual stars and HII regions is more difficult than in IC 5332 for two reasons: (1) the background surface brightness of the NGC 7713 disk is higher than that in IC 5332, and (2) the problem is made worse by the high inclination of NGC 7713 to the line of sight.

The largest of the several HH-region candidates resolve into disks at about the 2" level.

NGC **701** **Sc(s)II-III**
CD-1558-S/Br
April 8/9, 1980
103aO + GG385
4-5 min

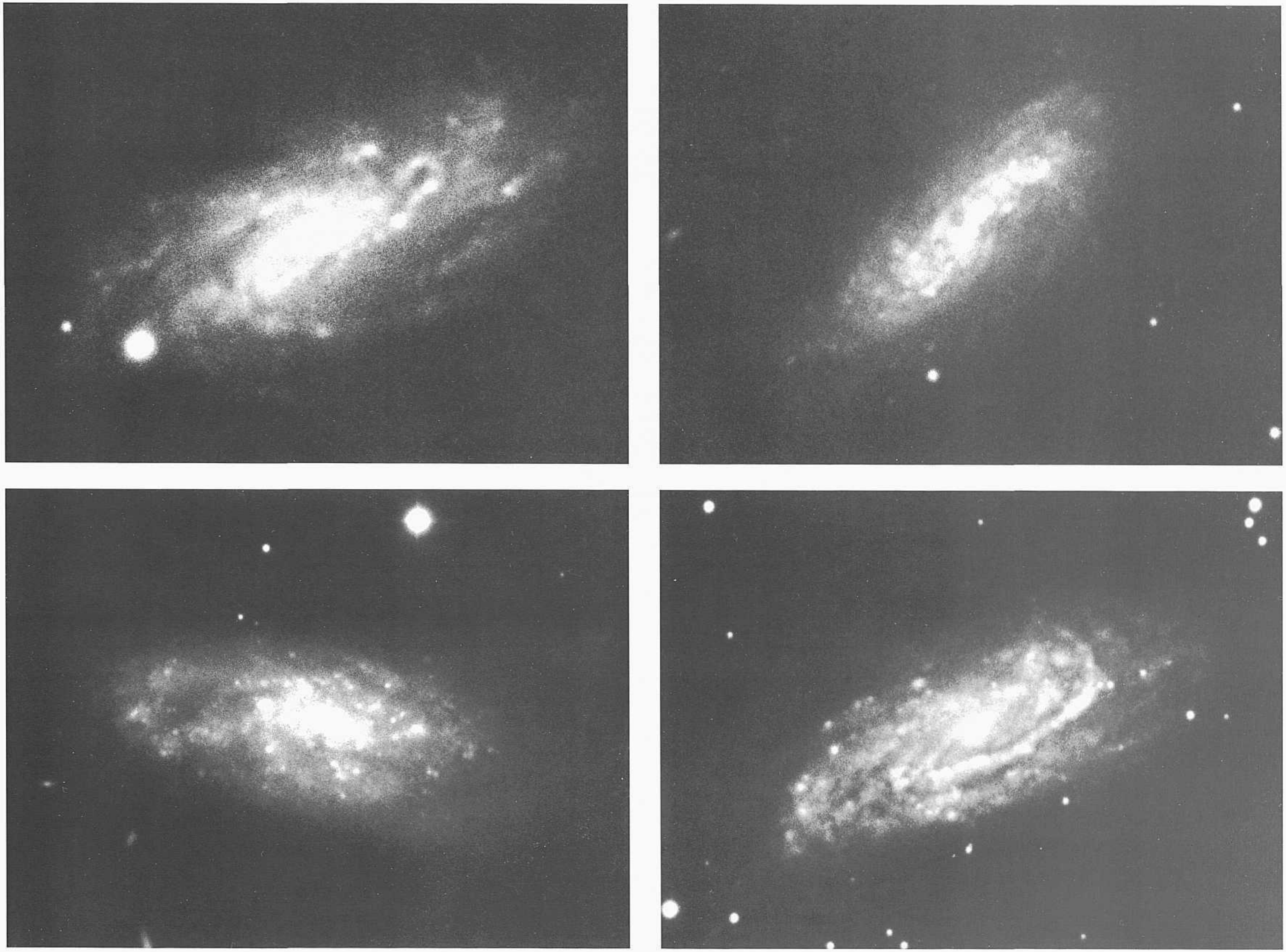
The multiple-armed pattern in NGC 701 is similar to the **spiral** morphology of the arms in NGC 7713, at the lower left.

The **HII** regions are unresolved. The redshift of NGC 701 is v_o= 1923 km s"[1].

IC 3253 **Sc(s)II-III**
CD-207-S
Feb 9/10, 1978
103aO + GG385
45 min

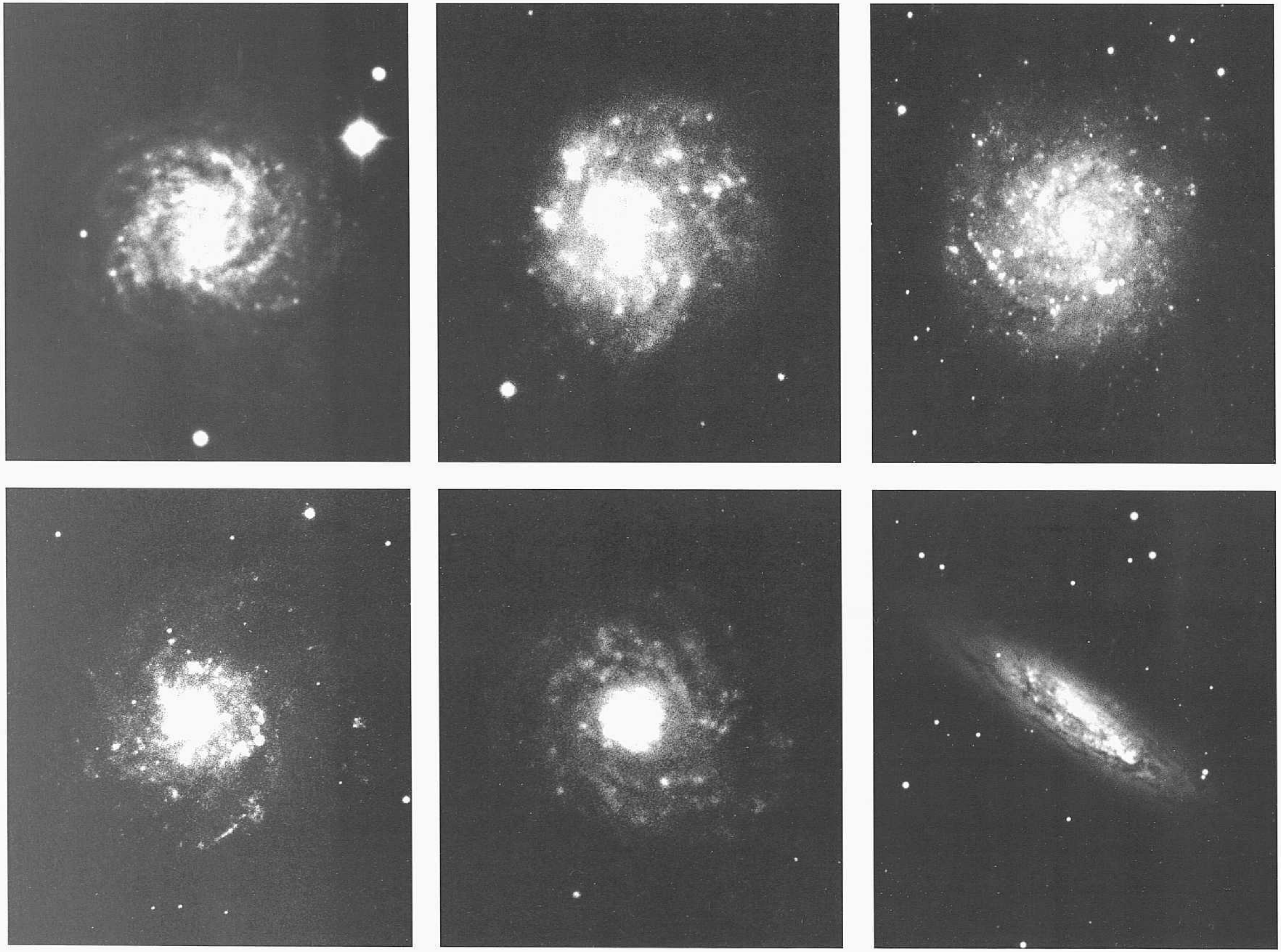
IC 32 53 has the standard morphology of a multiple-armed **spiral** pattern in a highly inclined galaxy of late-luminosity class, of the Ml 0 1 type. The disk surface brightness is high: the arms fill the disk.

The **HII** regions will not usefully resolve from the ground. The redshift is v_0 = **2582 km** s^{-1}.



PANEL
267

PANEL
268



Galaxies on this panel complete the illustrations of multiple-armed, Sc types of late-luminosity class having arms of intermediale thickness.

IC 5325 Sc(s)II-III
CD-1145-Br
Aug 21/22, 1979
103aO + GG385
45 min

The arm pattern in IC 5325 is similar to that in M101 (Hubble Atlas, pp. *27, 31;* panel 218 here) although the individual arm fragments are more tightly wound and somewhat less fragmented.

Individual HII regions are unresolved. The redshift of IC 5325 is v_0 = 1459 km s"[1].

NGC 5668 Sc(s)II-III panel 264
CD-2114-S
March 19/20, 1982
103aO + GG385
35 mil!

NGC 5668 is also shown on panel 264. It is shown again here to illustrate the similarity of its arm pattern to the pattern of other galaxies on this panel.

The largest HII region is complex. Its halo diameter resolves at about the 2" level. The redshift is v_n = 1491 km s"'.

NGC 4775 Se(s)III
CD-1882-HB
April 11/12, 1981
103aO
75 min

The arms of NGC 4775 arc filled with 1111-region candidates, the largest of which are complex and resolve into a combined halo diameter at about the 4" level. The redshift of NGC 4775 is v_0 = 1375 km s^{-1}.

A large number of candidates for dE, Sm, and Im dwarf companions exist in the 2° field surrounding NGC 4775.

NGC 4041 Sc(s)II-HI Ursa Major Cluster triplet
S-1912-H
Jan 27/28, 1946
103aO
60 mill

NGC 4041 forms a kinematic triplet with NGC 4036 (SO/Sa: panel 60: v_n = 1509 km s"') at a separation of 15', and with the non-RSA galaxy UGC 7009 (Im; v_o = 1248 km s"' at a separation of 12'): perhaps also associated is another galaxy of type Sd? in the field (separation of 17'), of unknown redshift (c. 1990). The redshift of NGC 4041 is «$_o$ = 1361 km s"'. At the mean redshift distance of 27 Mpc, the projected linear separations of NCG 4036 and UGC 7009 from NGC 4041 are 118 kpc and 94 kpc. respectively. These galaxies are probable members of the Ursa Major Cluster, whose mean redshift is about 980 km s~'.

The spiral pattern of NGC 4041 is similar to that in M101. Numerous Hll-rcgion candidates exist, but none are resolved on this plate, taken with the Mount Wilson 60-inch telescope.

NGC 1()5« Sc(s)II-IH NGC 1023 Gr
PH-1553-B
Oel8/9, 1956
103aO + GGl
25 min

NGC 1058 is a member of the loose NGC]023 Group which, in addition to its eponymous galaxy, contains NGC 891, NGC 925, NGC 1003. and NGC 1058 shown here.

The redshift, v_0 = 221 km s"', for NGC 1058 in tlumason, Mayall, and Sandage (1956) is incorrect. The redshift adopted in the RSA, based on many later sources, is v_o = 746 km s^{-1}, belying an earlier conclusion, based on the smaller (incorrect) redshift, that NGC 1058 was a nearby dwarf spiral.

Individual stars begin to resolve at *V* = 22. At a redshift distance of 15 Mpc (i.e.. *m* - *M* = 30.9), such stars are of absolute magnitude *Mg* = -9, which is consistent with the calibration of brightest resolved blue supergiants in galaxies with M_B = -1 9 (Sandage and Carlson 1 988).

NGC 3175 Sc(s)Ill:
CD-715-S
Jan 31/Feh 1, 1979
103aO + GG385
45 min

The arm pattern in NGC 3 1 75 is traced in the highly inclined image primarily by the dust. There is no large central bulge. There is a point-like nucleus; hence the Sc type is required. The type in the RSA2 is Sell I: pec, but aside from tin' mostly dust arms there is no peculiarity; hence the type is changed here.

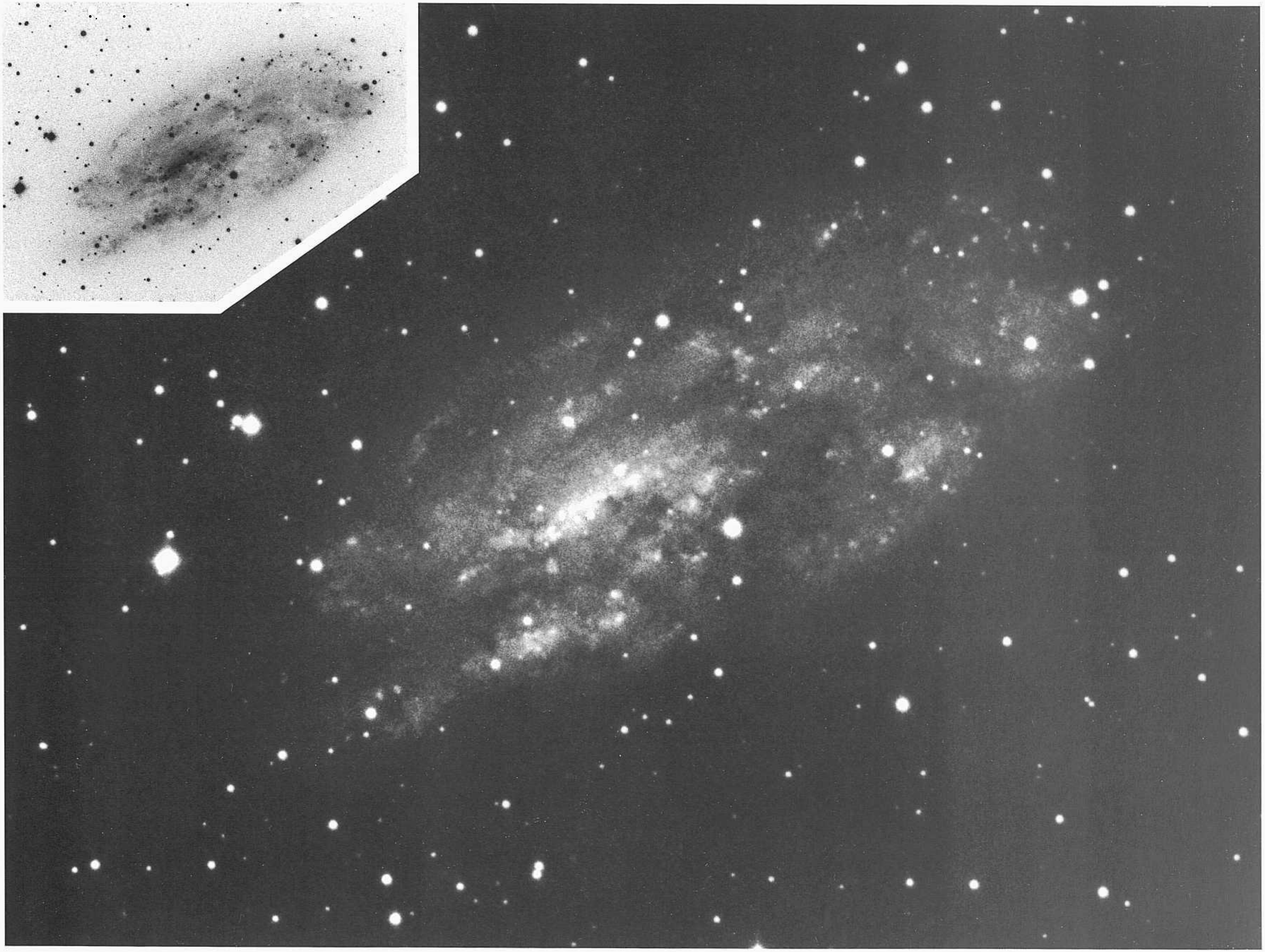
The redshift is r„ = 843 km s"'.

Most of the galaxies on this and the next three panels have massive arms in the sense of Reynolds (1927a,b). Such arms cover the disk and provide a high-surface-brightness background against which it is difficult to identify individually resolved stars.

NGC 2427 **Sc(s)II-III**
CD-798-S
Feb 24/25, 1979
103aO + GG385
45 min

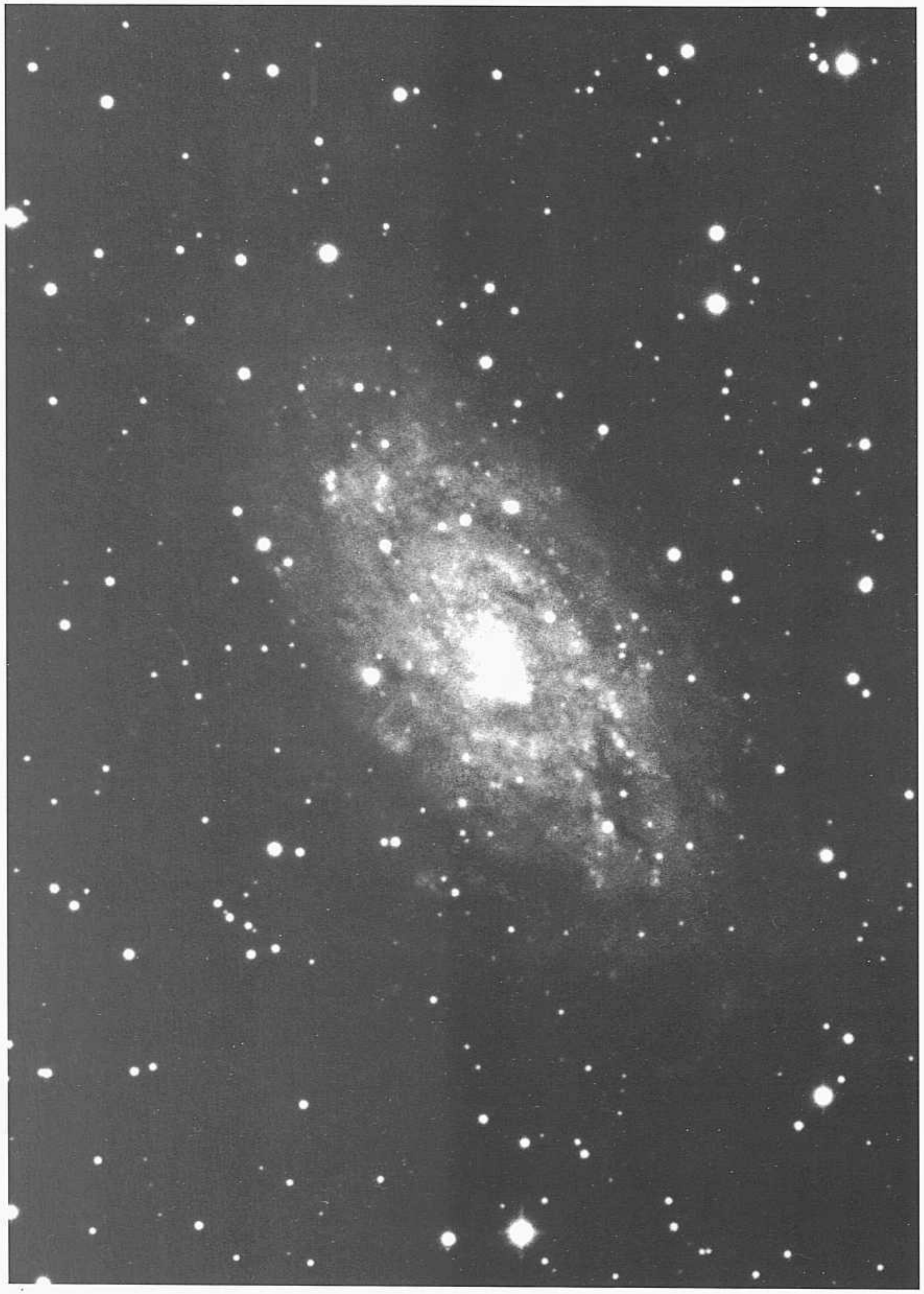
NGC 2427 is a very late Sc; it is near the StI edge of the Sc morphological box in the classification progression. There is no central bulge or identifiable nucleus. **Individual** stars may begin to resolve at about $B = 22$. The redshift is v_o = 707 km s^{-1}.

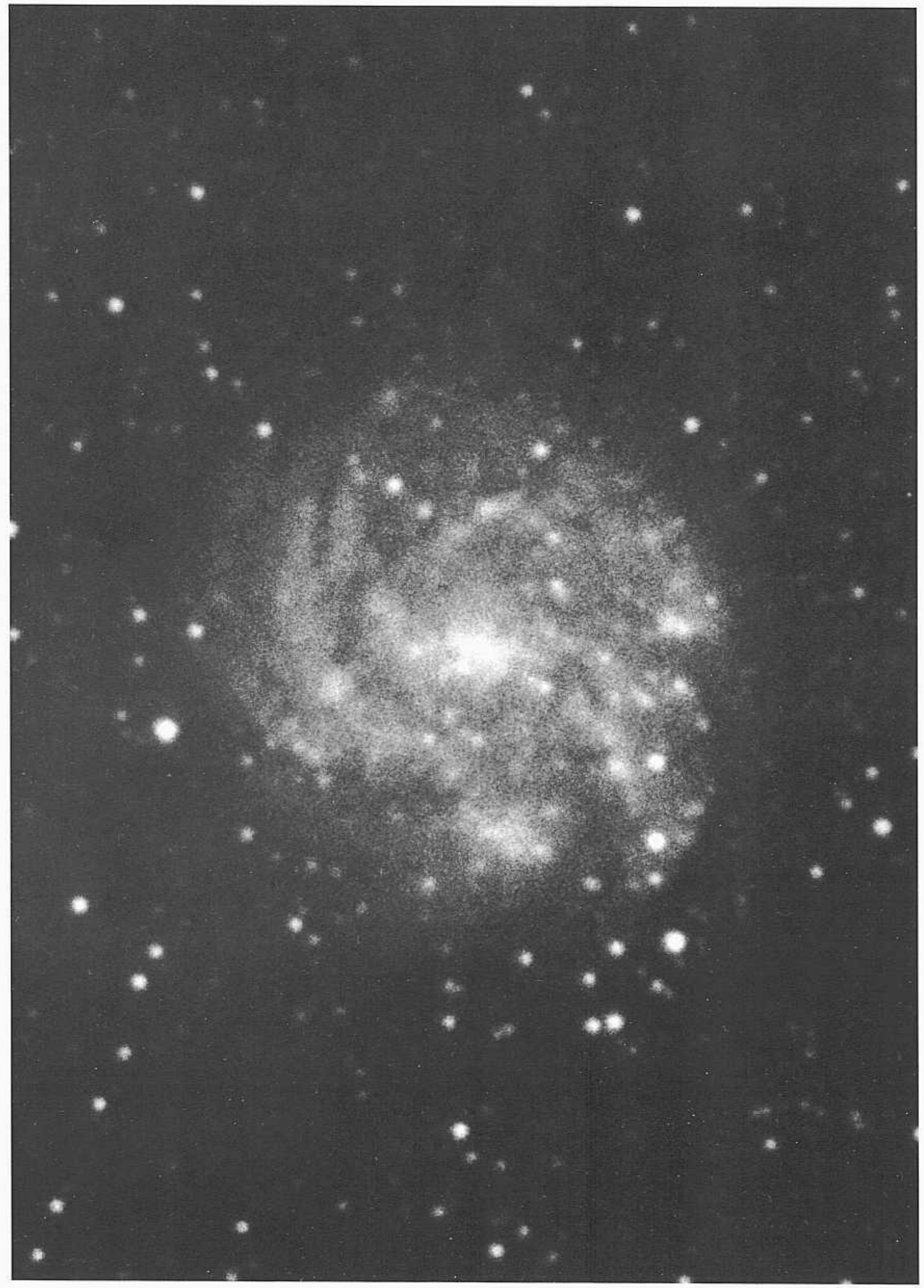
The mixed classification SAB(s)dm. between ordinary and barred spiral, given in the RC2, emphasizes the bar characteristics but assigns **a** later galaxy type (Sdm) than we have done here.



PANEL
269

PANEL
270





NGC 5530 Sc(s)II.8
CD-1412-S/Br
March 23/24, 1980
103aO + GG385
45 min

The disk of NGC 5530 is filled with fragments of thick arms and their associated dust lanes. The arm pattern is multiple. There is only a small central nuclear region. Most of the pattern is dominated by the arms.

Resolution into individual stars and 11II regions does not occur on the available plate material. The redshift is $v_{,,}$ = **943** km s^{-1}.

NGC 2082 Se(s)II-III
CD-167I-S
De<- 31/Jan 1, 1980/1981
103aO + GG385
10 min

NGC 2082 is in a rich field of LMC disk stars. It is located about 5° north ol the hiirof the LMC. close k> Shaplcy's Constellation I II of the LMC.

No resolution into stars or Mil regions oc-curs. The redshift is r,, = 1038 km s^{-1}.

The six galaxies on this panel and the two on the next complete the section showing late-luminosity-class Sc galaxies with massive arms.

NGC 4088 **Sc(s)II-III/SBc** Ursa Major **Cluster**
S-1971-H **HA, p.** ***30***
Feb **19/20, 1947**
103aO
15 niin

NGC 4088 forms a pair **with** NGC 4085 (Sc; panel 291) at a separation of 11'. The redshifts are i_0(4088) = 820 km s"' and u_o(4085) = 823 km s"'. Both arc considered to be members of the Ursa Major Cluster, whose mean **redshift** is <r_o> = 980 km s^{-1}. At a redshift distance of 20 Mpc (H = 50), the projected linear separation of the pair is 64 kpc.

NGC 2701 **Sc(s)II-IH**
PH-7552-S
Nov 6/7, 1978
103aO
12 min

One of the two major arms of NGC 2701, which begin near the center with the (s) arm configuration, is considerably brighter than the other. In addition, the arm pattern is asymmetric about the small bright nucleus. There is no evidence of a close encounter or a merger (no close companion is seen). The asymmetry of the pattern appears to be natural, endemic to the galaxy.

The redshift is v_n = 2421 km s^{-1}.

IC5179 **Sc(s)II-III**
CD-1563-S/Br
Aug9/10, 1980
103aO + GG385
45 niin

The nucleus of IC 5179 is unresolved (it is starlike, seen in the insert) at the 1" level. The redshift is v_0 = 3453 km s^{-1}.

NGC 1359 **Sc(s)H-III**
CD-2008-Bedke/Gregory
Oct 23/24, 1981
103aO + GG385
45 **min**

NGC 1359 is close to but just outside the catalog boundaries of the NGC 1400 Group (Ferguson and Sandage 1990) whose mean redshift is <v_o> = 1581 km s"1. The redshift of NGC 1359 itself is v_0 = 1972 km s"1.

Active star formation is occurring throughout the arms, evidenced by the many bright HII regions in the central bar and especially in the one well-developed major arm.

A bright asteroid trail is evident in the reproduction.

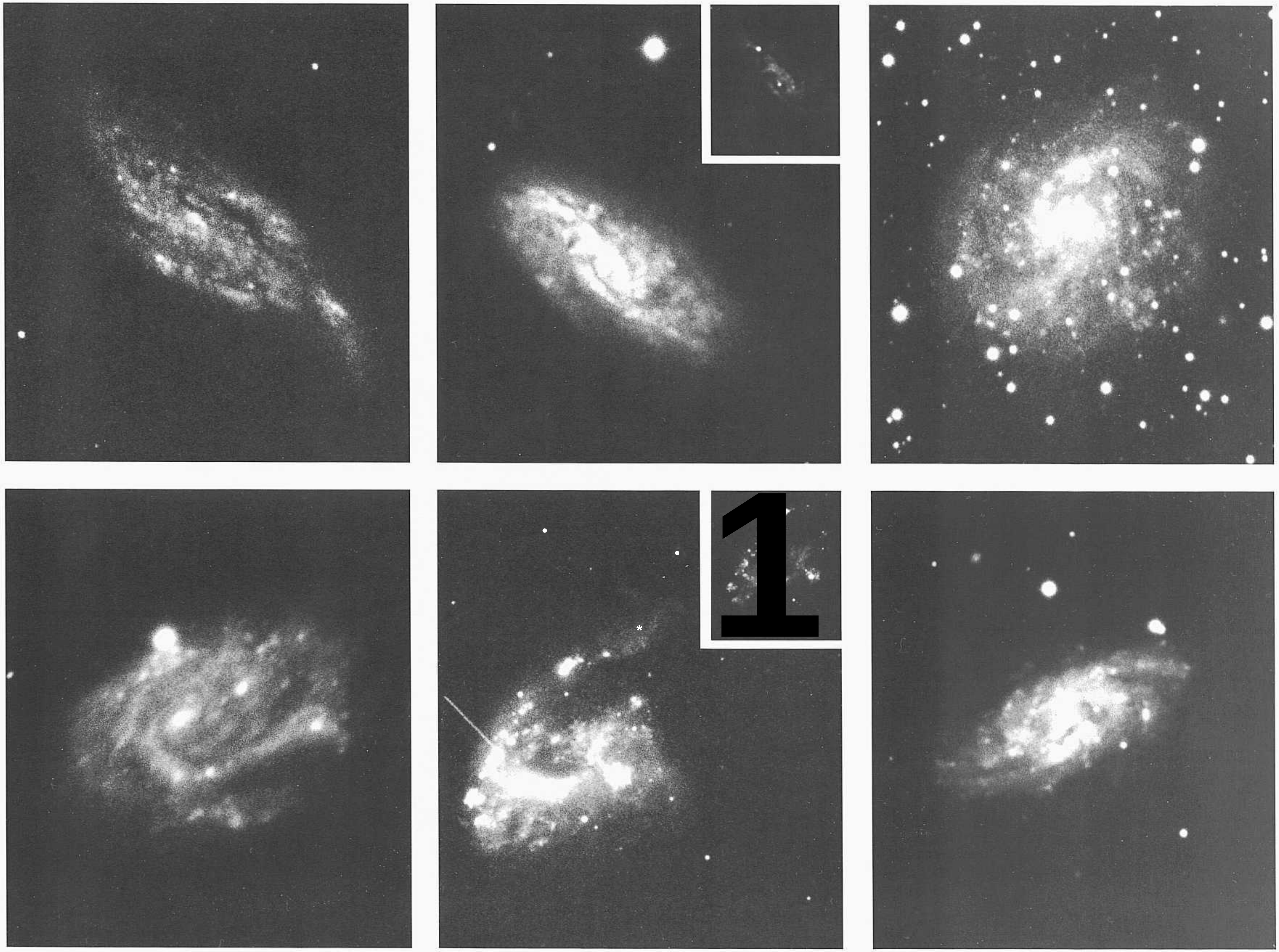
HA 72 = A1357 **Sc(s)II-IH**
CD-1538-S/Br
Aug 7/8, 1980
103aO + GG385
45 **niin**

Galactic foreground stars in this low-latitude field (b = 16°) contaminate the face of the galaxy, complicating the identification of the stellar and the HII components of HA 72. Nevertheless, the existence of HH-region candidates is evident in each of the two principal arms.

The redshift of HA 72 is v_o - 1192 km s~'.

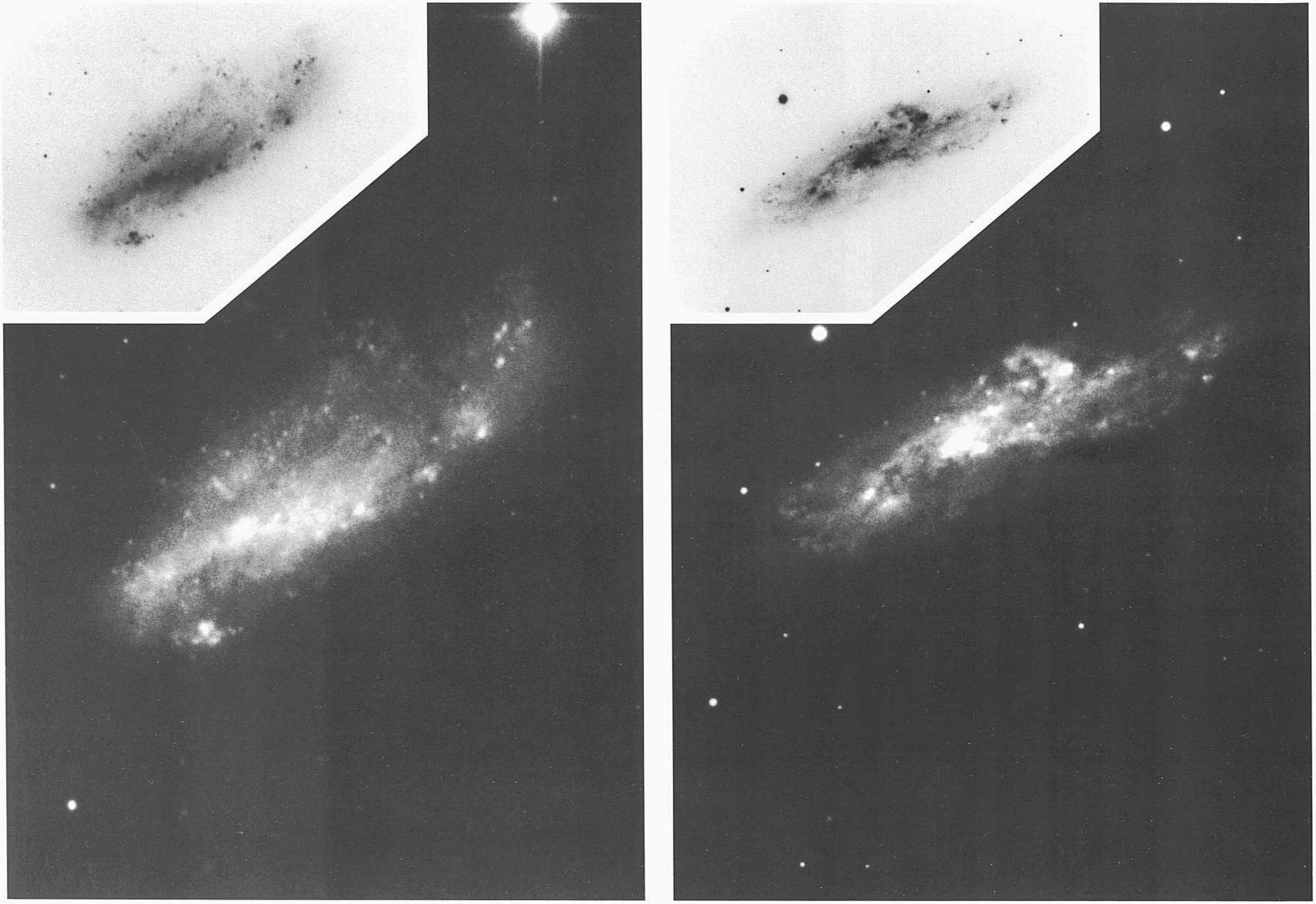
NGC 7218 **Sc(s)II.8**
CD-1509-S/Br
Aug 4/5, 1980
103aO + GG385
45 niin

The surface brightness of the arms of NGC 7218 is very high. No useful resolution into HII regions is evident on the available plate material. The redshift of NGC 7218 is v_a = 1781 km s"'.



PANEL
271

PANEL
272



NGC 1518 **ScIII**
CD-2009-Bedke/Gregory
Oct 23/24, 1981
103aO + GG385
45 nün

NGC 1518 is nearly on edge, making it impossible to trace the spiral pattern or accurately to classify the galaxy. There is no central bulge; hence the late-type classification is required. There is possibly **a** bar **and** an arm structure, as in NGC 1300 (but later), where **the** arms spring from the ends of **the** bar.

The arms contain many Hll-region candidates and **possibly** individual resolved stars. The redshift is v_n = **914** km s"'.

IC 2995 **S<(s)III**
CD-2I8-S
Feb 11/12, 1978
103aO + GG385
40 mill

The pattern of **IC.** *2')<)5* is similar lo [hat of NGC 15 18 **al the left.** The largest of the many **IIII** regions **resolve at about** *2".* **No resolution into** individual stars is seen on **the** available **plate** material. The redshifl is v_0 = 1566 km a^{-1}, Galaxies of luminosity classes III and III-IV are shown on this and the next two panels. A spiral pattern is still evident and traceable, but the regularity of the arms is generally poor. Although the chaos in the pattern is great (large geometrical entropy), the surface brightness of most of the 18 galaxies on these three panels is very high; yet the absolute magnitudes of many of these galaxies are faint. Evidently, surface brightness is not an indicator of absolute luminosity in the ScIII galaxies as defined here. The opposite is true, however, for Sd, Sm, and Im types in the later sections of the classification.

NGC3511 Sc(s)II.8 pair
CD-722-S HA, p. *35*
Feb 1/2, 1979
103aO + GG385
4-5 niin

NGC 3511 forms a close pair with NGC 3513 (SBc: panel 299) with a separation of 10.5'. The redshifts are P_O(3511) = 951 km s⁻' anil r,,(3513) = 845 km s~'. At the mean redshift distance of 18 Mpc (// = 50), the projected linear separation is small, at 55 kpc.

The surface brightness of the spiral pattern overlaying the entire disk is very high, as shown in the print at the upper left. A lighter print from the same plate is shown at the lower left.

The arms are massive in the sense of Reynolds (1927a,b). The pattern is similar to that in NGC 2427 (Sc: panel 269) and NGC 4088 (Sc: panel 271) although slightly less regular.

NGC 3511 Sc(s)II.8 HA, p. 35
CD-722-S
Feb 1/2, 1979
103aO + GG385
45 min

The image here is made from the same plate used for the print above, but printed more thinly to show the spiral pattern and the associated heavy dust lanes that are predominantly on the insides of the heavy luminous arms.

NGC 3621 Sc(s)II.8
CD-811-S
Feb 25/26, 1979
103aO + GG385
4-5 niin

NGC 3621 is highly resolved into individual brightest stars, beginning at about *B* = 20 in some of the outer associations. The HII regions are not numerous but are present, the largest of which have halo diameters of about 4". The galaxy is similar in its spiral pattern to NGC 2403 in the print below. It also resolves into brightest stars in the same way but at a level about 1.5 mag fainter. This more-difficult resolution is consistent with the larger redshift of u_o(3621) = 435 km s^{-1} compared with $i;_o$(2403) = 299 km s^{-1}.

NGC 2403 Sc(s)IH HA, p. *36*
PH-344-B
Nov 6/7, 1950
103aO
30 min

The stellar content of NGC 2403, including its brightest stars, the HII regions, the bright irregular blue variables, and the Cepheids require a distance modulus of *m* - M = 27.6 (Tammann and Sandage 1968). This value was confirmed in a modern study by Freedman and Madore (1988).

The brightest blue stars begin to resolve at *B* = 18: the brightest red supergiants begin at *V* = 19.5 (Sandage 1984b). NGC 2403 was the first galaxy beyond the Local Group in which Cepheid variables were found. It was the first step in taking the distance scale outward into the true expansion field. The large difference in the distance modulus obtained from Cepheids of *m* — *M* = 27.6, compared with Hubble and Humason's (1931) value of *m* - *M* = 24.0, was a major correction that eventually led to a stretching of Hubble's original scale at large distances by a factor of slightly more than ten, giving the global value of the Hubble constant as near *II* = 50 km s'" Mpc"[1].

NGC 4781 Sc(s)IH
CD-1848-HB
April 3/4, 1981
103aO + GG385
75 niin

NGC 4781 (u_o = 689 kms"')is in a complex field where, within a radius of about 1°, are NGC 4742 (E4; panel 10; v_0 - 1114 km s~'), NGC 4760 (SO; panel 30; u_o = 4451 km s"'), and NGC 4790 (Scd; panel 315; v_0 = 1154 km s"[1]). NGC 4742 and NGC 4790 may be kinematically related to NGC 4781, although a spread in redshift larger than 400 km s~[1] is relatively rare. (See the later comment on resolution of the stellar content in the description of NGC 4790 on panel 315, in the Scd section.)

Also in the field are a number of partially resolved late-type dwarf galaxies (Sm and 1m types) which may be related to NGC 4781.

The surface brightness of the thick spiral fragments that cover the disk is high. HII regions exist, and a few brightest stars may begin to resolve out of the background at about *B* = 21.5.

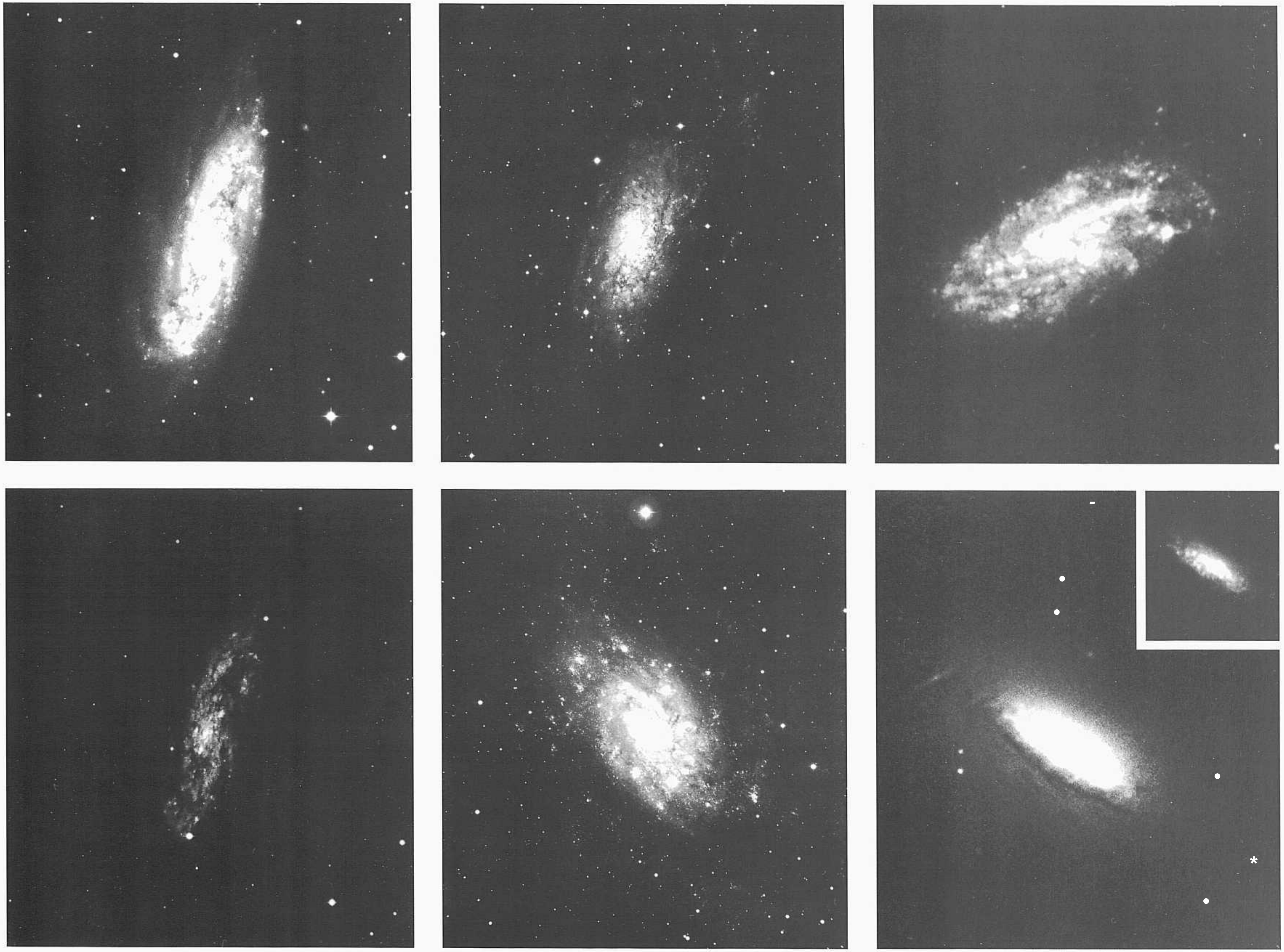
NGC 1546 Se(s)III
CD-219-S
Feb 12/13, 1978
103aD + GG495
4-5 min

NGC 1546 insert Sc(s)III
CD-1675-S
Jan 1/2, 1981
103aO + GG385
10 min

NGC 1546 has a very-high-surface-brightness arm pattern, seen almost edge on. The surface brightness is so high that on low-resolution photographs the image would appear to he an SO galaxy having no structure. In both the RC1 and RC2 the classification is listed as SO?, based on a 30-inch Stromlo reflector plate. But the pattern is that of a nearly edge on Sc spiral with multiple arms, similar to the morphology of NGC 3511 and NGC 4781 on this page.

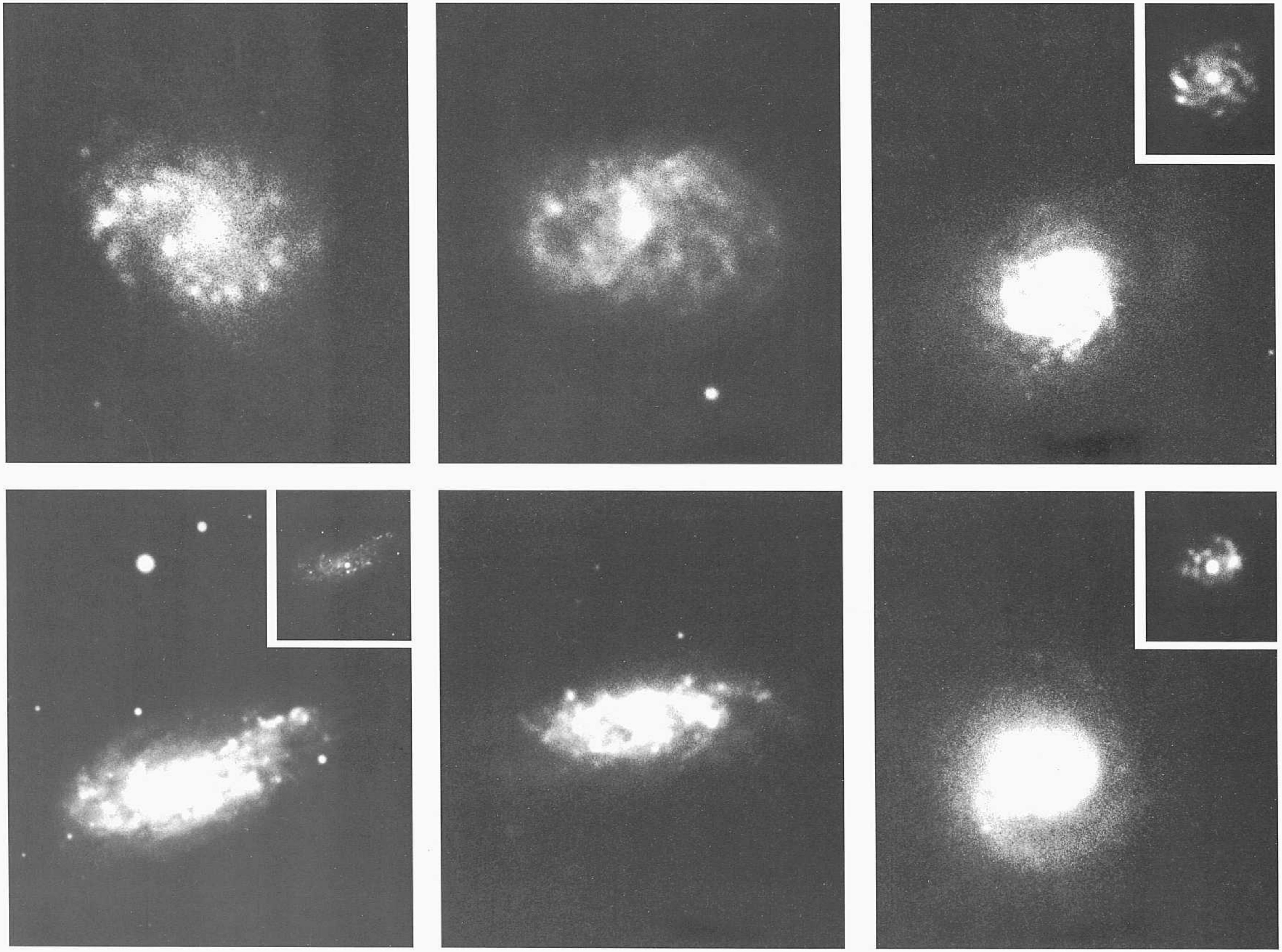
The redshift of NGC 1546 is *v,,* = 1007 km s .

The image in the insert frame is made from a different Las Campanas plate than was used for the heavier main print. Tin? thick-armed, multiple-spiral-arm pattern that begins at the center is hinted at in this print.



PANEL
273

PANEL
274



The six galaxies on this panel continue the pattern of high-surface-brightness arm fragments, often massive, thai cover the disk in a way similar to the galaxies illustrated on the preceding panel.

NGC 4928 Sc(s)III.3
H-2387-H
Feb 21/22, 1947
103aO
30 iniii

NGC 4928 is a two-armed spiral where the arms are massive. Many HH-region candidates exist in the arms. The surface brightness of the luminous parts of the arms between the IIII regions is high; evidently the current rate of star formation is robust.

The redshift is v_o= 1434 km s~^{1}.

NGC 6207 Sc(s)III
PH-775-S
Aug 24/25, 1954
103aO + GG385
30 min

NGC 6207 insert
PH-7683-S
Sep 26/27, 1979
103aO
8 min

NGC 6207 is similar to NGC 2403 (Sc; panel 273) in the character of the spiral arms and the high surface brightness over the inner disk. The redshift of NGC 6207 is v_o = 984 km s^{-1}.

The insert print of NGC 6207 is made from a different original plate of shorter exposure than the one used for the heavy main print.

NGC 5480 Sc(s)IH Racine wedge
PH-7740-S Karachentsev 416
June 11/12, 1980
103aO
12 min

NGC 5480 forms a close pair with NGC 5481 (EO/SO; not in the RSA) at a separation of 3.1'. The pair is number 416 in the catalog of close pairs by Karachentsev. He gives the red-shifts of u_o(5480) = 2023 km s~' and u_o(548 1) = 2143 km s^{-1}. At the mean redshift distance of 42 Mpc (*H* = 50), the projected linear separation of the pair at 38 kpc is small.

The pair is especially important because of the vast difference in the morphological types (E/SO vs. ScIII); yet they are obviously associated kinematically.

The arm pattern of NGC 5480 is multiple. Five arm fragments can be identified, four on one side and one on the other, all originating near the center.

NGC 4420 Sc(s)III VCC 957
CD-2174-S
March 28/29, 1982
103aO
50 min

NGC 4420 is at the southern edge of the Virgo Cluster survey area used in the Virgo Cluster Catalog (Binggeli, Sandagc, and Tammann 1985), but it may not be a member of the cluster.

The galaxy is illustrated in the atlas of Virgo Cluster candidates where the photographs are enlarged to the same angular scale (Sandagr, Binggeli, and Tammann, 1985a: panel 10 there).

The surface brightness over the disk is high. The angular diameter is small. No useful resolution into individual stars is evident on the available plate material.

The redshift is v_o = 1515 km s^{-1}.

NGC 5653 Se(s)Ill pec
H-2258-H
May 3/4, 1946
I03a0
40 mill

NGC 5653 insert
H-2302-H
July 3/4, 1946
103aO
10 min

The surface brightness of the multiple-arm pattern over the inner disk of NGC 5653 is exceedingly high. Most of the detail of these arms is burned out in the main print. The five arm fragments, resembling a pinwheel. are seen in the insert. Very faint, smooth outer arms are visible in the overprinted main image here.

The redshift is v_o = 3587 km ī'.

The insert print showing the main multiple spiral arms of NGC 5653 has been made from a different original plate than the one used for the main print. Both plates were taken with the Mount Wilson 100-inch Hooker reflector.

NGC 3732 Sc(r) pee
CD-1376-S/Br
March 20/21, 1980
103aO + GG385
20 min

NGC 3732 insert
CD-1377-S/Br
March 20/21, 1980
103aO + GG385
10 min

The inner .spiral pattern is tightly wound about a small nucleus seen only in the insert. A set of faint, smooth outer (fossil?) arms, brighter on one side than the other, is seen in the main print. No useful resolution into stars or Mil regions is evident on the available plate material. The spectrum is rich in emission lines (Sandage 1978), evidence of the high rate of star formation suggested by the high surface brightness of the arms.

The angular diameter of NGC 3732 of 30" is remarkably small for the small redshift of v_o = 1493 km s"'.

Tile insert print has been made from an original Las Campanas plate other than the one used for the main print.

All galaxies on this page are of the lowest luminosity classes of the Sc galaxies in the RSA. This panel completes the formal Sc illustrations. Special attributes of the Sc class follow, on panels 276-293.

NGC 3445 Sc(s)III triplet
PH-8048-S
Feb 4/3, 1981
103aO
12 min

NGC 3445 forms a triplet with NGC 3440 (possible Sbc merger in progress: not in the RSA) at a separation of 9.9', and NGC 3458 (SBO, panel 54) at a separation of 14.0'. The redshifts are L_O(3440) = 2021 km s"[1]. u_o(3445) = 2083 km s"[1]. and f_o(3458) = 1 899 km s'[1]. At the mean redshift distance of 40 Mpc *(H* = 50) the projected linear separations of NGC 3440 and NGC 3458 from NGC 3445 are 115 kpc and 163 kpc, respectively.

The importance of the triplet is that the morphological types for two of the companions are so very different (Sc and SBO). The case is similar to that of NGC 5480/5481 on the preceding panel.

The face of NGC 3445 is covered with a thick spiral pattern within which numerous HII-region candidates exist. At the end of the single principal arm is a shred that may be a separate galaxy (or was at one time). The angular separation of the shred from the center of NGC 3445 is 1.2', which is a projected linear separation of only 14 kpc. This close pair is number 256 in Karachentsev's catalog of pairs. He lists the redshifts of $i!_o$(3445) = 2058 km s~' and v_o = 2004 km s^{-1} for the shred which he classifies as type Sm.

NGC 2537 **ScIII** pec
H-2254-H
May 3/4, 1946
103aO
40 miii

The strange morphology of NGC 2537 may be due to an encounter in progress. Both galaxies are visible, one near the center of the arch: the other is the arch itself.

Both segments are filled with bright HII regions, the largest having a halo diameter of about 8" though it may be a complex of several overlapping separate regions. The redshift is small at v_o = 5] 3 km s^{-1} , consistent with the good resolution into disks of the **largest** 1111 regions.

NGC 4625 Sc(s)H-III pec Karachentsev 349
PH-7666-S
April 29/30, 1979
103aO
6 niin

NGC 4625 is not in the RSA but is a companion to NGC 4618 (SBbc: panel 212), which is in that catalog. The pair have closely the same redshifts, at u_o(4618) = 563 km s~' and «$_O$(4625) = 640 km s~[1] . The angular separation of 8.5' at a redshift distance of 12 Mpc *(H* = 50) gives the small projected linear separation of 30 kpc. The pail[1] is number 349 in Karachentsev's catalog of close pairs.

The morphology of both NGC 4618 (panel 212) and NGC 4625, here, is peculiar. Both galaxies have a single dominant arm, as if pulled out by a tidal encounter. The resolution into stars and HII regions is at the same level in both galaxies. The high degree of resolution is consistent with the low mean redshift of $<v_o>$ = 602 km s^{-1} for the pair.

NGC 4630 Sc(s)III VCC 1923
CD-2166-S
March 27/28, 1982
103aO
50 min

NGC 4630 is in the extreme southeastern corner of the survey area of the Virgo Cluster Catalog (Binggeli, Sandage, and Tammann 1985). No decision was made in that catalog as to cluster membership.

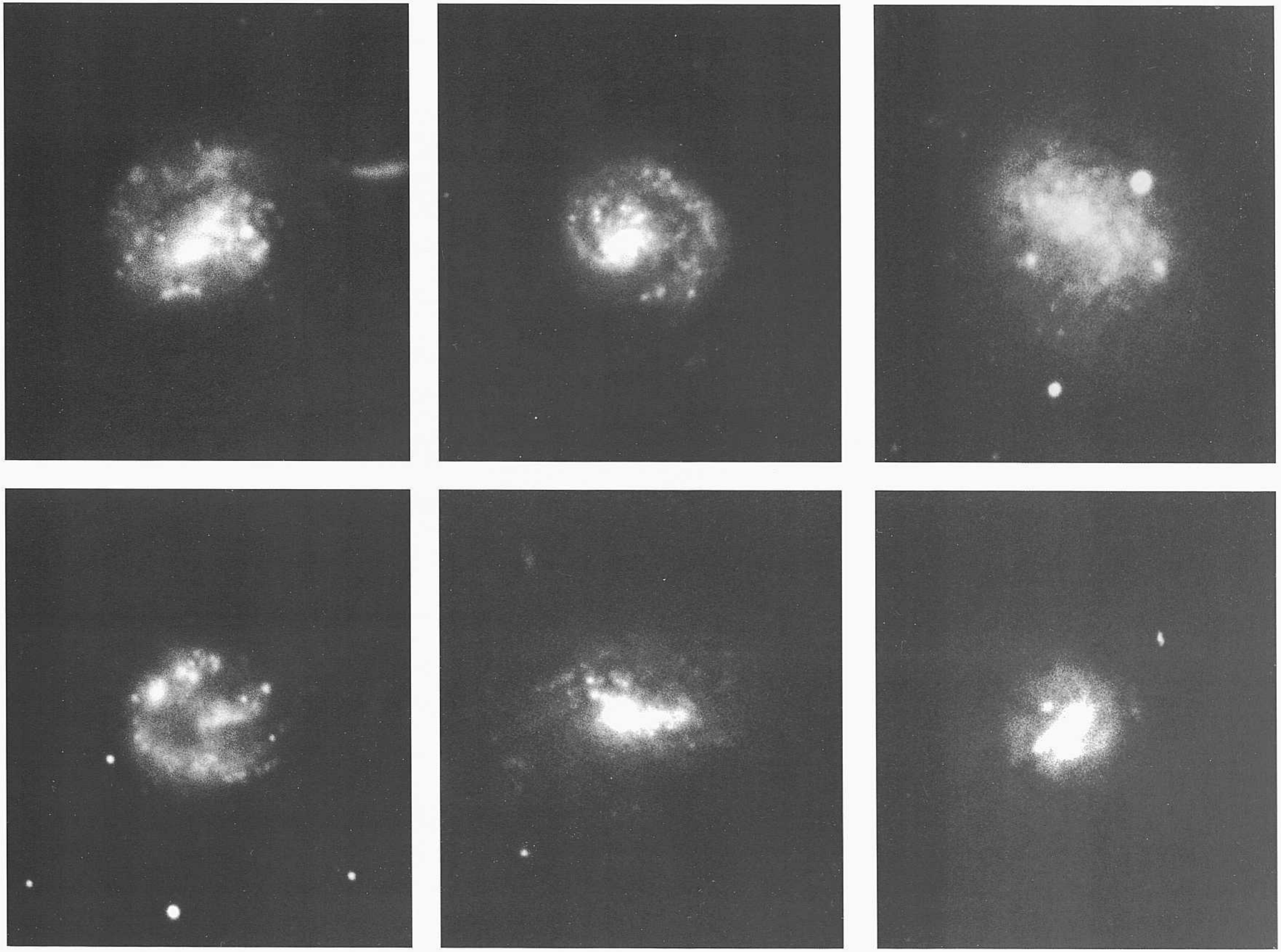
Hll-region candidates are evidently present. The redshift of NGC 4630 is v_n = 533 km s~'.

NGC 4540 Sc(s)HI-IV VCC 1588
CD-2130-S
March 21/22, 1982
103aO
50 min

NGC 4540 is about 3.5° northeast of the center of Virgo subcluster A associated with NGC 4486 . It is listed as a cluster member in the Virgo Cluster Catalog (Binggeli, Sandage, and Tammann 1985).

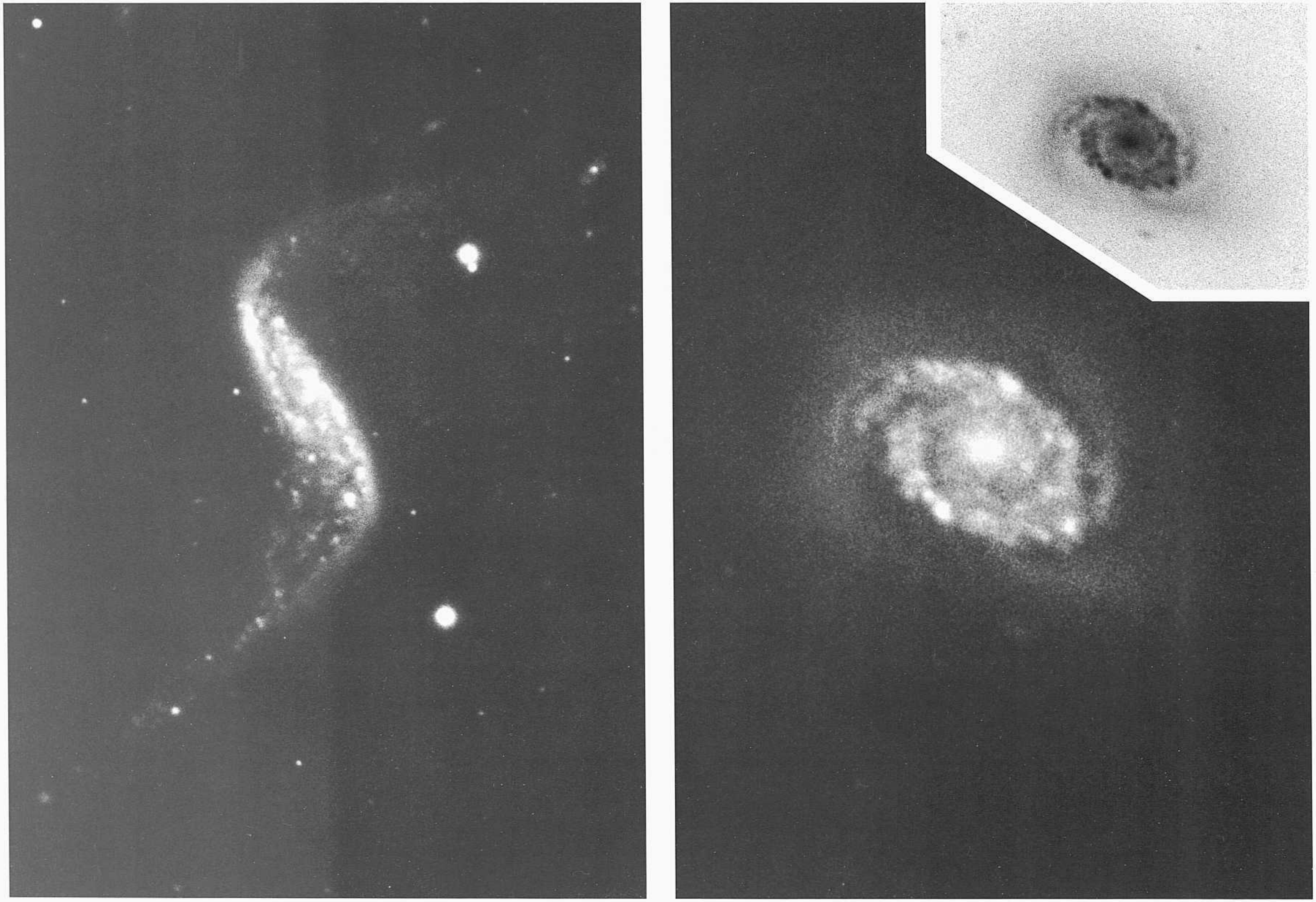
NGC 4369 Sc(s)III-IV
H-2508-H
March 5/6, 1948
103aO
30 min

The spiral pattern in NGC 43 69 is not well traced in the high-surface-brightness central region of this small, almost irregular spiral. The redshift of NGC 4369 is v_n - 1069 km s"'.



PANEL
275

PANEL
276



The two galaxies on this panel are peculiar enough to be outside the classification system. They are placed in the Se section here because of the late stellar content and small nuclear region of both.

NGC 3187 Sc/SBc quartet
PH-149-MH
April 12/13, 1950
103aO
30 niin

NGC 3187 (not in the RSA) is a member of the famous quartet whose other members are NGC 3185 (SBa; panel 99; v_o = 1151 km s~'), NGC 3 190 (Sa; panel 76 :v_o = 1384 km s"[1]), and NGC 3193 (E2; panel 5; v_0 = 1307 km s"[1]).

NGC 3187 is highly distorted, having two long plumes which are drawn out from the lenticular central region. The closest member of the quartet to NGC 3 187 is NGC 3 190. which is also distorted, having a tilted fundamental plane in its outer regions. The circumstantial evidence suggests that a close encounter occurred involving NGC 3187 and NGC 3 190; the present angular separation of the two is 4.8'. At the mean redshift distance of 27 Mpc (H = 50) corresponding to <u$_o$> = 1336 km s^{-1}. the projected linear separation of the pair is small at 38 kpc.

Hll-region candidates exist both in the central bar and in each plume. They are unresolved at the 1" level.

NGC 1580 Sc(s)/Sa HA, p. *21*
CD-2187-S VCC 1730
March 29/30, 1982 panel 86
103aO
50 niin

NGC 4580 has also been described and illustrated in the Sa section on panel 86. The smooth outer arms arc .similar to non-star-producing arms in the early section of the Sa types. The small nucleus, the lack of a central bulge, and the obvious HII regions in the inner ring, which is nearly complete, have the character of the content of Sc galaxies.

NGC 4580 is one of the few galaxies in the RSA having these mixed characteristics. The unusual classification assigned here is to identify the combination.

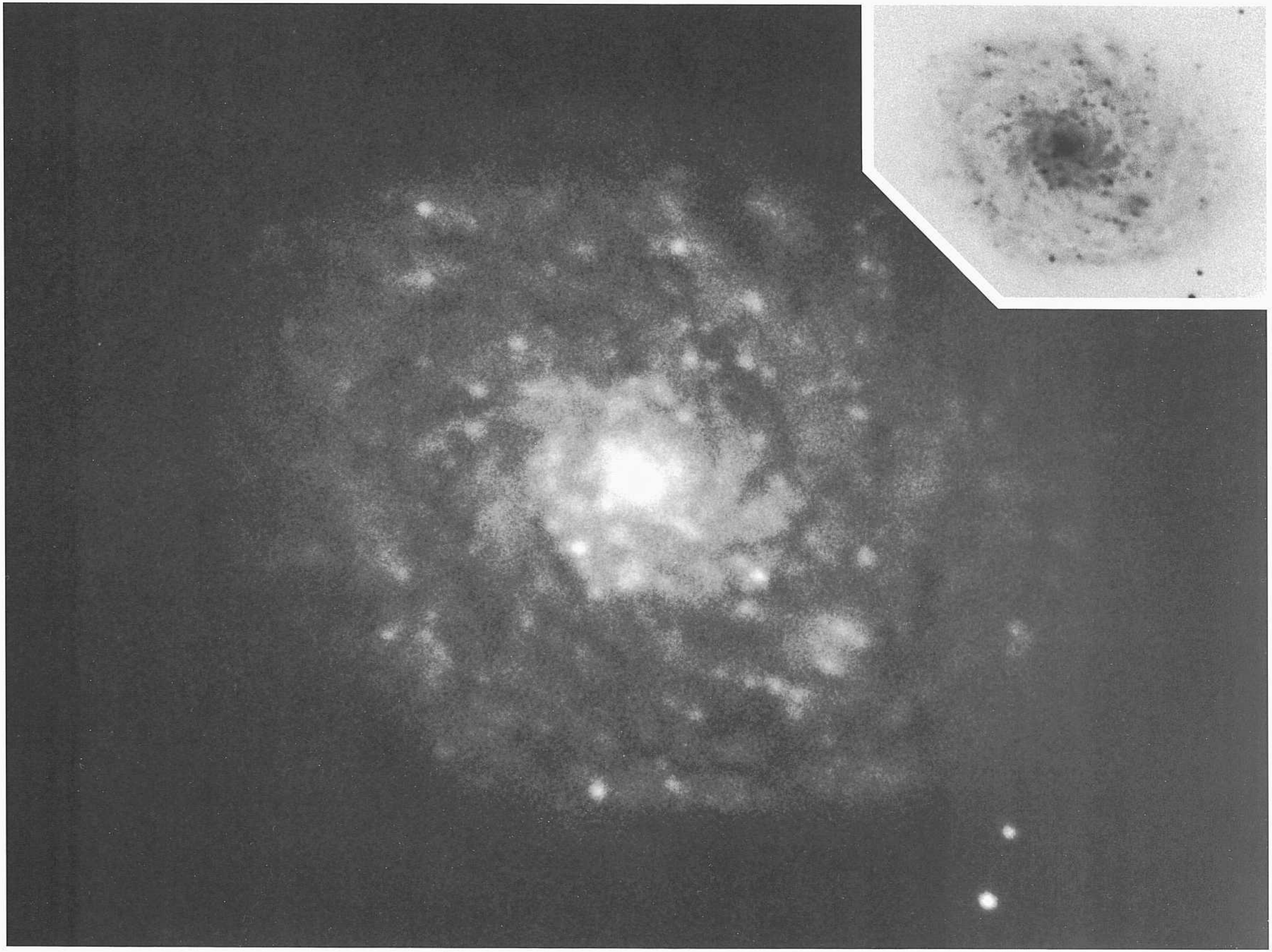
The nine galaxies on the next three panels have Sc multiple-arm spiral patterns that are similar to but later in stellar content than that of NGC 488 (Sab; panels 115, 116, S3, S12), the prototype example of the form. The galaxies are arranged on these panels to show the development of the form along the classification sequence. A similar summary of the development of the NGC 488 type along the sequence is shown in the Summary, panels S12 and S13, but with less morphological resolution than is given in the next three panels.

NGC 4689-S **Sc(s)II.3** **VCC 2058**
CD-2138-S
March 22/23, 1982
103aO
50 niiii

NGC 4689 is in the extreme northeastern corner of the survey area for the Virgo Cluster Catalog **(Binggeli,** Santiago, and Tammann 1 985). It is listed as a cluster member, at redshift v_0 = 1508 **km** s^{-1}. A **photograph** printed to a common angular scale with other members is given in the photographic atlas of the Virgo Cluster (Sandage. Binggeli, and Tammann l'J85a. panel 6) showing that NGC 4689 is among the **largest** of the Sell-luminosity-class galaxies in the cluster.

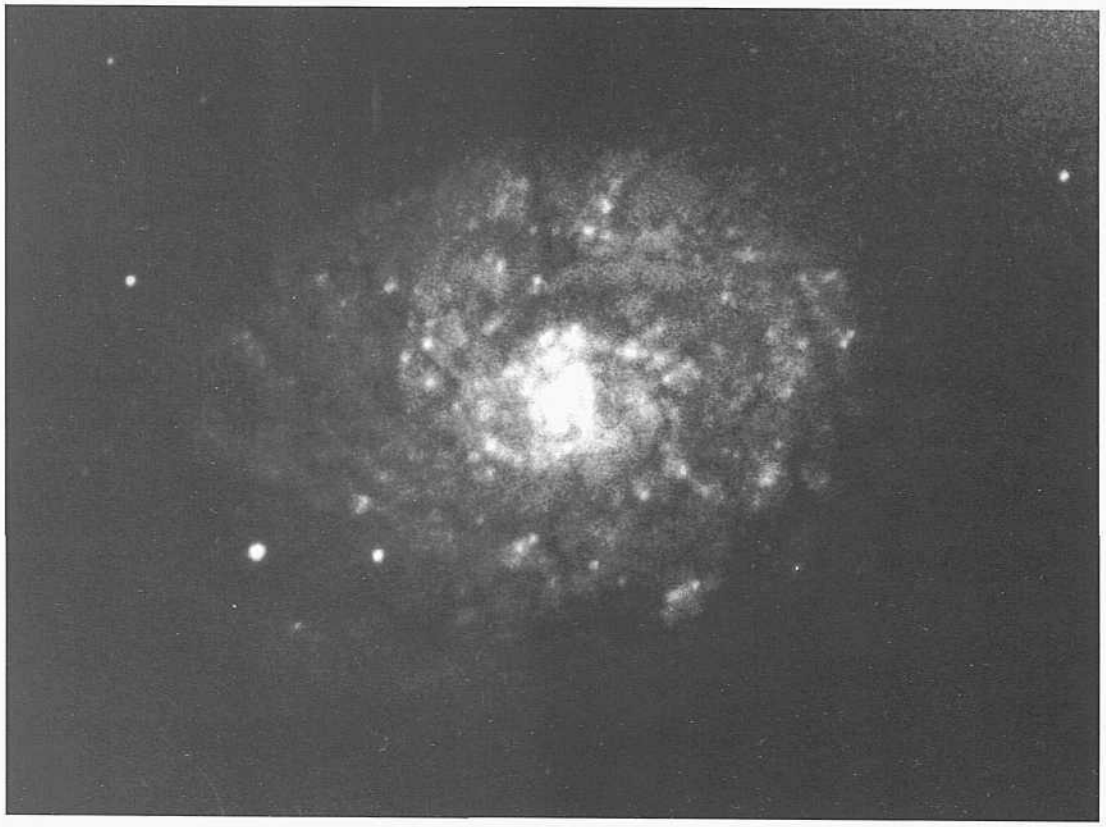
The HH-region candidates in many of the arm fragments are unresolved at the 1.5" level on the available plate material.

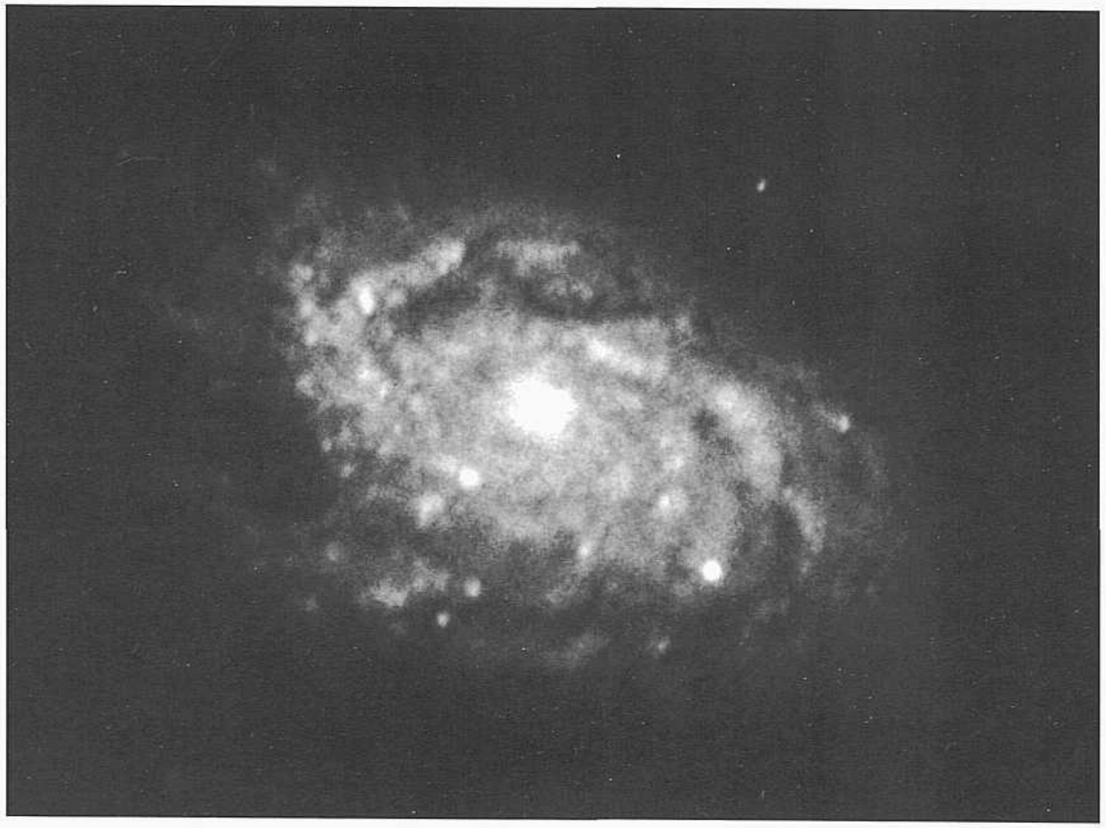
Upon inspecting this image on this plate, one viewer commented, "When man creates a sharper telescope, God will create a fuzzier object."

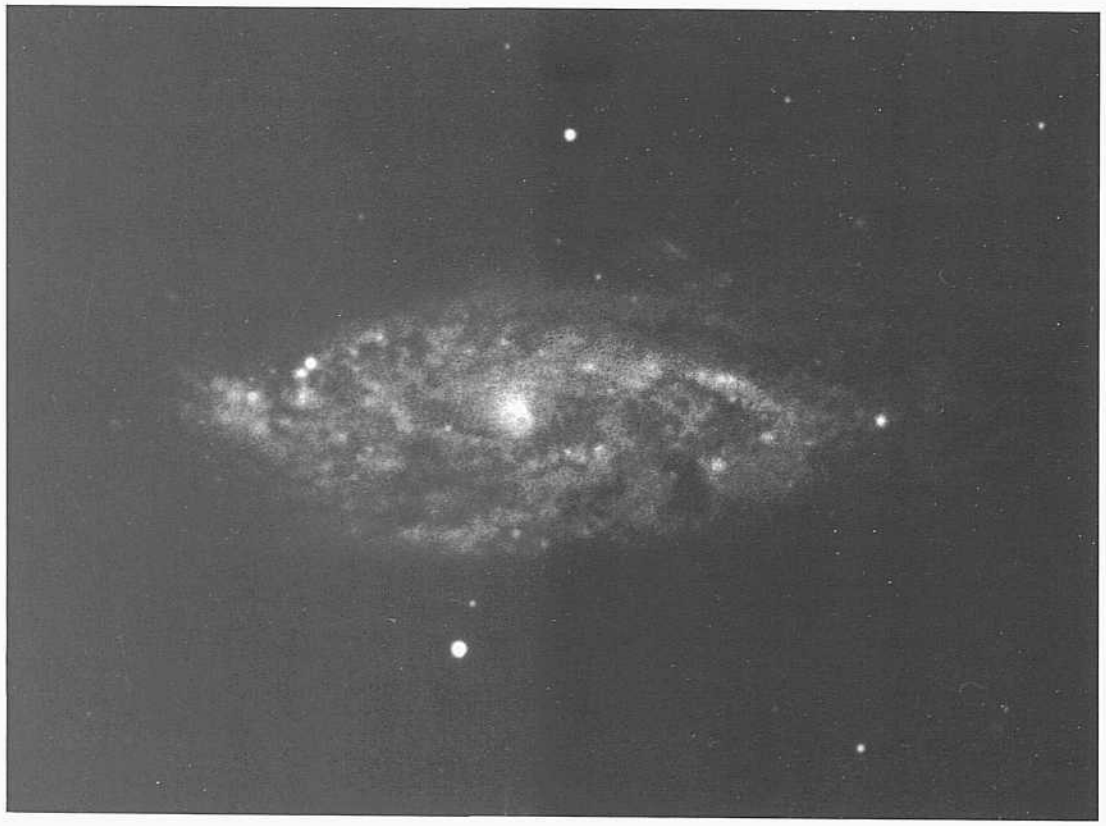


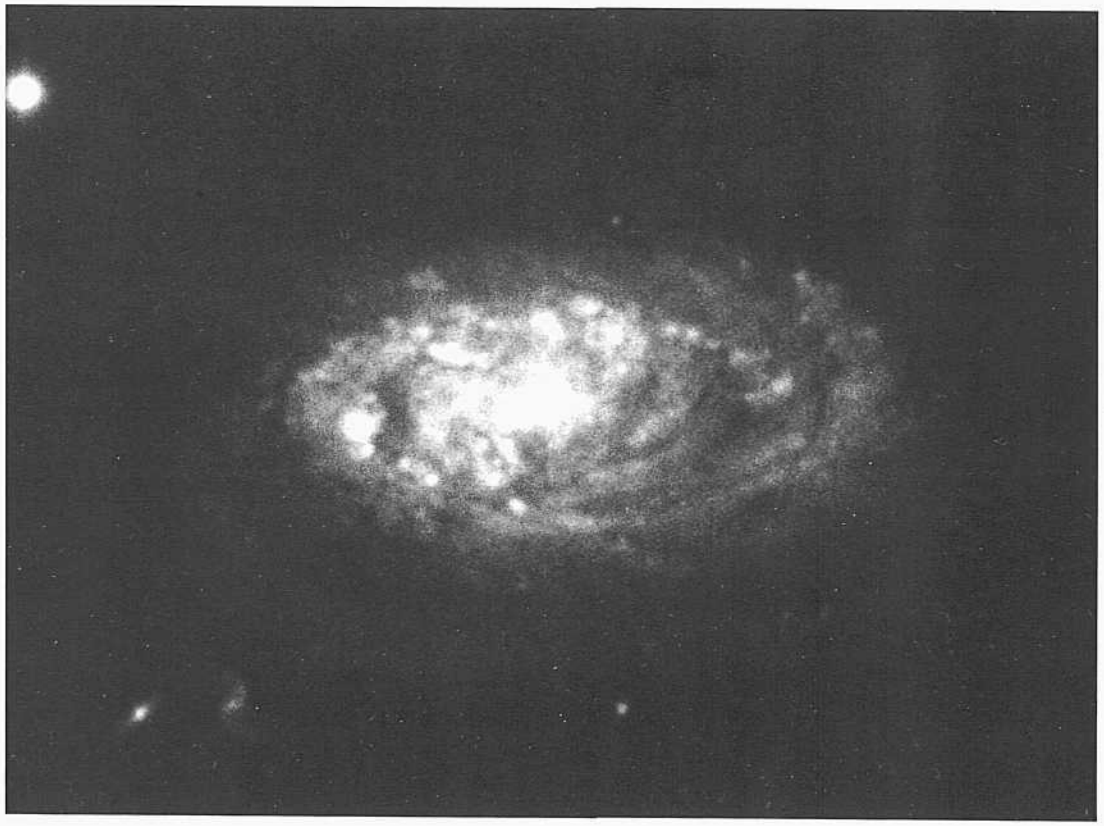
PANEL
277

PANEL
278









NGC 4647 Sc(rs)III pair
CD-802-S VCC 1972
Feb 24/25, 1979 panels 51, S14
103aO + Wr2c
45 min

NGC 4647 with v_0 = L331 km s"[1] forms a close (physical?) pair with NGC 4649 (M60; SO;; panel 51 ; v_0 = 1142 km s~[l]). The pair- is shown in panel 10 of the Virgo Cluster photographic alias of spirals (Sandage, Binggeli, and Tammann 1985a). The angular separation of the pair is 2.8', which corresponds to a small projected linear separation of 18 kpc at a distance of 2 1.8 Mpc if the galaxies arc physically associated.

Numerous EQI-region candidates exist in some of the arm fragments. The largest resolve into disks at about the 1 .5" level.

NGC 7314 Sc(s)HI HA, p. *30*
CD-1574-S/Br
Aug 10/11, 1980
103aO + GG385
45 min

The small nucleus, the absence of a central bulge, and the evident presence of HII regions in some of the multiple arm fragments are the classification characteristics of the Sc morphology.

The redshift is v_a = 1491 km s"[1].

NGC 4212 S<-(s)II-III VCC 157
CD-793-S
Feb 23/24, 1979
I03a0 + Wr2c
55 min

NGC 12 12 is located in the northwestern corner of the Virgo Cluster survey area, about 1° from the center of Virgo subcluslcr A associated with NGC 4486. ll is listed as a member in the Virgo Cluster Catalog and is illustrated to a common scale with other cluster members in tin- Virgo Cluster atlas of spirals (Sandage, Binggeli, and Tammann L985a, panel ')).

NGC 5678 Sc(s)II-III
PH-7647-S
April 28/29, 1979
103aO
12 min

The numerous Mil regions in the multiple arms are unresolved at the 1" level. 'Flic redshift of NGC 5678 is v_0 = 2446 km s~'.

NGC 5949 Sc
PH-58-H
April 27/28, 1949
103aO
30 min

The arm pattern in NGC 5949, composed as in NGC 488 of **multiple** fragments hut later in the classification sequence, begins at a poinllikc nucleus. There is no **centra]** bulge or evidence of **a** halo.

The **redshift** is small, v_0 = 624 km s^{-1}, yet the few Hll-region candidates are unresolved. And there is no sign of resolution into individual stars, as would be expected at such a small redshift by comparison with galaxies of similar redshift such as NGC 5194 (M5 1; panels 172, 177) at v_0 = **541** km s^{-1}.

NGC 4298 Sc(s)III VCC 483
CD-1399-S/Br pair
March 22/23, 1980 panel 289
103aO
75 niin

NGC 42 98 forms an apparent pair with NGC 4302 **(Sc** on edge: panel 289) at a separation of 2.4'. The redshifts listed in the RSA are identical at v_o = 1004 km s^{-1}. However, as the pair is in the Virgo Cluster, the similarity of redshifts does not assure a dynamical relation because of the large virial velocities of parts of the cluster complex. If the pair is at the same distance of 21.9 Mpc (m - *M* = 31.7), their **projected** linear separation is small at 1 5 kpc.

As in NGC 5949 above, and NGC 7314 on the preceding panel, the nucleus of NGC 4298 is pointlike. There is no central bulge or evidence **of** a halo.

NGC 2397 **Sc(s)IH**
CD-159-S
Feb 4/5, 1978
103aO + GG385
45 **min**

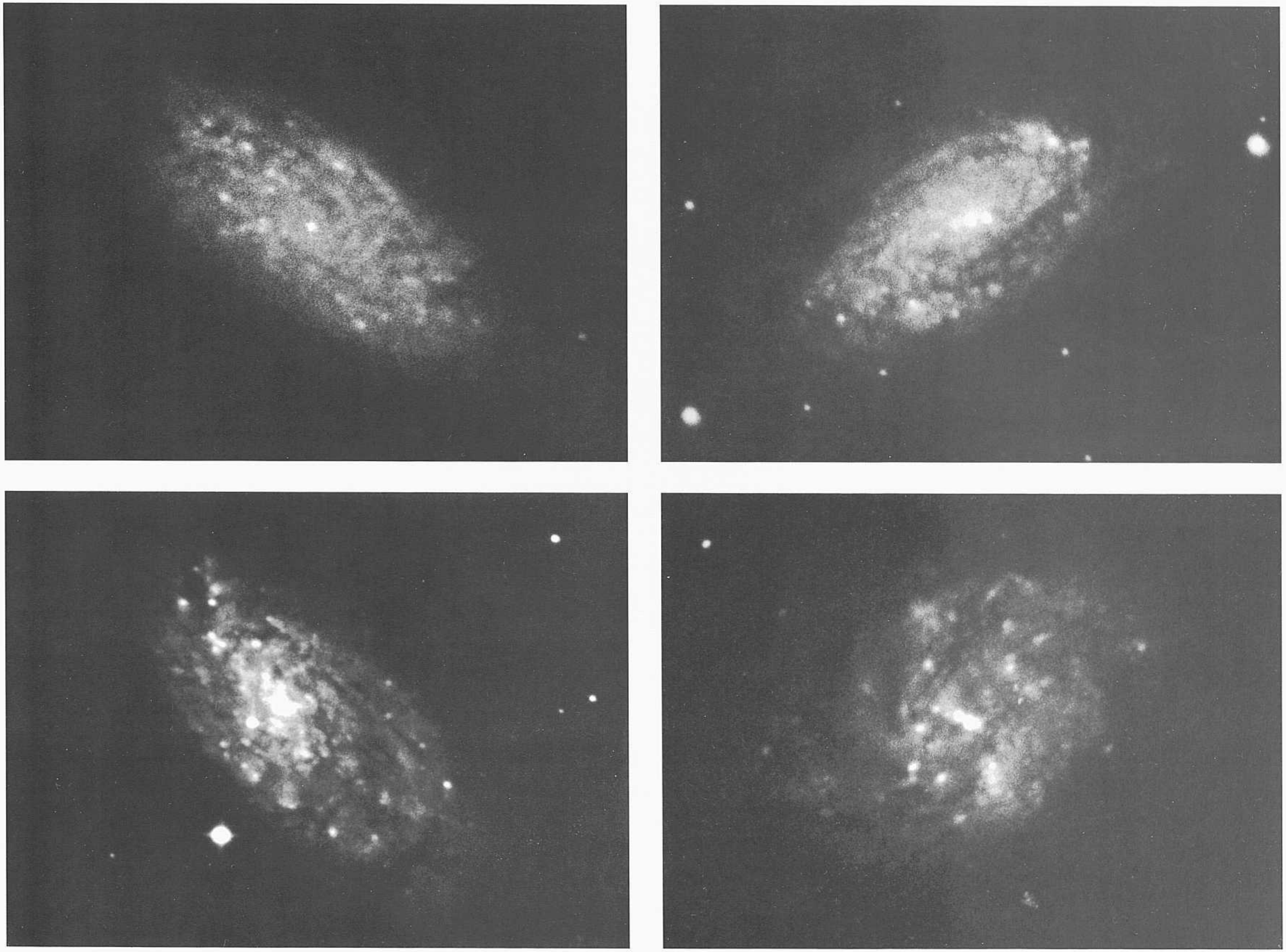
The spiral pattern in NGC 2 39 7 is similar to that in NGC 5949 and NGC 4298, also on this panel.

The redshift of NGC 2397 is v_0 = 1044 km s^{-1}.

Several candidates for Im dwarf companions exist within 0.5° of NGC 2397.

NGC 1087 **Sc(s)III.3** **HA, p.** ***35***
H-2337-H
Nov 27/28, **1946**
103aO
10 min

Hll-region candidates exist within the disordered spiral pattern of the multiple-armed type. The redshift of NGC 1087 is v_0 = 162 8 km s"'.



PANEL
279

PANEL
280

The next five panels show Sc galaxies thai arc in pairs and in some eases in close encounters. The illustrations here for Sc types are similar to the illustrations of such pairs and/or encounters in earlier sections describing galaxies of type K (panels 21-23), SO (panels 51, 52), Sa (panels 81-86), SBa (panel 105). Sl> (panel 153), Six- (panel L98), and SBbc (panel 2 12).

NGC 1038/1039	**Sc(tides)**	**group**
CD-1679-S	**Sc(lides)**	
Jan 1/2, 1981		
103aO		
60 min		

This well-known **interacting** pair with its **tidal plumes** was **simulated in the famous** N-body **calculation by Toomre** and **Toomre {1 9 72). They** gave **there** tin* first **convincing proof that such morphological features** as **tails are** due **in tidal interactions in a close encounter.**

This **interacting** pair is in **a** loose **group of** five other RSA galaxies and several **fainter non-**Dreyer **galaxies** that may **be kinematically** associated. The **five** bright **group** members with their **redshifts** and separations from NGC 4038/4039 are NGC 3957 (SO; panel 44: v_o = 1583 km a"[1]; **separation** 2.1°). NGC **3981** **[SbcI-II** (tides?); panel 178; v_0 = 1554 km s~'; separation 1.7°], NGC 4024 {SO; panel 31; v_o = 1444 km s"[1]; separation 58'), NGC 4027 (Sell.2: panel 252: v_o= 14 L9 **km** s⁻*; **separation** 41'), **and** NGC 4033 (SO; panel 35; v_0 = 1273 km s^{-1}: separation 65'). **The** redshift **of** NGC 4038 is v_o = 139 1 km a"[1].

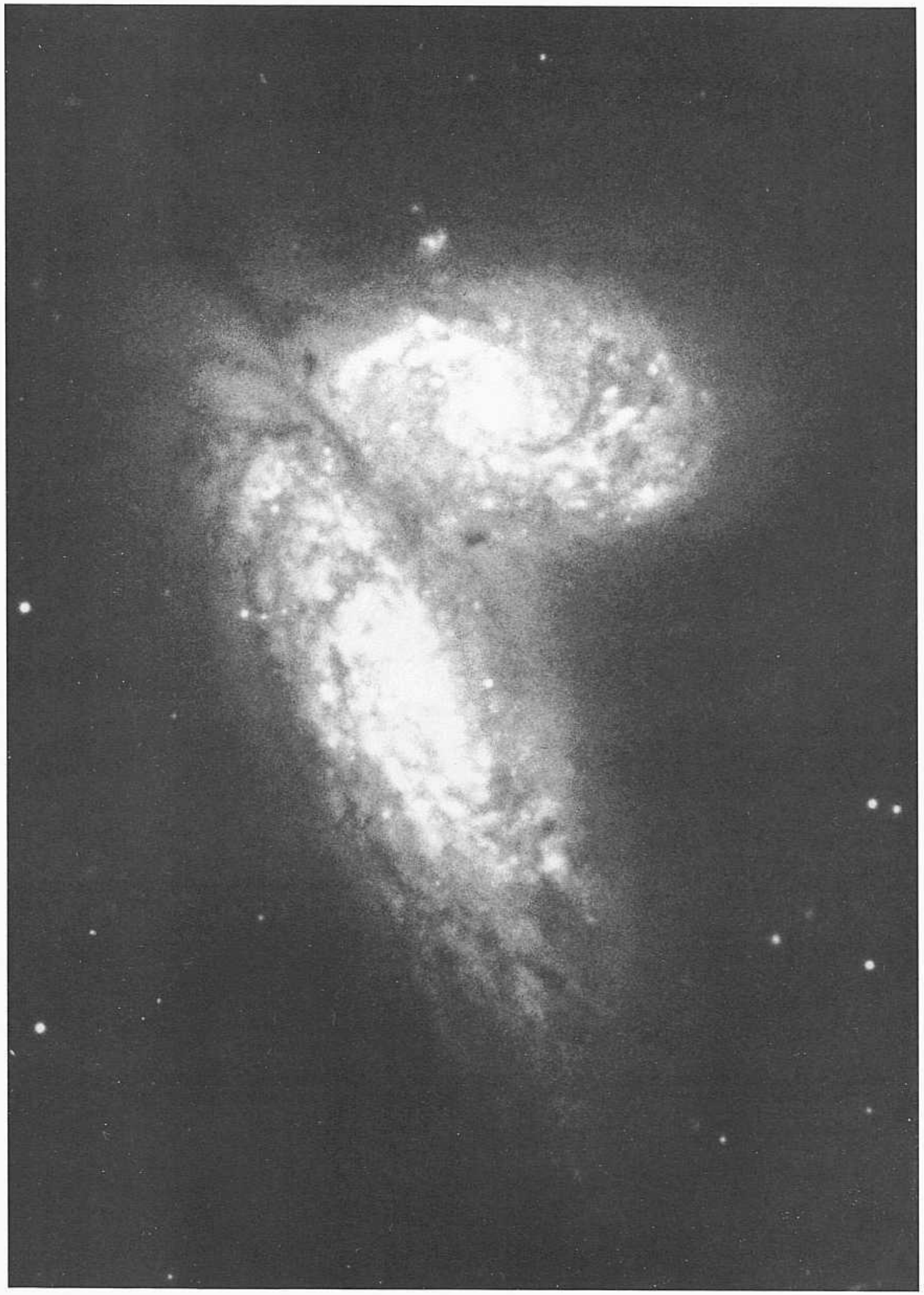
The mean redshift **of** the six **galaxies** is $<v_n>$ = 1444 **km** s[1]. **At the redshift** distance **of** 29 Mpc (// = 50) a separation **of** 1° **corresponds** to a projected linear separation of 506 **kpc. Hence all projected distances of the five** listed **galaxies from** NGC 4038/4039 **are** less than about 1 Mpc. The group is similar in size **to the Local** Group **and** may **be** a good model.

The three prints on **the** facing **page have all** been made from the same original **photograph** taken at Las **Campanas** with **the** 100-inch **reflector.** Robust recent star formation is **evident** in the central regions **of the apparently merging configuration.**

NGC 4567/4568	**Sc(s)II-III**	**VCC 1673**
CD-733-S	**Sc(s)H-III**	**VCC 1676**
Feb2/3, 1979		**W 2 1 9**
103aO + Wr2c		**Karachentsev 347**
45 mill		

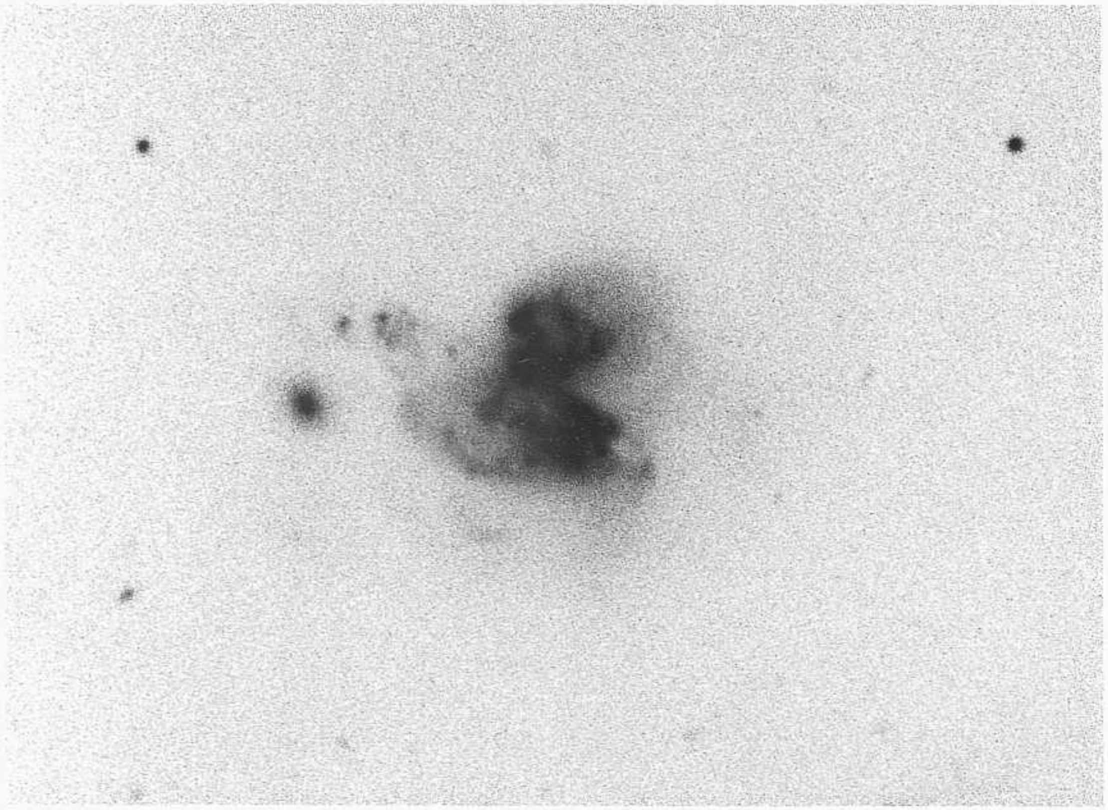
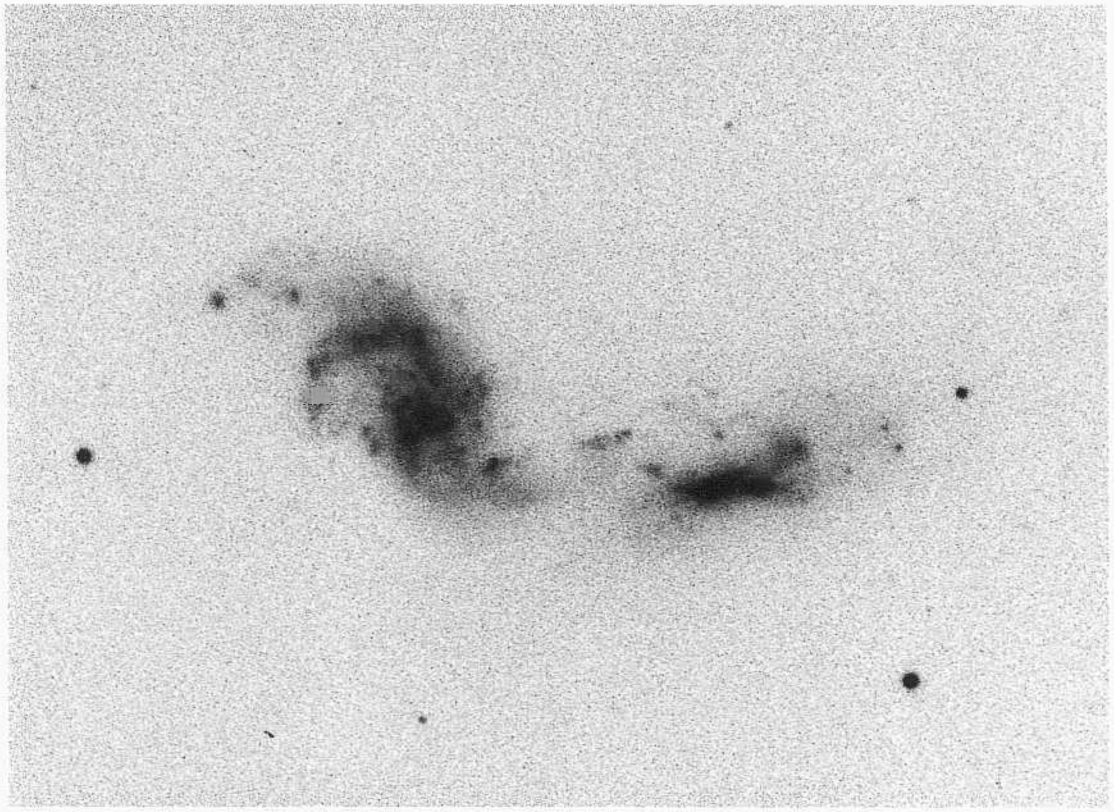
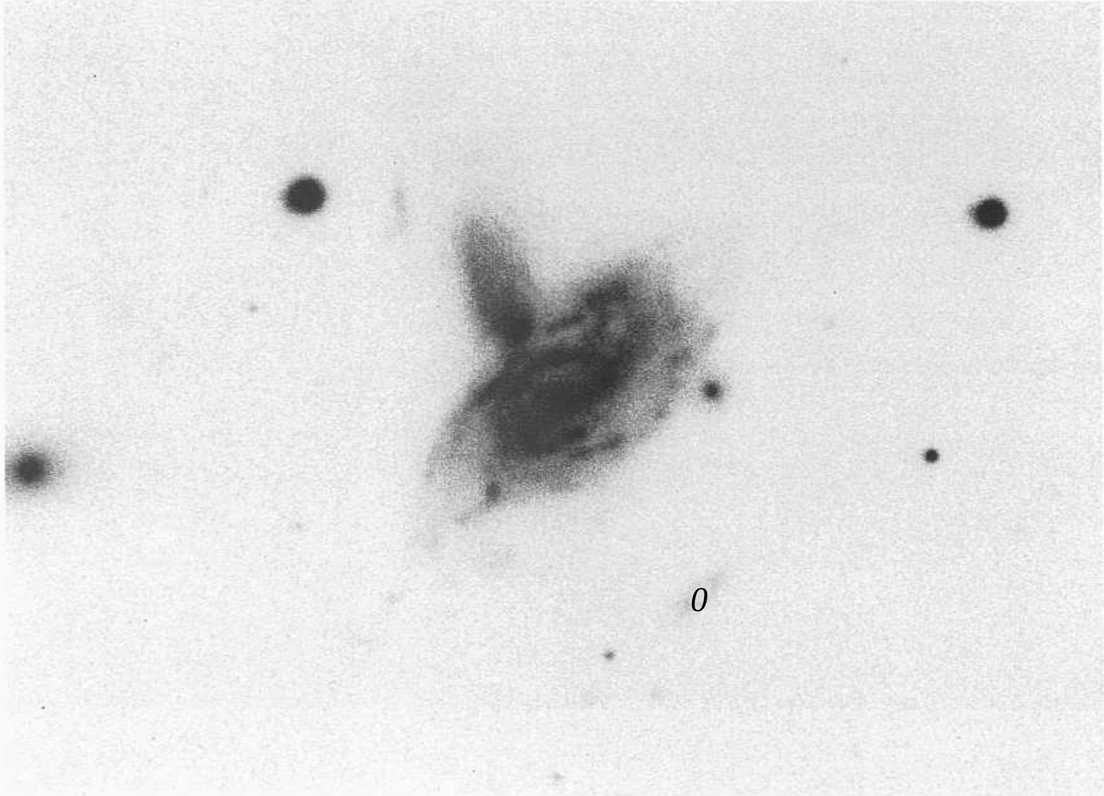
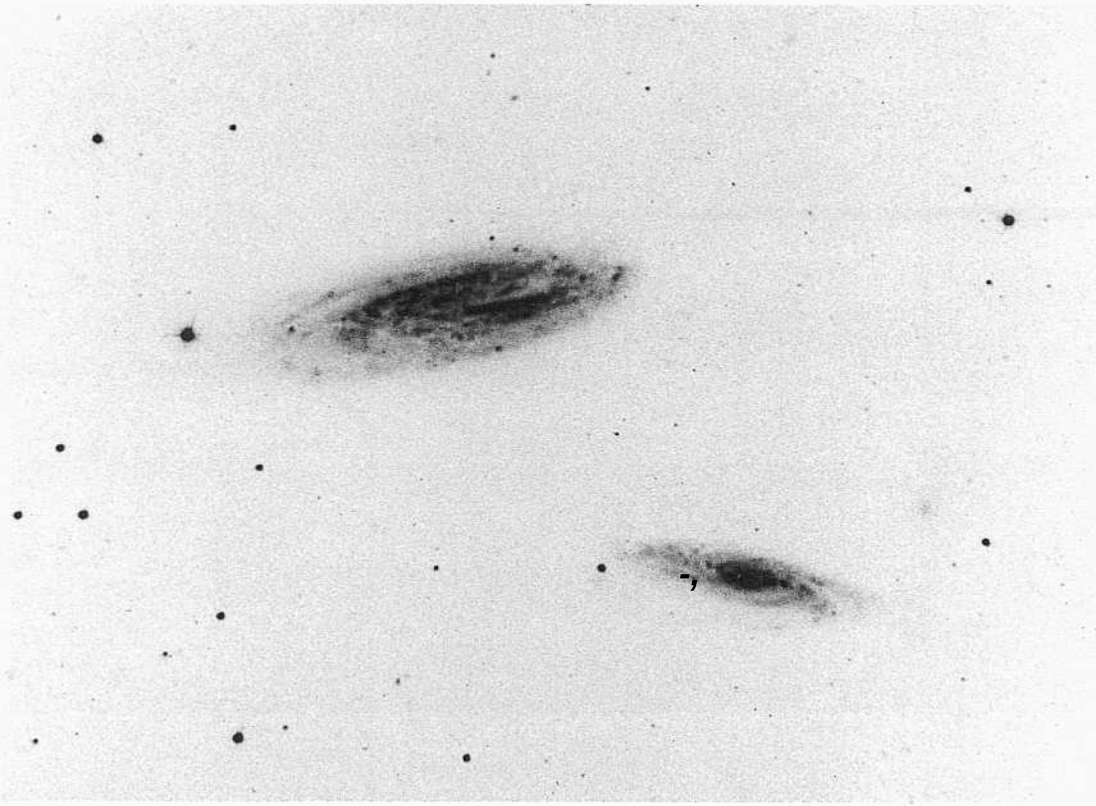
The **redshifts of** the **components** ol this **pair** are **u_o(4567)** = 2136 km s^{-1} and **v_o(4568)** = 2199 km s^{-1}. The separation of centers is 1.3'. If the pair is in the Virgo Cluster at a distance of 21 .9 Mpc. **the** projected linear separation is small at 8 **kpc.**

A most interesting aspect of the **combined morphology** is the lack of evidence for tidal **distortion** in either member **of the** pair. Each galaxy has **the morphology** of a normal Sc galaxy of intermediate luminosity class. Each has a small nucleus and well-developed multiple spiral arm fragments of the NGC 488 type. Either the separation is large **in** the **line** of sight or the **orbital** circumstances of the encounter are unfavorable for tidal plumes (orbital **angular** momentum **could be** opposite to the direction of the **individual** spin angular momenta).



PANEL
281

PANEL
282

NGC 3690 Sc(tides) Karaehciilsev 288
PII-8058-S
Feb4/5, 1981
103aO
12min

A close encounter is clearly in progress in this close pair whose separation of centers is 26". Karachentscv lists the individual v_0 redshifts as 3156 km s"' and 3 196 Um s⁻'. At the redshift distance of 64 Mpc *(II* = 50) the projected linear separation is 8 kpc. A possible third E eompanion exists at a separation of 66", hut it may be in the background.

The morphology of each companion is highly disturbed. Faint outer plumes are associated with each galaxy.

NGC 7119 Sc(s)II pair?
CD-1121-Br
Aug 20/21, 1979
103aO + GG385
45min

NGC 7119 and its possible companion, with a separation of only 2 1", may be a chance superposition in the line of sight. Other galaxies of the same small angular diameter as the companion exist in the surrounding field as if there is a background group.

There is no distortion of the morphology of either member of the pair, again suggesting a chance alignment.

The redshift listed in the RSA2, v_0 = 9825 km s^{-1}, is suspect because of its very high value for RSA galaxies. It is based on a single measurement quoted in a private communication. The kinematics of the system are clearly of interest. There is, of course, the possibility that the high redshift applies to the small companion and that the redshift of NGC 7119 itself is unknown (e. 1990).

NGC 3395/3396 Sc(s)II-lII Karachentsev 219
PH-7995-S Sc(tid.-s)
Feb2/3, 1981
103aO
12min

Clearly a close encounter is in progress. The redshifts listed in the HSA2 are u_o(3395) = I 599 km s^{-1} and u_o(3396) = 16 19 km s^{-1}. The angular separation of 68" corresponds to a projected linear separation of 10 kpc at the redshifl distance of 32 Mpc (// = 50).

The pair is apparently connected by a faint (tidal?) plume. The fainter of the pair appears to be partially disrupted. Robust star formation may be occurring in the center of the fainter member.

NGC 7541/7537 Sc(s)II Karachentsev 578
H-915-Dimcan Sc(s) panel 255
Sep 2/3, 1945
103aO
60 mill

NGC 7541, shown on panel 255. is the brighter member of a physical pair with NGC 7537. The redshifts listed by Karachentsev are u_o(7537) = 2834 km s"¹ and u_o(754]) = 2793 km s^{-1}. The angular separation of 2.7' corresponds to a projected linear separation of 44 kpc at the redshift distance of 56 Mpc *{II* = 50). The spiral pattern of neither member of the pail' shows evidence of an encounter.

Two Im candidates for dwarf companions to the pair exist within 11' of NGC 7541. They have Hll-region candidates at the same brightness as the II1I knots in the two main Sc galaxies and are therefore very likely at the same distance. Three candidates for dK dwarf companions also exist in the immediate field.

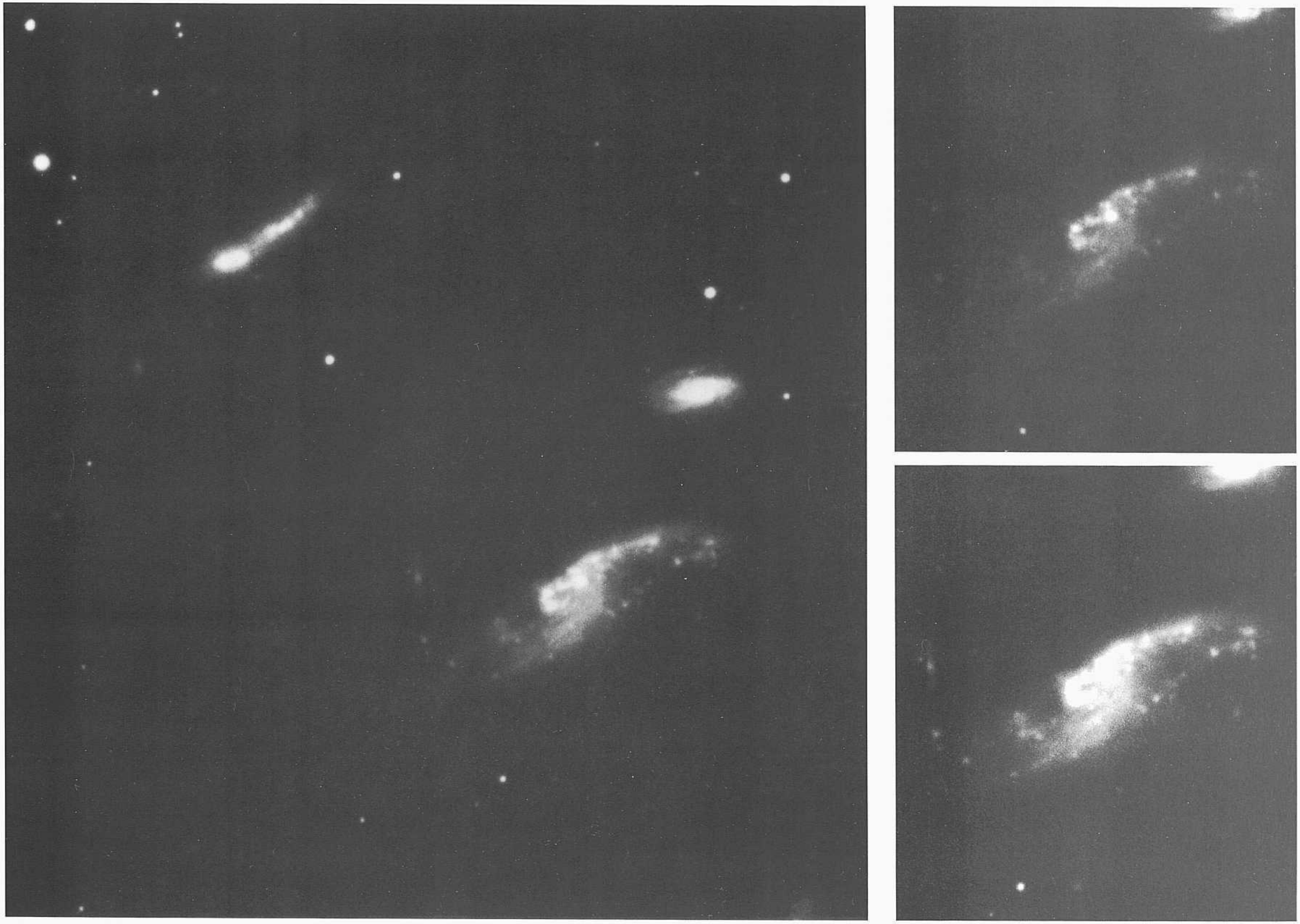
NGC **3995/3991/3994** **Karaclicntsev 311**
PH-8054-S Sc(tides) Racine wedge
Feb 4/5, **1981** **Pec(tides)** **Arp 313**
103aO **Sbc or Sc**
12 inin

NGC 3995 is **the** brightest galaxy **of** a multiple interacting group whose next-brightest **members** are NGC 3994 (She: **it** is the closest galaxy to NGC 3995) and NGC 3991. The **morphology** of NGC 3991 is dominated **by** a thin **tidal** plume in **which** very bright **HH-region** candidates are present. Karachentsev lists **redshifts** of r,,(3394) = 3086 kins"' and u_o(3395) = 3232 km s"[1]. The redshift listed **for** NGC 3991 by **Palumbo** *el* ***al.*** (1983) is 3256 km s"'. From these three redshift values, the mean redshift distance of the group is 64 Mpc *(H* = 50).

The angular separations of NGC 3994 and NGC 3991 from NGC 3995 are 1.9' and 3.7', respectively. The corresponding projected linear separations are 35 kpc and 68 kpc.

The morphology **of** NGC 3994 (the fainter of the close pair) is normal for a late-type Sbe or Sc. There is no evidence of tidal distortion despite its apparent closeness to NGC 3395. However, tidal disruption is clearly evident in NGC 3991, the more distant in projection of the triplet.

The **two** main prints **of** NGC 3395 (the **brightest** galaxy of the **group)** also show evidence of morphological distortion. It would seem that the interaction has been between NGC 3995 and NGC 3991. not involving NGC 3994.



PANEL
283

PANEL
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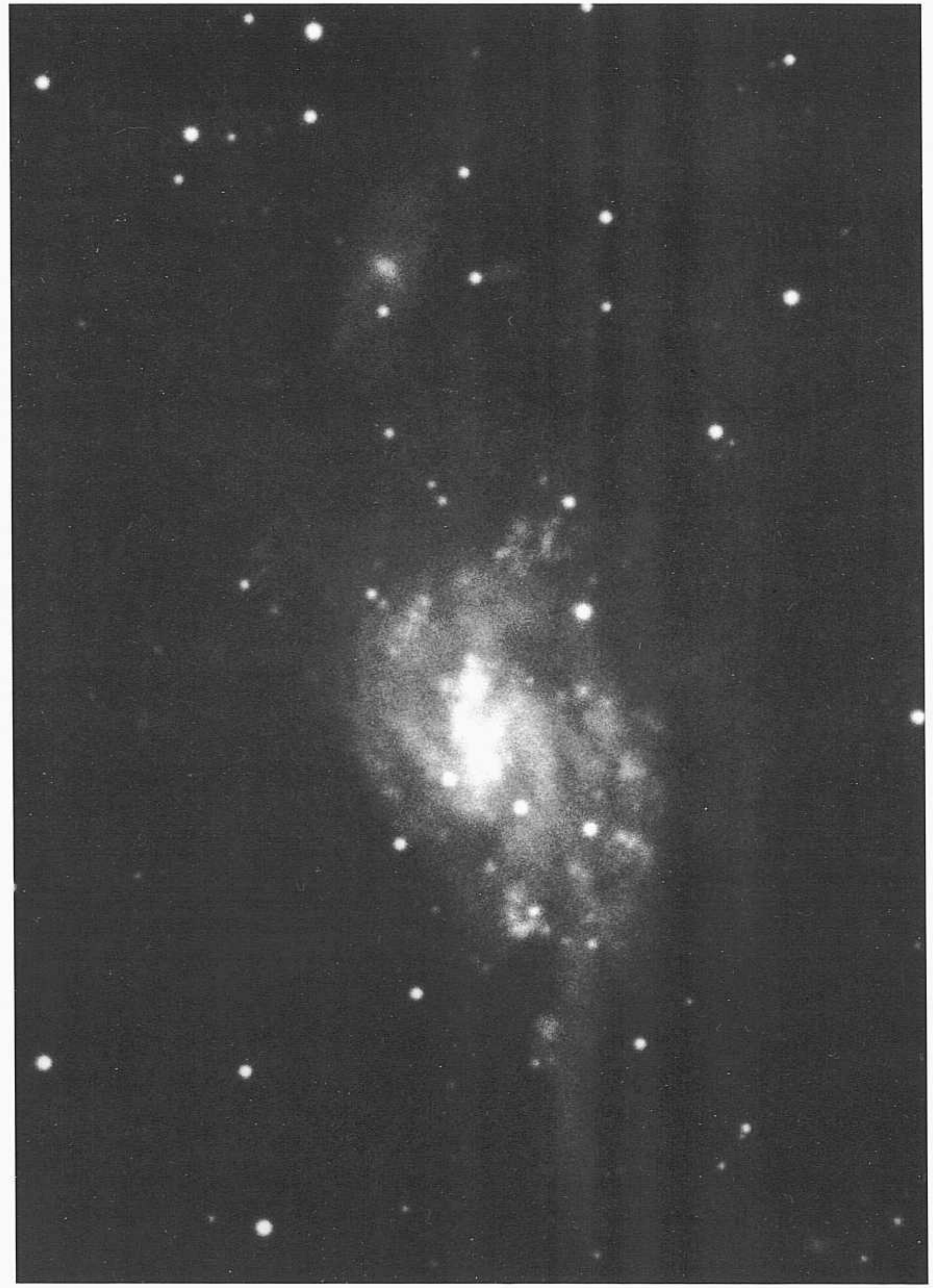


IC 1837/1839 S<(s)ll-lll
CD-537-S **Sab(a)1.2**
Ocl 1/2, 1978
103aO + GG385
45 mill

The pair has an angular separation of 3.4'. Only IC 4837 (the late-type Sc) is in the Shapley-Ames. although IC 3839 (the more regular Sab) is nearly as bright. Mo redshift is known for 1C 4839 (e. 1990). The redshifl for IC 4837 is v_0 = 2575 km r'.aa listed in the RSA2. [flC 4839 is at the same redahift distance of 52 Mpc, the projected linear separation of the pair is 55 kpc.

The spiral morphology of IC 483 7 (shown alone at the right) is too normal to provide evidence of tidal interaction. The extension of the outer arm on one side of the pattern, although asymmetric, is not unusual even in isolated galaxies.

Galaxies on this and the next six panels are Sc types that are either highly inclined or are nearly edge on. They are grouped together at the end of the Sc section to illustrate the smallness of the nuclear region, the absence of a central bulge, and the absence of an appreciable luminous halo. These characteristics separate the Sc class from the Sb types. The three criteria are best seen in galaxies that are nearly edge on.

NGC 247 **Sc(s)III-IV** **South Polar Gr**
CD-512-S
Sep **28/29, 1978**
103aO + GG385
45 min

NGC 247 is a highly resolved nearby galaxy in the South Polar Group (de Vaueouleurs 1959a). Among members of the group are NGC 55, NGC 247, NGC 253. NGC 300, and NGC 7793 . all in the RSA and all shown in this atlas.

The stellar content of NGC 247 is easily resolved into individual stars, star clusters, associations, and a few small HII regions. The resolution begins at about B = 17 for the blue supergiants. The distance modulus must be nearly the same as that of NGC 3 00 (panels 26 1, S6) at m - M = 26.5 from Cepheids (Graham 1984). Hence the brightest blue supergiants have absolute magnitudes of about Mg = —9.5, consistent with the calibration given elsewhere (Sandage and Carlson 1988). The redshift is small at v_0 = 22 7 km s^{-1} , consistent with the small distance modulus.

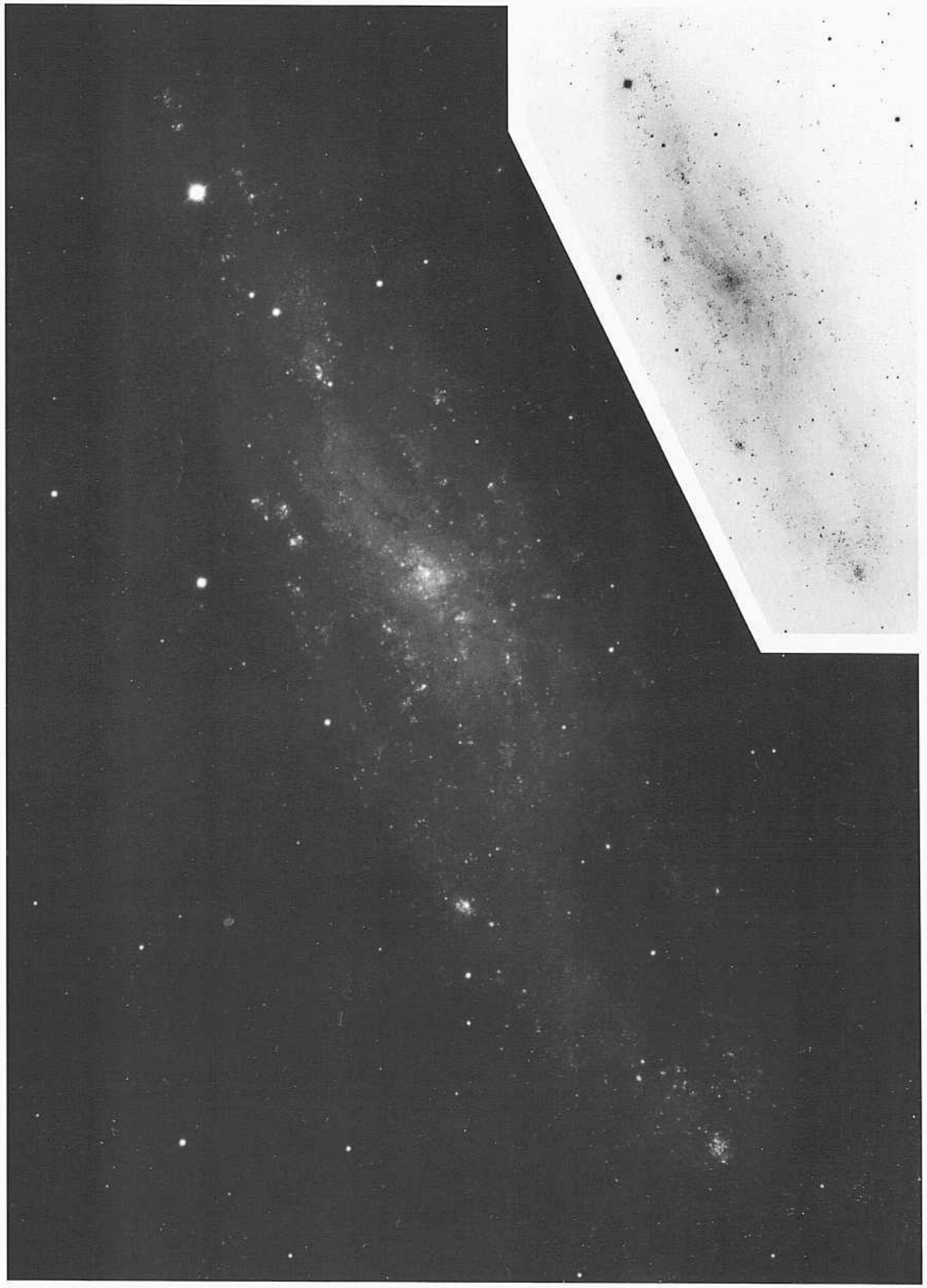
The type is very late Sc. Note the small nucleus and the absence of a central bulge.

NGC 4945 Sc
CD-144-S
Feb 1/2, 1978
103aO + GG385
30 niin

NGC 4945 is seen nearly edge on, hiding the spiral **pattern.** The heavy dust on the near side, silhouetted against the background disk, obscures whatever nucleus may be present, but it is certain that there is no central bulge and that the nuclear region is small.

No useful resolution into individual stars is achieved on the available plate material. Although individual stars can be identified in parts of the arms, peeking out of the dust, they are much fainter than in NGC 247 , which has nearly the same redshift. Contamination by Galactic stars is also a problem at the low galactic latitude offc = 13°.

The redshift of NGC 4945 is small, u_o = 2 75 km s^{-1} . Closeness is also indicated by the large angular size (D_{95} =2 0'), consistent with the small redshift. Although the distance is evidently small, the high inclination and the dust obscuration prevent NGC 4945 from being useful for the calibration of distance indicators normally used for measurements of extragalactic distances.



PANEL
286

NGC 253 Sc(a) South Polar Gr
CD-2036-Bedke/Gregory HA, p. *34*
0ct31/Nov 1, 1981
098-04
90 min

NGC 253 is a member of ihc South Polar Group. Its redshift is small at v_Q = 293 km a^{-1}. The estimate of the distance modulus in the RSA2 is m - *M* = 27.5. As suggested there, the group may extend in distance from the nearest members such as NGC 55, NGC 247, and NGC 300 al about *m* - *M* = 26.6. lo more-distant members such as [NGC, 253 here, and then to NGC 7793 (Sd; panels 321, S6), which may be a magnitude more distant.

Resolution into individual stars is more difficult than in NGC 247 on the preceding panel. but is not as difficult as in NGC 4945. also on that panel. The brightest stars are in associations: they resolve beginning at about *H* = 11!. But the dust obscuration is very heavy. Limiting their use in NGC 253 for calibration purposes in measurements of the extragalactic distance scale. Yet star clusters, associations, and HII regions are clearly evident in the regions which have a small optical depth in the dust.

The nucleus is small. There is no central bulge. The type is prototypical Sc(s). but there is much more dust than in NGC 247 and NGC 55 (Se; panel 318).

The four galaxies on this panel are similar to NGC 253 but are at much greater distances, masking the details of the dust lanes. This apparent lack of dust gives a false security that obscuration and dust-dimming of the stellar content are unproblematic in photometry of individual stars and HII regions. Because of this, caution is in order using stars in these galaxies for addressing the problem of the distance scale.

NGC 3877 **Sc(s)II** Ursa **Major Cluster**
PH-8081-S
Feb 5/6, 1981
103aO
12 min

A few HII-region candidates are present in some of the arm fragments of NGC 3877. The spiral pattern is multiple armed. There **is** a small nucleus and no central bulge. The redshift of NGC 3877 is v_o = 939 km s^{-1}. It is considered to be a member of the Ursa Major Cluster.

NGC 3495 **Sc(s)II-III** **panel SI 1**
CD-1840-HB
April 2/3, 1981
103aO + GG385
45 **min**

The morphology of NGC 3495 is almost identical to that of NGC 3877, above. The redshift is v_o = 970 km s^{-1}.

NGC **4096** **Sc(s)II** **M51 Gr?**
S-1979-H
Feb 20/21, 1947
103aO
30 min

Thin, multiple spiral arms are well defined, but the high inclination of NGC 4096 makes luminosity classification uncertain. Because of the rather-well-defined nature of the arms, the luminosity class has been reassigned here relative to the **II-III** class listed in the RSA2.

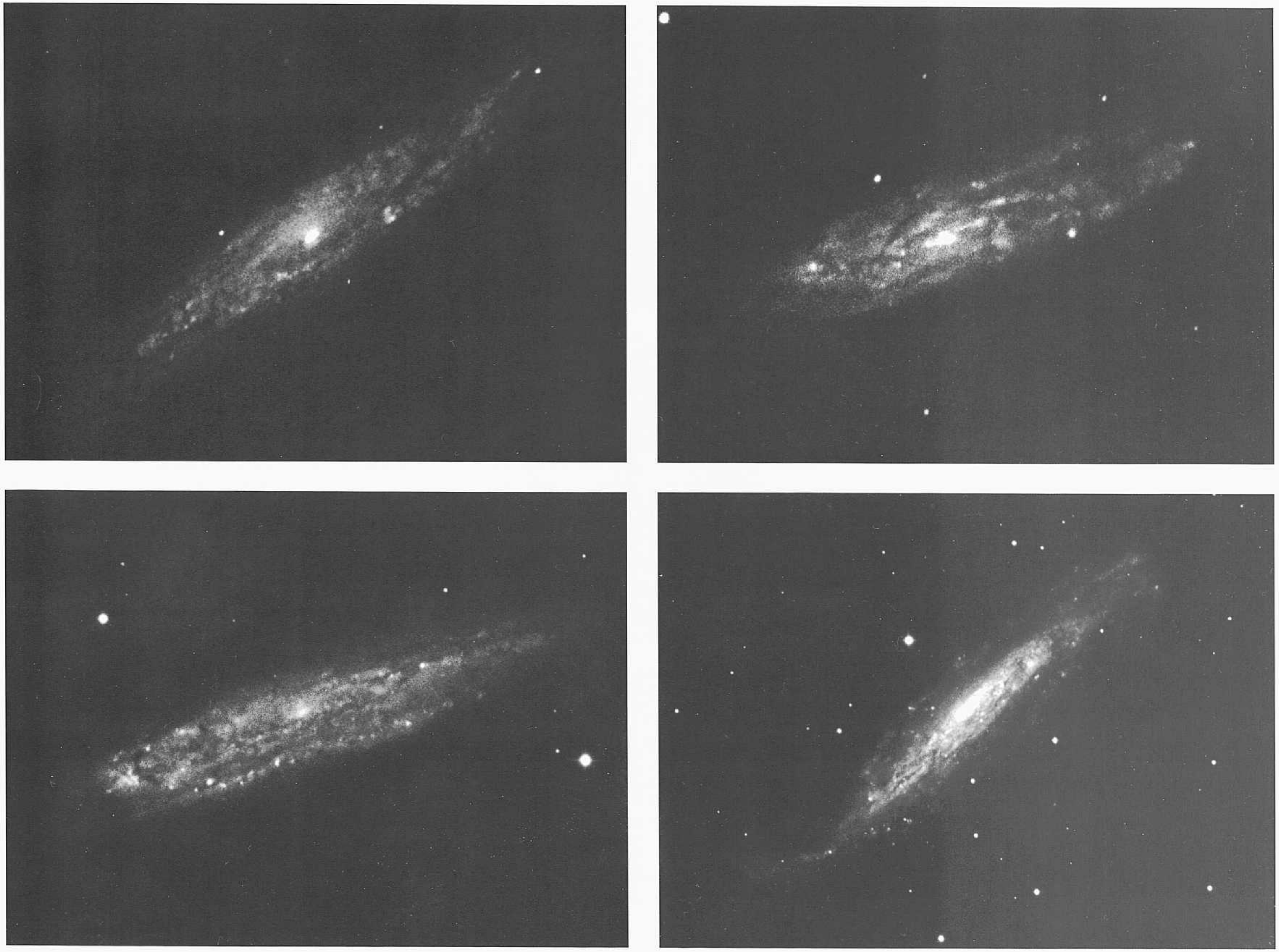
The redshift of NGC 4096 **is** v_o = **616** km s^{-1}. The galaxy is tentatively assigned to the M51 Group, which also contains NGC 4258 (v_o = 520 km s^{-1}), NGC 4460 (v_0 = 605 km s^{-1}), NGC 4490 (v_o = 601 km s^{-1}), NGC 4618 (v_o = 563 km s^{-1}), and M51 (v_o = 552 km s^{-1}). Whether these galaxies actually form a physical group, as suggested by the similarity of their small redshifts, is uncertain. The maximum separation of 16° on the sky of the suggested members corresponds to a projected linear diameter of the group of 3.4 Mpc at the mean redshift distance of 12 Mpc. If M51 is excluded from consideration of membership, the linear diameter of the remaining group is smaller, at 2.2 Mpc.

The original plate from which this print was made was taken with the 60-inch reflector at Mount Wilson.

NGC 1448 **Sc(s)II**
CD-1590-S/Br
Aug 11/12, 1980
103aO + GG385
45 min

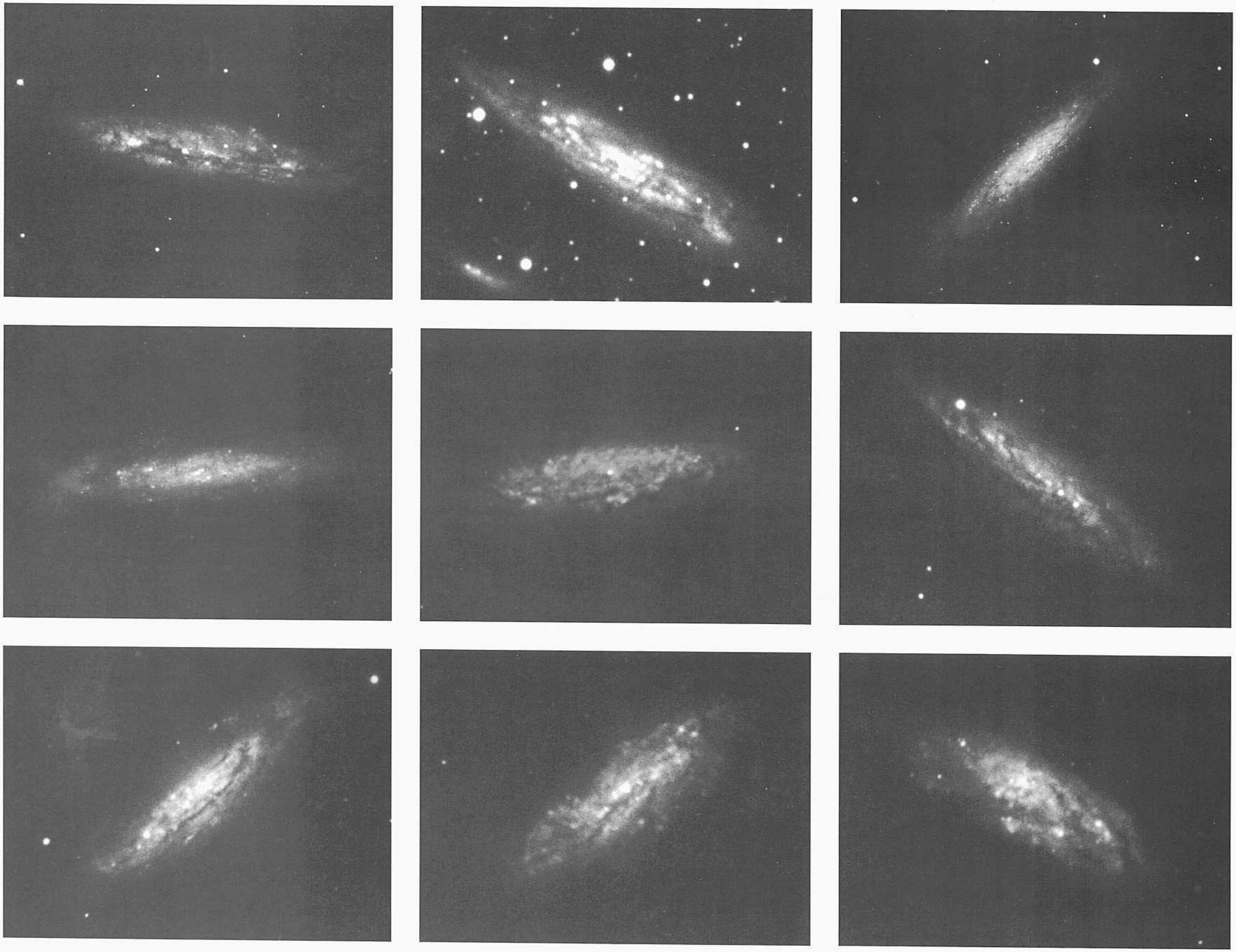
HII-region candidates exist in the arms of NGC 1448. On this plate, taken with the Las Campanas 100-inch telescope in excellent seeing, the brightest stars seem almost ready to resolve individually.

The redshift is v_o = 1038 km s^{-1}.



PANEL
287

PANEL
288



The nine galaxies on this panel have similar morphologies. They have multiple-arm spiral patterns oi the NGC 488-NGC 2841 type but are later in the sequence; they generally have small, pointlike nuclei or none at all; they have no central bulge or evidence of a luminous halo. These attributes are characteristic of late Sc galaxies.

NGC 3556 Sc(s)III HA, p. *35*
S-1742-H
Dec 6/7, 1937
Imp. Eel.
60 niin

The original Mount Wilson 60-inch plate used for NGC 3556 here is the same used in the Hubble Atlas. The description there suggests the morphological similarity of NGC 3556 and NGC 253.

Several Hll-region candidates exist in parts of the arms not obscured by the dust lanes on the near side. The largest of these regions may begin to resolve at about the *2"* level. The redshift of NGC 3556 is v_a = 790 km s"[1].

NGC 7361 Se(s)II-III
CD-1545-S/Br
Aug 7/8, 1980
103aO + GG385
45 min

The largest of the several HII regions may just begin to resolve at the 1" level. The redshift of NGC 7361 is v_0 = 1276 km s"[1].

NGC 2748 Sc(s)II
PH-7930-S
Nov 7/8, 1980
103aO
12 min

The morphology of NGC 7361 is similar to that ofNGC253.TheHII regions are unresolved at 1". The redshift is v_{n} = 1634 km s~[1].

NGC 4835 Sc(s)H pair
CD-2148-S
March 23/24, 1982
103aO + GG385
45 min

NGC 4835 forms an apparent pair with a dwarf shred (Im or BCD: classified as dIBm in the RCl) as a possible companion visible on this print near the lower-left border, at 1.6' separation. The resolution into knots (presumed HII regions) in the companion and in NGC 4835 itself is the same, suggesting a common distance.

The redshift of NGC 4835 is v_o = 1973 km s"[1]. At the redshift distance of 39 iVIpc *(H* = 50) the projected linear separation of the pair is small, at 18 kpc.

NGC 6503 Sc(s)II.8 Racine wedge
PH-7687-S
Sep 26/27, 1979
103aO
5 min

The spiral pattern in NGC 6503 is similar to the multiple-armed structure of NGC 488, but is much later, and the arms are not as well defined.

The well-determined redshift of NGC 6503 is small, at v_o = 303 km s~[1]. Individual stars and HII regions resolve out of the high-surface-brightness background on a red-sensitive plate taken with the Palomar 200-inch telescope, but the resolution in the blue on the print here is not nearly as prominent. Incipient resolution into stars occurs in one of the outer arms that is not silhouetted against the high-surface-brightness disk, but the exposure on the original plate used here is short, made to see the central regions rather than the individual stars that begin to resolve out at about 6 = 20.

NGC 4808 Sc(s)III
H-2265-H
May 4/5, 1946
103aO
40 min

The original plate used for the print here was taken with the Mount Wilson 100-inch Hooker reflector.

The surface brightness of the multiple-arm pattern that covers the disk is high. The nucleus is either small and faint or is nonexistent. The redshift of NGC 4808 is 630 km s~'.

NGC 2<1 S<(s)II-III
CD-53O-S
Sep30/Ocl 1, 1978
103aO + GG385
45 min

The outer regions of NGC 24 thai arc mil silhouetted against the highly inclined bright disk are highly resolved into individual stars beginning at about *B* = 21.

The redshift of NGC 24 is v_o - 62 1 km s"'.

NGC 5690 Sc(s)H:
CD-1850-HB
April 3/4, 1981
103aO + GG385
45 min

The redshift of NGC 5690 is $v_{,,}$ = 1 653 km s^{-1}.

NGC 4632 Sc(s)II.3 triplet
CD-1411-S/Br
March 23/24, 1980
103aO
75 min

NGC 4<632 forms an apparent triplet with NGC 4666 (Six-: panel 194: $v_{,,}$ = 1474 km s"[1]) and NGC 4668 (SBc; panel 313; K, = 1 53(1 km s"'). The redshift of NGC 4632 is $v_{,,}$ = 1 557 km s^{-1}. The angular separation of NGC 4666 from NGC 4632 is 45.9'. At the mean redshift distance of 30 Mpc (H = 50) for the triplet, the projected linear separation of NGC 4666 from NGC 4632 is 400 kpc, similar to distances within the Local Group.

Most of the galaxies on this and the next two panels are more nearly on edge than those on preceding panels of the ScII-III section. The thinness of the disk and the absence of a strong central bulge are the classification criteria.

NGC 5907 So(on edge) panel SI 1
PH-186-MH
May 10/11, 1950
103aO
40 iiiin

NGC 5907 shows the ahsence of the central bulge particularly well because of its high inclination.

The redshift is $v_o = 779$ km s^{-1}.

NGC 4302/4298 Sc(on edge) VCC 497
CD-1399-S/Br Sc(s)III VCC 483
March 22/23, 1980 panel 279
103aO Karachentsev 332
75 niin

NGC 4302 and NGC 4298 in the Virgo Cluster may form a physical pair. Their redshifts are identical at $v_0 = 1\,004$ km s~J , as listed in the RSA2. The angular separation of 2.4' corresponds to a projected linear separation of only 1 5 kpc at the distance of 2 1.9 Mpc. There is no evidence for tidal distortion in either NGC 42 98 or NGC 43 02. Note that the thin disk seen edge on in NGC 43 02 is not warped: yet NGC 4298, in projection, is nearly in the pole of NGC 4302.

The lack of morphological distortion in either galaxy suggests that the true separation is considerably larger than the projected separation. Similarity of redshift in the Virgo Cluster does not necessarily mean a common distance because of the large (virial) spread in the velocities of cluster members.

NGC 5775 Sc(on edge) Karachentsev 440
CD-1884-HB
April 11/12, 1981
103aO + GG385
45 niin

NGC 5775 forms a physical pair with NGC 57 74 [SBc(s)II] at a separation of 4.2'. The redshifts are similar at $u_o(5774) = 1488$ km s~^{1} and $y_o(5775) = 1687$ km s^{-1}, as listed by Karachentsev. At the mean redshift distance of 31 Mpc *(H* = 50) the projected linear separation of the pair is small at 38 kpc.

No morphological distortion is evident in either galaxy. In particular, the thin disk in NGC 5775, seen nearly edge on, is not warped.

NGC 5301 Sc(s) Racine wedge
PH-7719-S
Feh 11/12, 1979
103aO
12 niin

The original plate used for the print here was taken with a Racine wedge, giving secondary images that are 5.0 mag fainter than the primary and separated from the primary image by 18".

NGC 5301 is nearly *on* edge, showing the thinness of the disk.

The redshift is v_n - 1 709 km s~'.

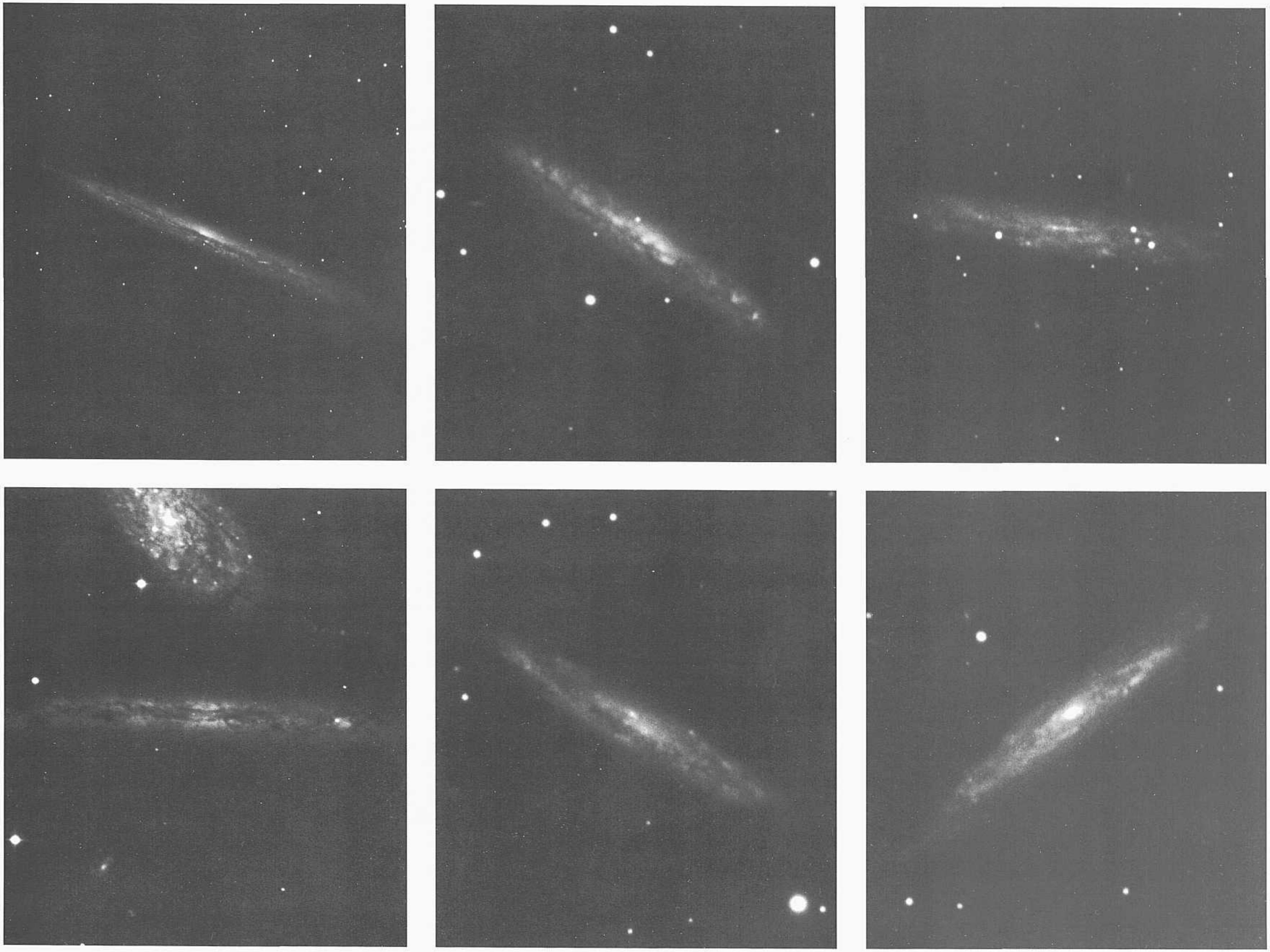
NGC 5496 Sc(s)II
CD-1591-S/Br
Aug 12/13, 1980
103aO + GG385
45 niin

NGC 5496, seen nearly on edge, may have a small luminous bar near the center, seen well in the print here.

The redshift is $v_o = 1398$ km s~'.

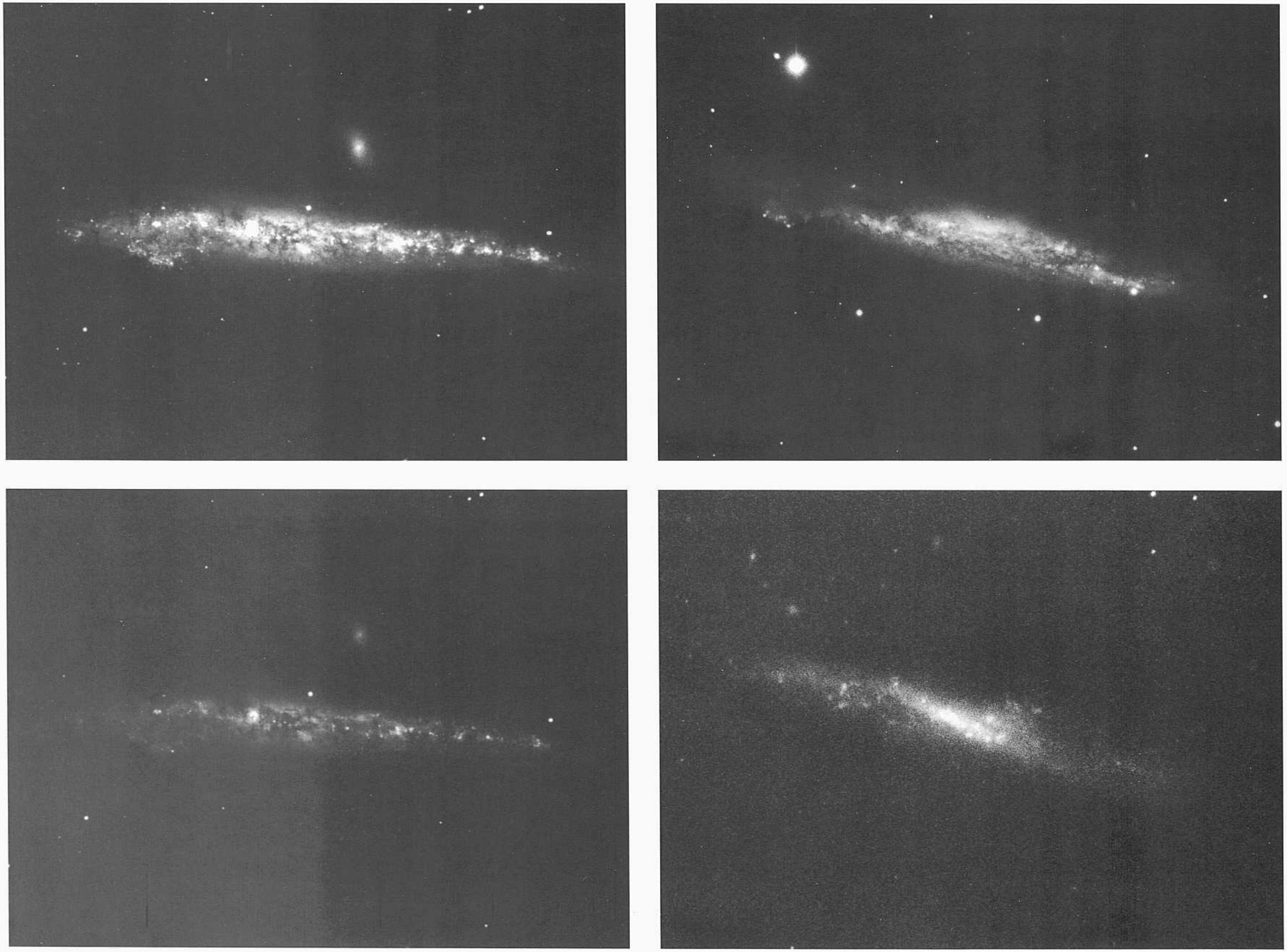
NGC 3735 Sc(s)(I) Racine wedge
PH-8110-S
Feb 7/8, 1981
103aO
12 min

NGC 3735, seen nearly on edge, has a redshift of $v_n = 2838$ km s"^{1}.



PANEL
289

PANEL
290



NGC 4631/4627 Sc(on edge) pair
H-2161-II dE5,N HA, p. 25
Jaii 29/30, 1941
CrHiSpSp
120 min

NGC 463 1 forms a close pair with the dwarf elliptical NGC 4627 (dE,N) at a separation of 2 .7', and a wide pair with NGC 4656 (Im; panels 32 7, S6) with a separation of 31'. These galaxies are in the nearby group called the CnV II Cloud (de Vaucouleurs 1975: Sandage and Tammann 1975a), which has $<v_o>$ of about 750 km s"[1].

A study of the 2 1 -cm HI content of the wide NGC 4631/4656 pair (Weliachew, Sancisi, and Guélin 1978) gave evidence that a tidal encounter had occurred or is now occurring (Combes 1978) between this apparent pair. At an assumed redshift distance of 12 Mpc *(H* = 50) the projected linear separation of NGC 4631 from NGC 4656 is 108 kpc. If a smaller distance of 5 Mpc is used, based on the stellar content (Sandage and Tammann 19 74d), the projected linear separation is 44 kpc. At this distance, the projected linear separation of the much closer NGC 4631/462 7 pair is only 4 kpc.

NGC 4631 is highly resolved into brightest stars starting at about *B* = 1 9. However, because the galaxy is viewed nearly edge on, the dust obscuration is high and variable, making photometric studies of the stellar content difficult and the results uncertain.

NGC 4631/4627 **Sc(on** edge) **pair**
H-3634-S c!E5,N HA, p. 25
Feb 18/19, 1963
103aO + GG13
25mm

The dwarf companion NGC 462 7 has a nucleus and is surrounded by a swarm of about ten images brighter than *B* = 22. These may be globular clusters similar to the; case in NGC 205 (panel 25), the companion to M31. Also like NGC 205, NGC 4627 has tidal tails pointing toward and away from its larger companion. This is clear evidence of a close encounter, pointed out and shown well in the deep photograph in the *Atlas of Peculiar Galaxies* (Arp 1966). A similar case is the pair NGC 1531/1532 (panels 197, 337).

NGC 462 7 has nearly the same redshift as NGC 4631. Ulrich, quoted by Weliachew *et al.* (1978), has measured v_o(4631) = 647 km s~'. Chinearini and Rood (1971) quote $t)_o$(4627) = 727 km s^{-1}. Combes (1978). who has calculated encounter parameters for the three-galaxy interaction, suggests that NGC 462 7 was once a recent star-producing Im dwarf whose HI was swept out, leaving a nucleated dwarf E galaxy from the encounter.

NGC 3079 **Se(s)II-IlI** **triplet?**
PH-7933-S Racine wedge
Nov 7/«, 1980
103aO
12 min

iNCC 3 0 7')(.•„ = 1225 km a''') forms a pair with NGC 3073 (SO pec!;t;$_0$- 127 1 kms"';nol in the USA), al a separation of 10.1'. A third anonymous galaxy (Im or- lid)) of unknown *rri*\-shifl exists in the field, separated by 6.6' from NGC 3079. From its stellar content, this candidate companion appeal's to be al the same distance as NGC 3079.

At the mean redshift distance of 25 Mpc (// = 50) the projected linear separations of the two supposed companions from NGC 3079 are small, at 73 kpc and 48 kpc. respectively.

The plane of NGC 30 79 is warped in the outer regions. Furthermore, the morphology of the two companions is abnormal, suggesting an earlier encounter.

A few individual stars (or more probably II11 regions) resolve' out of the background light in the outer regions of the image starling al about *B*=21.

A Racine wedge has produced secondary images to the bright stars 5 magnitudes fainter than the primary at 1 8" separation.

NGC 3510 Sc(warped plain-)
PH-8O79-S
Feb 5/6, 1981
103aO
12min

The outer regions of NGC 35 10 show a warped plane. There are no nearby companions upon which to blame the warping.

Many individual knots, supposed unresolved **Mil** regions, exist in the inner (bar-like) central part of the image. Individual slurs begin to resolve al about *B* = 22. The redshift of NGC 35 10 is !•„ = 660 km s '.

Many of the galaxies on this panel are of high surface brightness, indicating a high star-formation rate. But the surface brightnesses are also enhanced because of the nearly edge on viewing angle. We look through the long axis of the disk rather than through the galaxy's thin dimension if observed more face on.

NGC 1421 Sc
PH-7952-S
Nov 8/9, 1980
103aO
12 mill

The smallness (or absence) of the nucleus, the absence of a central bulge, and the thinness of the disk in NGC 1421 are the reasons for assigning the Sc classification. The spiral pattern can he traced by noting that the brightest linear segment of the image is a thin arm on the near side. This segment appears to attach to the small nucleus. The fainter pattern on the far side also spirals out from this center.

The redshift is u_0 = 2080 km s"'.

NGC 4522 Sc/Sb: VCC 1516
CD-1352-S/Br panel 194
March 15/16. 1980
103aO
75 nün

NGC 4522 is listed in the Virgo Cluster Catalog as a cluster member. It is not associated with either subcluster A or B but is located nearly midway between them. Its redshift is high, i-„ = 2186 km s~\

The galaxy is difficult to classify because it is seen neither enough edge on to determine the thinness of the disk nor enough face on to see any spiral pattern. Most galaxies on this panel are of this nature.

NGC 1406 Sc
CD-152-S
Feb 3/1, 1978
103aO + GG385
45 niin

The spiral pattern can lie inferred for NGC I 1116 by the curvature of the two dust lanes near the outer edge of the disk on both sides of the center.

The redshift is r„ = 998 km s'.

NGC 1035 Sc(s)III pah-
CD-1579-S/Br
Aug 10/11, 1980
103aO + GG385
45 nün

NGC 1035 forms a wide pair with NGC 1042 (Sc: panel 227) at a separation of 22.5'. The redshifts are u_o(1035) = 1307 km s"' and t'_o(1042) = 1436 km s~'. At the mean redshift distance of 27 Mpc (H = 50) the projected linear separation is 177 kpc.

NGC 4129 Se(s)II
CD-1834-HB
April 1/2, 1981
103aO + GG385
45 nün

The sense of the spiral pattern in NGC 4129 can be determined from the two low-surface-brightness outer arms, one on each side of the center.

The redshift is v_0 = 994 km s~\

NGC 4700 Sc or Sm panel 320
CD-1444-S/Br
May 6/7, 1980
103aO + GG385
45 nün

NGC 4700 is difficult to classify because the spiral pattern cannot be inferred from curvature in dust lanes, which are usually used for that purpose. The galaxy here is viewed almost directly edge on, so that no prominent dust lanes are seen.

The redshift is ▷„ = 1193 km s~' .

NGC 3683 Sc(on edge)
PH-8083-S
Feb 6/7, 1981
103aO
12 niin

The sense of the spiral pattern can be determined from the inner and the fainter outer arm on one side of the image.

The redshift is v_0 = 1785 km s^{-1}.

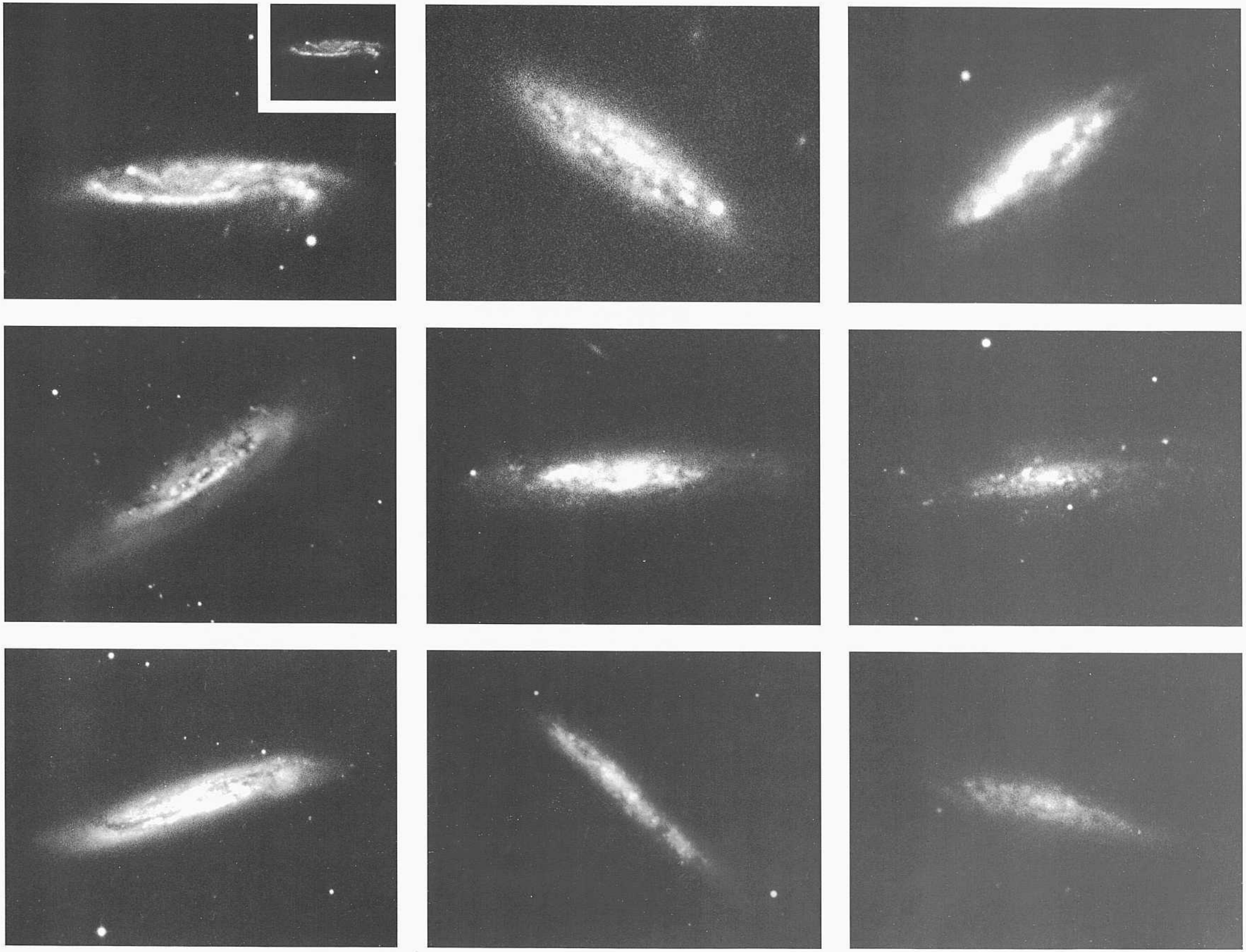
NGC 3666 ScII-III
H-2270-H
May 5/6, 1946
103aO
40 min

Hll-region candidates are visible over the image of NGC 3666: the sense of the spiral pattern can thereby be determined.

The redshift is v_0 = 926 km $s\sim^1$.

NGC 4085 ScIII: pair
S-1834-H
Jail 17/18, 1939
Imp. Eel.
60 min

NGC 4085 forms a physical pair with NGC 4088 (Se/SBc: panel 271) at a separation of 11.2'. The redshifts are u_o(4085) = 823 km s"' and u_o(4088) = 820 km s~'. At the redshift distance of 16 Mpc (*H* = 50) the projected linear separation is 52 kpc.



PANEL
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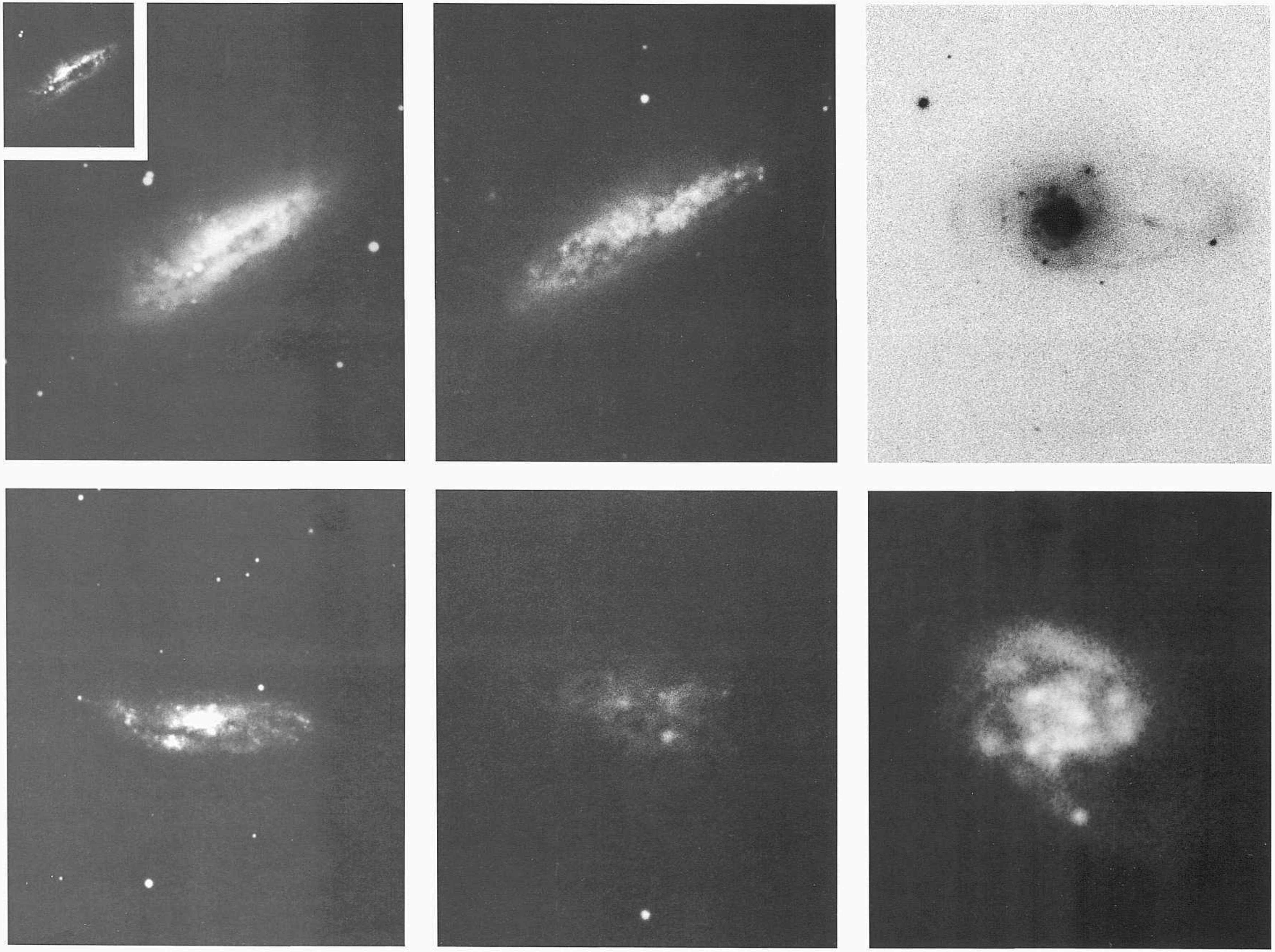
PANEL
292



The Se section is concluded **on** this panel **with four** nearly edge on galaxies, **continuing the** illustrations **begun on panel** 285. The section is **concluded with two final galaxies that** have peculiar **morphologies, combining** features **of** Sa and Sc systems.

NGC 1511 Sc pec or Amorphous? triplet?
CD-759-S
Feb 20/21, 1979
103aO + GG385
45 niin

NGC 1511 insert
CD-1744-S
Jaii 12/13, 1981
103aO + GG385
7 mill

NGC 1511 is an apparent triplet with NGC 1511A (Amorphous or BCD; not in the RSA) at a separation of 11.1' and NGC 151 IB (Sd or Sm on edge; also not in the RSA) at a separation of 7.6'. The known redshifts arc u_o(1511) = 1142 km s'" and u_o(1511B) = 1101 km s~'. At the redshift distance of 22 Mpc (H = 50) the projected linear separations from NGC 1511 are 71 kpc and 49 kpc.

The complex line of presumed HI! regions at the edge of the thick opaque dust lane is well seen in the short-exposure insert print.

NGC 5088 Se(s)II
CD-1874-HB
April 10/11, 1981
103aO
75 niin

NGC 5088 is in the neighborhood of the NGC 5077 group (mean redshift of about v_0 = 2500 km s^{-1} : Humason, Mayall, and Sandage 1956), but is in the foreground with a redshift of v_o = 1230 km s~] . Hll-region candidates are abundant but are probably unresolved at the 1.5" level.

NGC 4605 Se(s)III
S-1921-H
April 3/4, 1946
103aO
55 niin

The sense of the spiral pattern can be determined from the lower-surface-brightness side of the image where the multiple-arm pattern can be seen opening up.

The redshift is t'_o = 273 km s^{-1}.

NGC 3067 Sc(dust)
PH-7992-S
Feb 2/3, 1981
103aO
12 niin

The classification of NGC 3067 is difficult because of the dust and the inclination. Star formation is obviously occurring. Several HII-region candidates are visible.

The redshift is v_{r_o} = 1429 km s~'.

NGC. 7679 Sc(s)/Sa(lides?) pair
PII-7816-S panel 86
Sep2/3, 1980
103aO
12 mill

NGC 7679, also illustrated in the Sa section (panel 86). forms a physical pair with NGC 7682 (SBa) at a separation ol -1.5'. The redshifts arc u_o(7679) = 5397 km s~' am! i-,,(7682) = 5333 km s^{-1} . At the mean redshift distance of 1 07 Mpc (*H* = 50) the projected linear separation is 139 **kpc.**

The smooth outer arm that is pulled out on one side of NGC 7679 may be due to a tidal encounter with NGC 7682. However, the morphology of NGC 4682 is undistorted.

NGC 5665 Sa/Sc panel 86
CD-1868-HB
April 9/10, 1981
103aO
75 min

NGC 5665 is also illustrated in the Sa section (panel 86).

The smooth outer arms art* devoid of star-forming regions but the inner parts of the image are filled with Hll-region candidates. There is no nucleus or central bulge. There is a thin, single-inner-arm pattern that can be traced for ! 1/2 revolutions.

The SBc Classification Section

The division between the SBbc and SBc morphological boxes is arbitrary and therefore subjective, defined by the examples themselves. There is considerable width to the SBc section from early, near the SBbc section, to late, merging into the SBcd section.

The characteristics of SBc galaxies are (1) a high degree of resolution of the bar and of the spiral arms into knots (HH-region candidates) and associations, (2) smallness or absence of a high-surface-brightness inner disk associated with the central regions, and (3) openness of the spiral arms.

The 76 SBc galaxies on the next 21 panels are generally arranged in order of luminosity class, from the most-regular arm patterns of the class I galaxies to patterns with the most chaos (high geometrical entropy) of class III near the end of the section at panel 313.

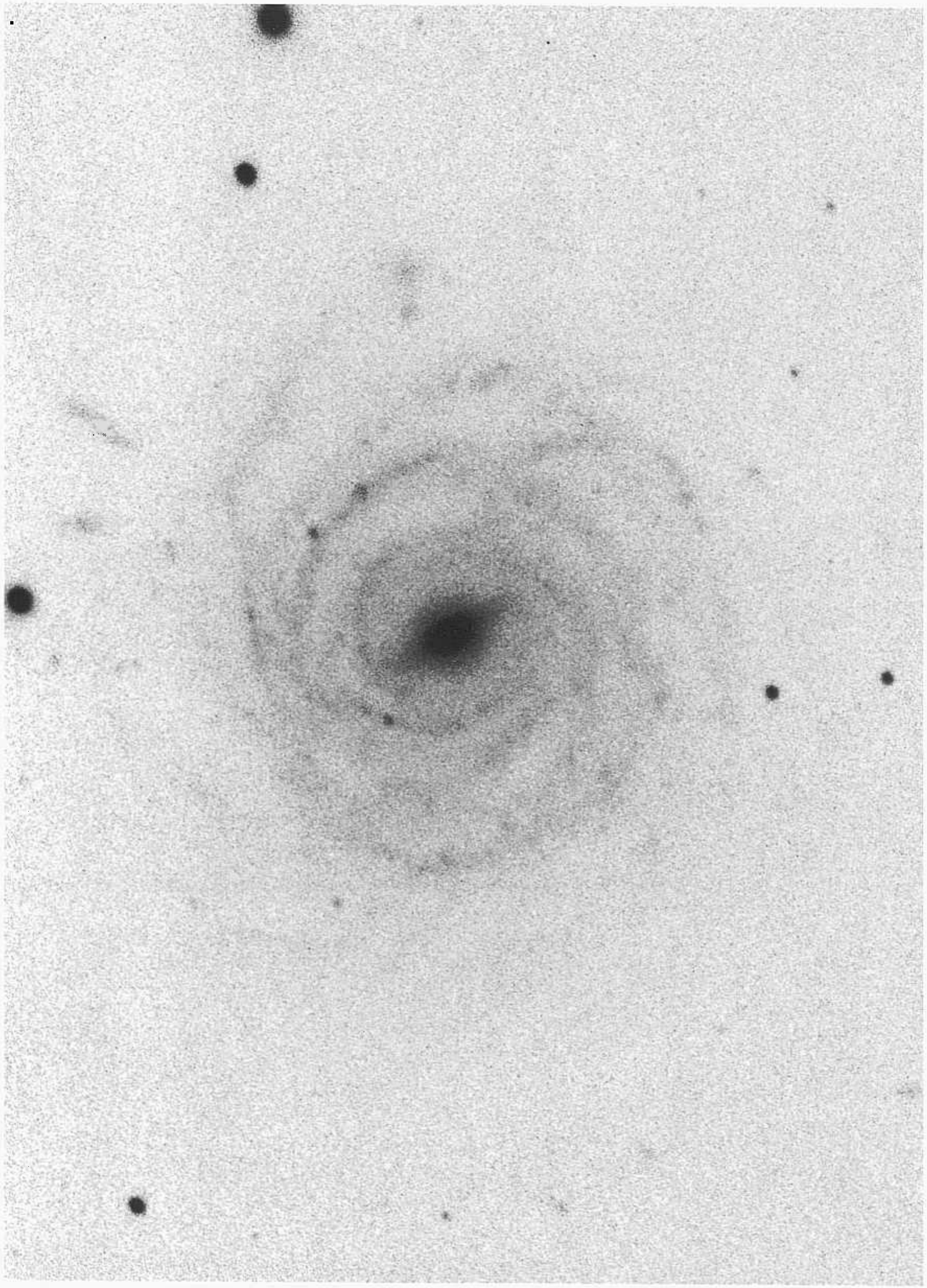
NGC521 **SBc(rs)I** **group**
PH-7547-S
Nov 6/7, 1978
103aO
12 min

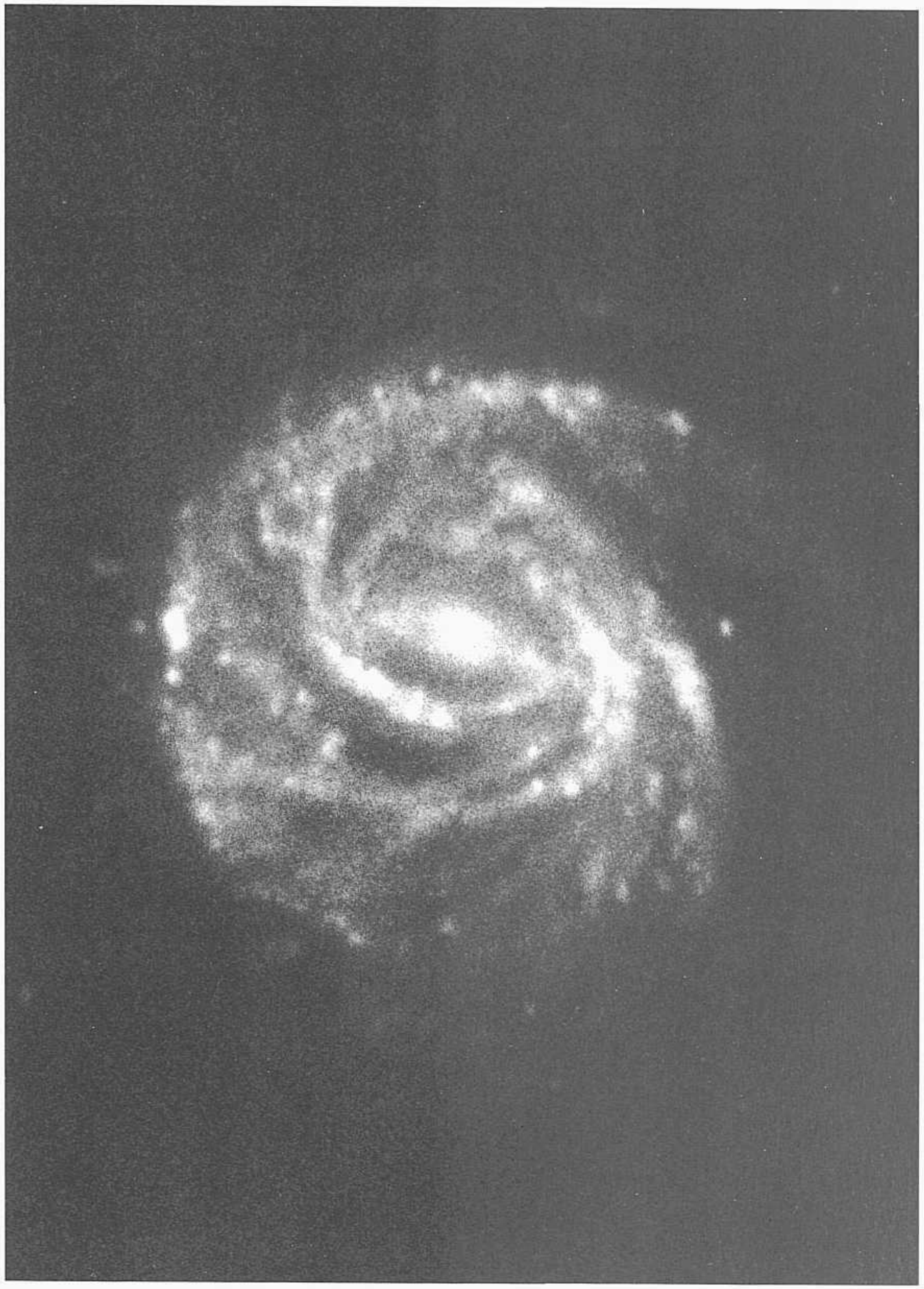
NGC 521 is the earliest of the SBc galaxies in this atlas, close to the edge of the SBbc morphological section. It may form a physical pair with NGC 533 (E3: panel 8) at a separation of 14.5'. The redshifts are **u_o(521)** = 5223 km s^{-1} and r_o(533) = 5664 km s^{-1}. At a mean redshift distance of 109 Mpc (H = 50) the projected linear separation is 460 kpc if the association is real. NGC 533 is the brightest member of a rich group of fainter E and SO galaxies within a radius of about 20'.

NGC 3367 SBc(s)II.2 HA, p. *49*
CD-1731-S
Jan 10/11, 1981
103aO
75 min

NGC 3367 is in the field of the Leo Group (Ferguson and Sandage 1990) but is judged to be in the background based on its high redshift of v_o = 2906 km s^{-1}. The mean redshift of the Leo Group proper is $\langle v_o \rangle$ = 909 km s^{-1}.

Many bright HII regions are strung along the inner parts of the two major arms that begin at the ends of the bar in the (s) configuration whose prototype is NGC 1300 (SBb; panels 154, S8). The two major arms fragment after about half a revolution, creating the multiple-arm pattern in the outer regions.





PANEL
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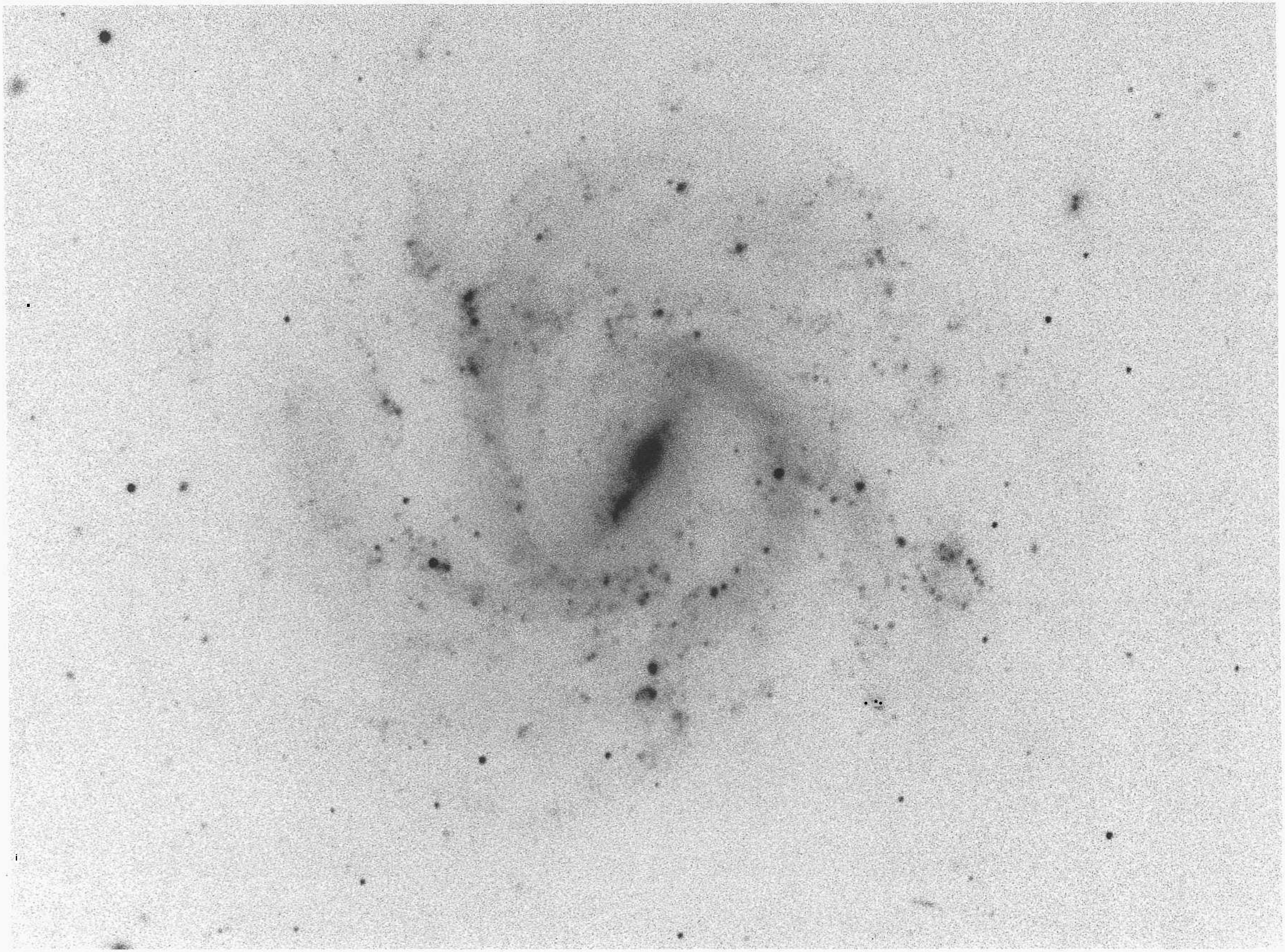
PANEL
294



NGC 1073 SU:(is)Il NGC1068Gr
PH-7892-S **HA, p. *49***
Nov6/7,1980
103uO
12 niiu

NGC 1073 is **the prototype** SBc **galaxy. The** arm **pattern** is open. **The bar contains IIII regions,** unlike **the** situation in most SBl> **galaxies where** no **recent** star* **formation** occurs, **evidenced** by the **smoothness** of the bar **light.**

The **redshift lisleil for** NGC **L073** in **the RSA2** is **i-, = L318 km s"[1]; evidently the velocity** listed in **Humason, Mayall,** and **Sandage** (1956) is incorrect.

NGC 1073 has been **considered** a **member** of the NGC **1** 068 group, which also contains **the** RSA galaxies NGC 1055 (Sbc; panel 194). NGC 1087 (Sc: panel 279). and **perhaps** NGC 936 (SBO/SBa; panel 106) and NGC 941 (Scd; panel 3 15).

The arms in NGC 1073 are well **resolved** into bright **Mil** regions, **the** largest **of** which have halo diameters of about 2". Individual brightest stars appear to resolve starting **at** about *B* - 21, but unambiguous discrimination **of** Mil regions from stars has not been done by the standard methods at this writing (199 I).

The four galaxies on this panel have similar morphology. In each, the arm pattern begins near the ends of the bar, thereafter fragmenting into the multiple-arm pattern in the outer regions.

NGC 7424 **Sc(rs)II.3/SBc(s)II.3** panel **S9**
CD-1511-S/Br
Aug **4/5, 1980**
103aO + GG385
10 min

NGC 7424 is of very large angular **diameter** (D_{25} = 7.6') and clearly is nearby, **judging from the** high degree of resolution of the arms into HII regions and individual stars. The largest of the many HII-region candidates have **angular** diameters (halo) of about 2". The individual stars that can be guessed not to be **HII** regions start to resolve at about $B = 22$. The stars and the **HII** regions have yet (1991) to be identified by standard means.

The **redshift** is v_0 = 925 km s^{-1}.

NGC 3359 **SBc(s)I.8** pec **HA, p.** ***49***
PH-1144-S
Oct 23/24, 1955
103aO + WG2
25 **min**

HII-region candidates and perhaps brightest stars are present in the well-developed **but** late-type bar in NGC 3359. The thin, multiple arms are full of HII-region candidates, only **two of** which resolve into disks at the 1.5" level. Individual stars have not yet been distinguished from the **HII** regions by standard methods.

The redshift is v_0 = 1138 km s^{-1}.

NGC **1179** **SBc(r)I1.2**
CD-1653-S
Dec 29/30, 1980
103aO + **GG385**
45 min

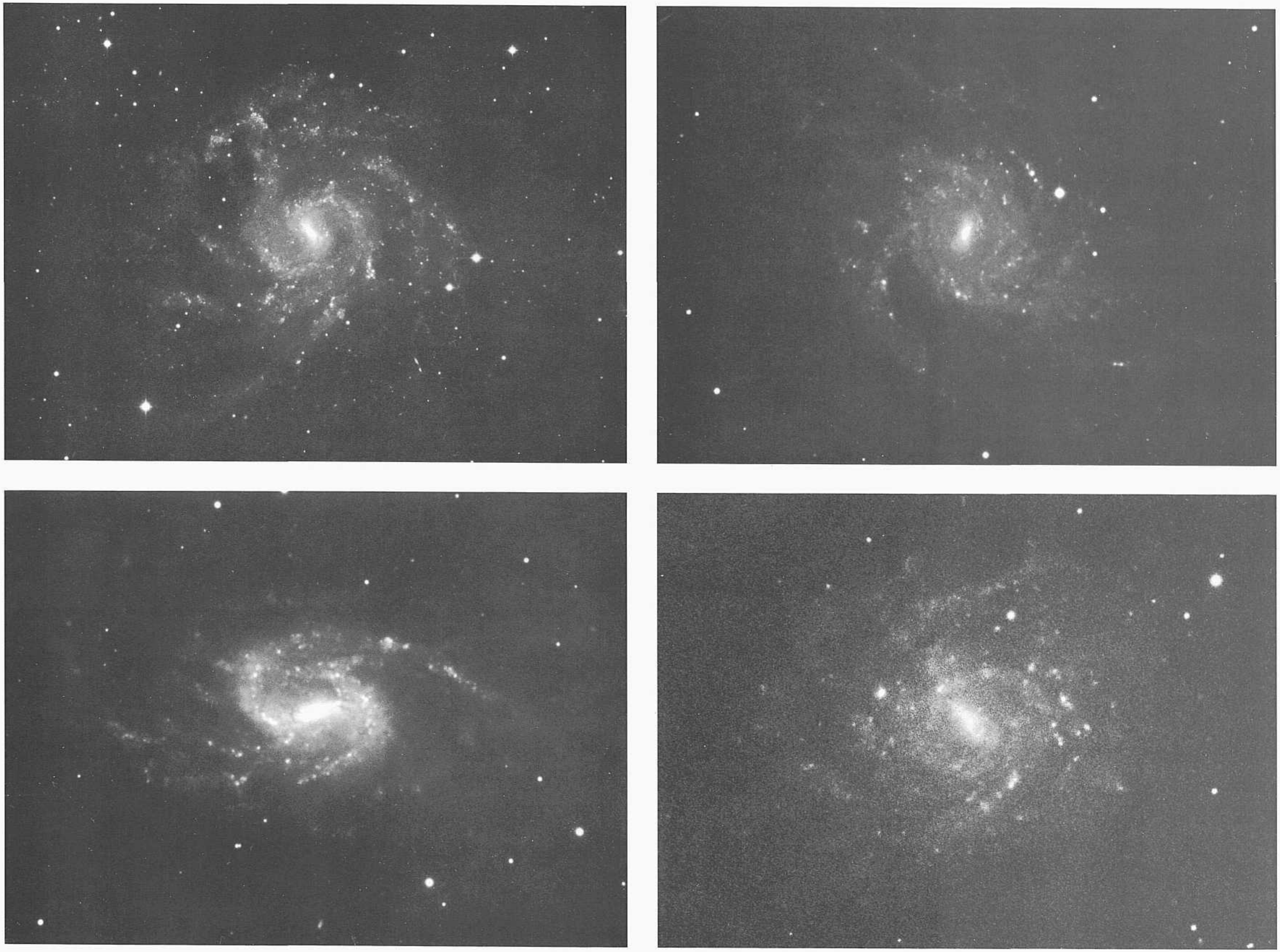
HII-region candidates exist in the central bar as well as in all the arm fragments of NGC 1179. Three particularly bright **HII-region** candidates are very compact and do not resolve at the 1.5" level. No individual stars resolve to the plate limit. $B = 23$.

The redshift is v_0 = 1776 km s^{-1}.

New 1 = A 0102-06 SBc(s)II.2 Racine wedge
PH-7673-S
Sep 25/26, **1979**
103aO
10 min

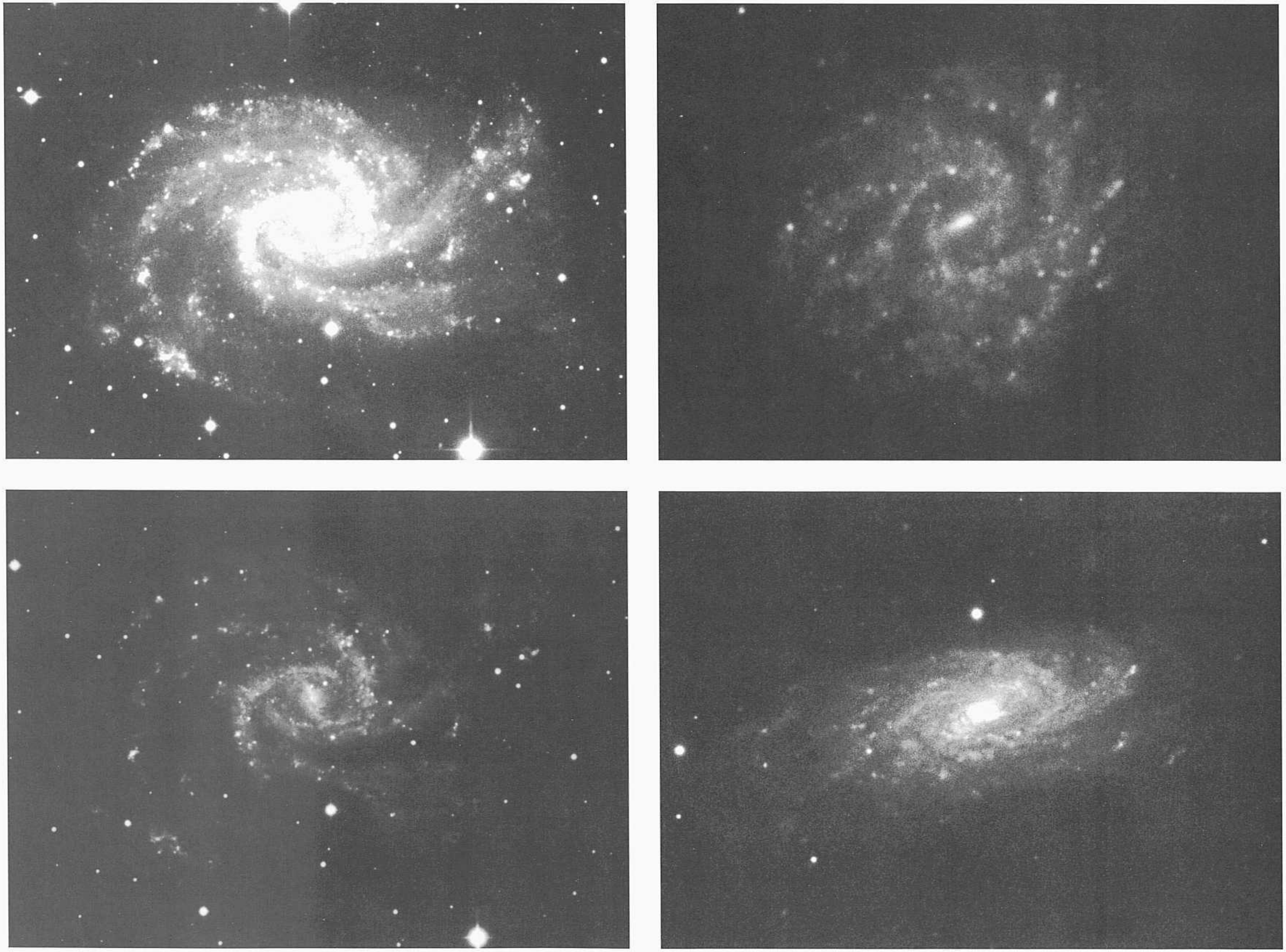
The image here is from an underexposed original plate which, nevertheless, shows a number of **HII** regions in the weak central bar and in the several multiple arms.

A low-surface-brightness shred (Im on edge) exists at a separation of 4.1'. Its **HII-region** candidates are **of** comparable brightness to those in the main galaxy. The redshift of New 1 is v_o = 1116 km s^{-1}. At the redshift distance of 22 Mpc (H = 50) the projected linear separation of the shred from New 1 is small at 26 kpc.



PANEL
295

PANEL
296



NGC 2835 SBc(rs)I.2 pair
CD-767-S
Feb 21/22, 1979
103aO + GG385
45 inin

NGC 2835 at a redshilt of v_o = 624 km a"[1] may form a wide physical pair with the S0i(4) galaxy NGC 2784. which has a similar redshift of v_o = 45 1 km s~[J] . The separation of the galaxies is 2.2°, giving a projected linear separation of 422 kpc at a mean redshift distance of I 0.8 Mpc (similar to separations within the Local Group).

The arms of NGC 2835 are filled with 1111-region candidates and stellar associations. The several largest of the Hll-rcgion complexes resolve into halo diameters of 5". Individual stars begin to resolve at about B — 21.

The Galactic latitude is low at b = 18.5°. suggesting that some Galactic obscuration may be present over the field.

NGC 2835 SBc(rs)I.2 pair
CD-767-S
Feb 21/22, 1979
103aO + GG385
45 niin

This light print from the same original plate used above shows the high incidence of **II**11 regions in the high-surface-brightness inner arms as well as in the bar.

NGC 33-16 **SBc(rs)II.2**
H-14-S
Jan 5/6, 1951
103aO
20 min

The twit principal arms begin as a partial ring upon which the bar terminates. On one side of the bar the ring-segment begins about 30° downstream (relative to the direction of rotation determined from the sense of the spiral arms) from tin[1] end of the bar; on the other[1] end of the bar the ring begins 90° downstream. Upon winding outward for less than half a revolution, each arm fragments into the multiple-arm pattern thai covers the outer disk.

The redshift is v_0 = I 138 km a'". The IIII regions are unresolved. Individual stare are undoubtedly present beginning at about B = 22, but a proper separation from the Hll-region candidates has not been done (c. 1 991).

NGC 1090 SBc(s)I.8 Racine wedge
PH-7916-S
Nov 7/8, 1980
103aO
12 niin

The bar in NGC 1090 is weak and subtle. However, two thin, straight dust lanes exist starting from the center: one dust lane crosses in front of the nucleus and the other behind, as in the classical dust pattern in SBb galaxies such as a prototype example NGC 5 3 83 (SBb; panel 168). The presence of these dust lanes, thought to be shock patterns in the gas resulting from highly non-circular motions in the neighborhood of a bar, accounts for the SBc classification.

The two principal inner arms begin at the ends of the bar in the (s) configuration of the NGC 1300 type. A few Hll-region candidates exist. The redshift is v_o = 2835 km s^{-1}.

NGC 4535 **SBc(s)I.3** VCC 1555
CD-801-S
Feb 24/25, 1979
103aO **+Wr2c**
45 niin

NGC 4535 is one of the largest spirals considered to be a member of the Virgo Cluster. It is shown with other cluster members, enlarged to a common scale, in the Virgo Cluster atlas (Santiago. Binggeli. and Tamiliann 1985a), where it is evident that this galaxy is among the seven largest galaxies associated with the cluster.

HI1 regions are prevalent in the thin, well-formed, regular arms, the largest of which begin to resolve at about 1 ".

The nucleus is bright and is star like (unresolved at *0.1").* similar to Seyfert (AGN) nuclei.

Two thin dust lanes winding outward from the central regions are evident. They are curved rather than straight, as in the prototype Sb galaxy NGC 1300. but the pattern as a shock in the central oval potential seems clear.

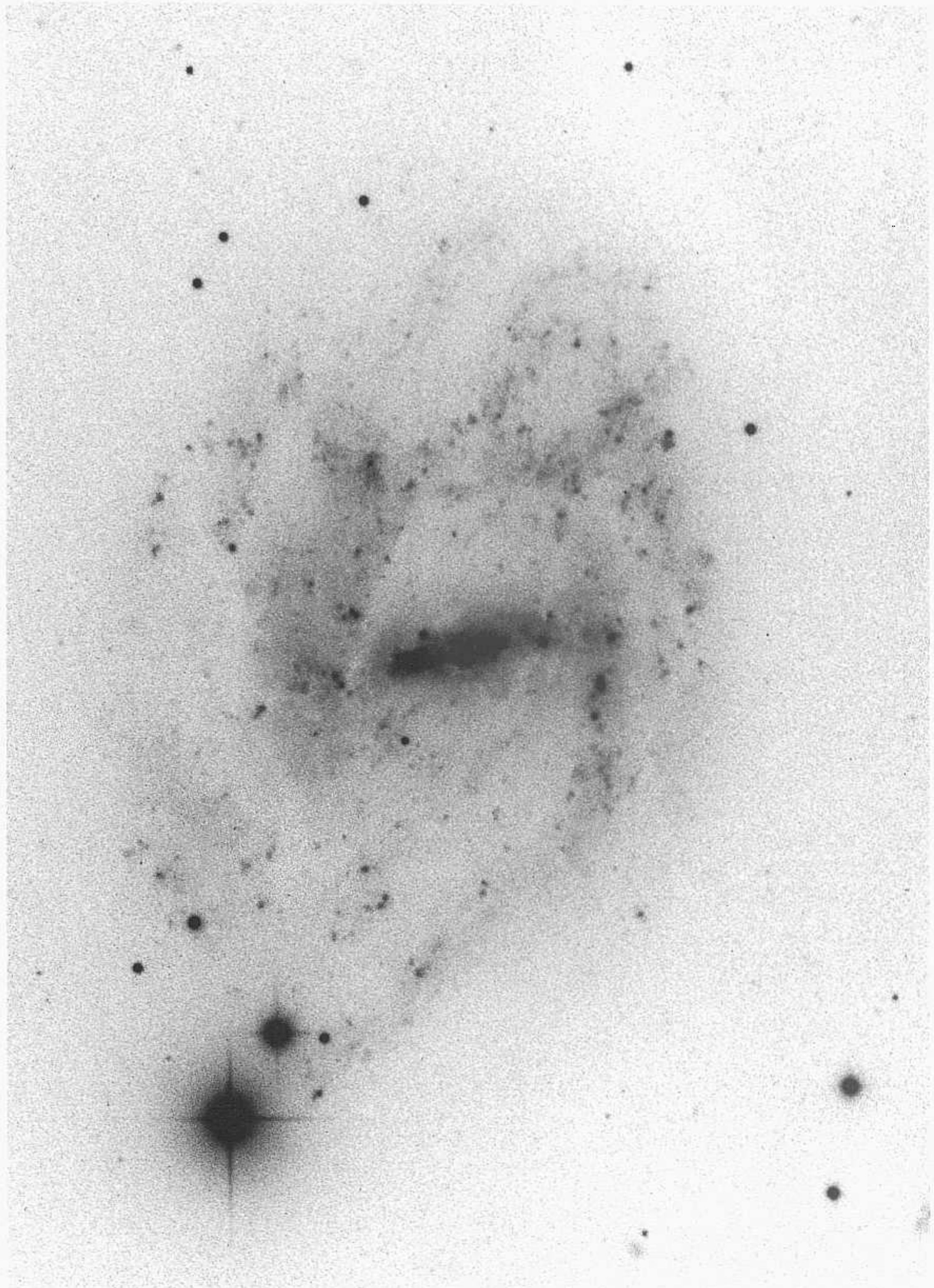
NGC 7741 **SBc(s)H.2** **HA, p.** ***49***
PH-66-H panel S10
Oct 13/14, 1950
103aO
30 min

Star formation is occurring throughout the well-formed bar in NGC 7741. It is also occurring everywhere in the arms, which are massive in the sense of Reynolds (1927a,b). in contrast to the thin arms in NGC 4535 shown at the left.

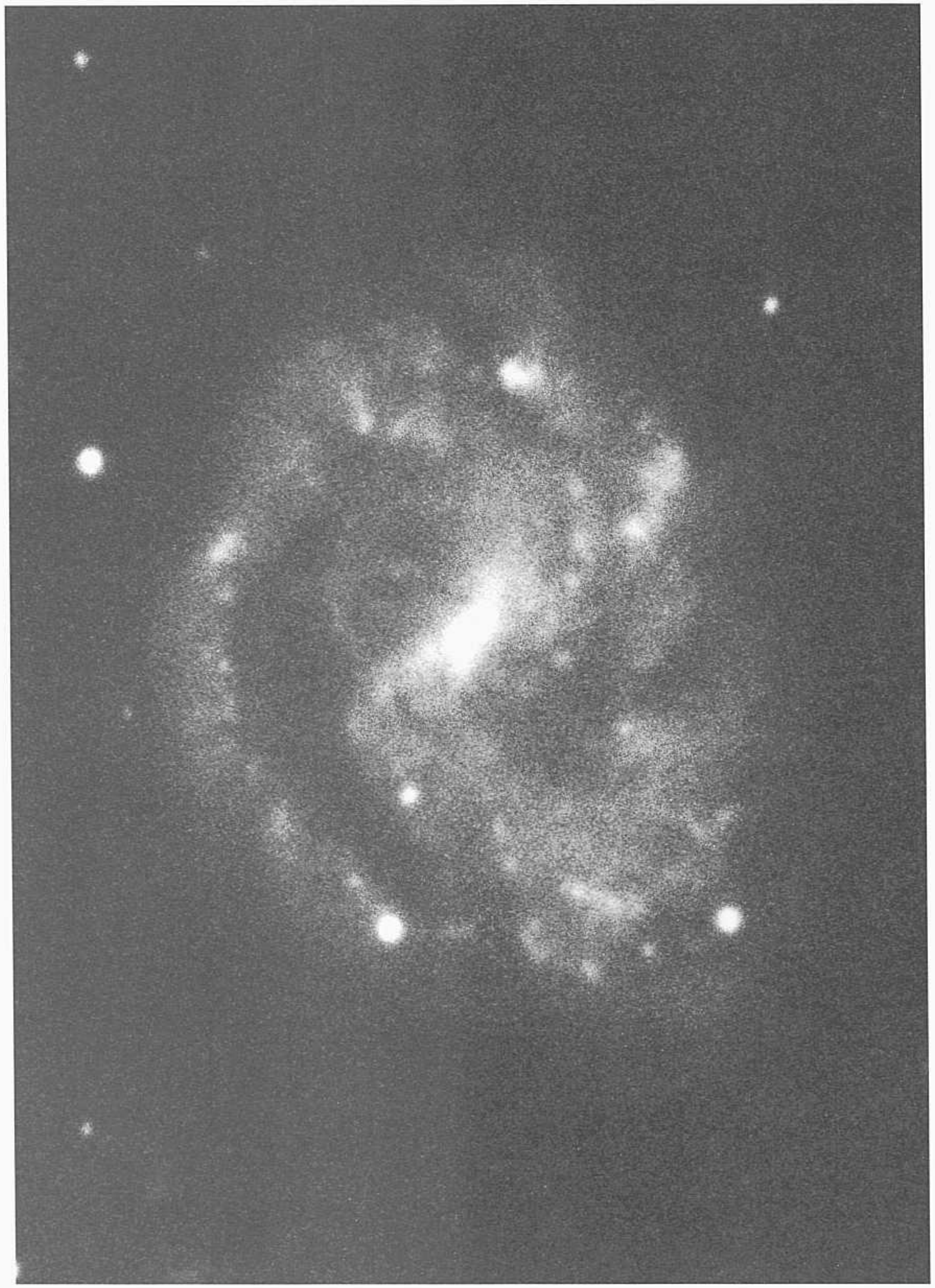
Individual stars are easily resolved and are **identified** as stars by comparing red plates (sensitive to the Hll-region Ha emission) and yellow plates (insensitive to emission lines but sensitive to the stellar continuum light). The brightest stars begin to resolve at about B = 21.5.

The largest **HII** complex is a superposition of two regions. It has a (halo) major axis diameter of about 3".

The redshift is v_0 = 1030 km s"[1] .



PANEL
298



NGC 5597 SBc(s)II pair
CD-1569-S/Br panel S10
Aug 10/11, 1980
103aO + GG385
45 niin

NGC 5597 forms a dose physical pair with NGC 5595 (Sc; panel 253) at a separation of 4.0'. The redshifts are $u_o(5595)$ = 2501 km s~' and $w_o(5597)$ = 2444 km s^{-1}. AL the mean redshift distance of 49 Mpc (// = 50) the projected linear separation is small at 58 kpc.

The largest of the several HII regions in NGC 5597 appears to he complex; its halo diameter is about 1.5". Star formation is occurring throughout the arms and in the central bar.

NGC 2525 SBc(s)lI HA, p. *49*
CD-779-S panelS 10
Feb 22/23, 1979
103aO + GG385
45 niin

The two principal arms in iNGC 2525 are classic prototypical (s) type in the sense of NGC 1300 hut are much later in the classification sequence. The arms arc massive in tin* sense of Reynolds (1927a.li)-

The surface brightness ol the arms is very high, making study of the evidently numerous HII regions difficult. 'The III! regions arc unresolved al 1". Individual stars are undoubtedly observed starting at about *B* = 22. The redshift of NGC 2525 is v_0 - 1395 km a '.

The nucleus is starlike at 0.7" resolution.

NGC **1559** **SBc(s)II.2** **pair?**
CD-1676-S
Jan 1/2, 1981
103aO + GG385
7 niiii

NGC 15 59 is in **the** complex Dorado region. It is located about 6° south of the center of the dense Dorado Group **(de** Vaucouleurs 1975, **No.** G16) and has about the same redshift. Ferguson and Sandage (1990) list $<v_o>$ = 1056 km s~[1] as the mean redshift of the Group. The redshift of NGC 1559 is v_0 =1093 km s~'.

NGC 15 59 may form a wide physical pair **with** 1C 2056 (Sc; panel 253) at a separation of 2.6°. The redshift of IC 2056 is u_o = 934 kms"'. At the mean redshift distance of 2 0 Mpc *(H* = 50) the projected linear separation is 909 **kpc,** somewhat larger than the distance from our Galaxy to M3 1 in the Local Group.

HII regions exist throughout the spiral pattern in NGC 15 59. The largest are complex, with halo diameters of about 6". Individual stars appear to resolve out of the background at about *B* = 22.

NGC 5669 **SBc(s)II** **companion**
CD-2113-S
March 19/20, 1982
103aO + GG385
35 **min**

Current star formation is occurring in the bar: Hll-region candidates exist there. The brightest Hll-region candidate in the arms is compact, bright, and unresolved at the 1.5" level.

The redshift is v_u = 1304 km s^{-1}. A dwarf (BCD?) candidate companion exists at a separation of 6.2' which, at the redshift distance of 26 Mpc *(H* = 50), corresponds with a projected linear separation of 4 7 kpc.

NGC 3513 **SBc(s)II.2** **pair**
CD-722-S
Feb **1/2, 1979**
103aO + GG385
45 min

NGC 3513 has a similar morphology to NGC 15 59 at the upper left.

The galaxy forms a close **physical** pair witli NGC 3511 (Sc: panel 273) at a **separation** of **1 0.5'.** The **redshifts** arc **u_o(35 1** 1) = 95 **1** km s"' and u_o(35 13) = 845 km s^{-1}. **At** the mean redshift distance of I H Mpc (// = 50) the projected linear separation is small, at 55 kpc.

The brightest part **of the stellar** content in NGC 35 13 resolves **well.** The brightest stars individually begin **to** resolve at about B - **21.5.** The largest **of the** numerous **HII** regions resolve into disks at the 2" level.

NGC **1688** **SBc(s)II**
CD-1683-S
Jan 2/3, 1980
103aO + GG385
43 **min**

As with NGC **1** 559 at the left, NGC 1688 is in the complex Dorado region and is listed as an extended member of the Dorado Group by Sandage (1975a). The mean redshift of the central part of this **group** is given by Ferguson and Sandage (1990) as $<v_o>$ = 1056 km s~'. The redshift of NGC 1688 is v_0 = 1040 km s~'.

The galaxy is listed by Maia, da Costa, and Latham (1989) as a member of their group number 7 in the Dorado region.

Hll-region candidates exist in the central bar. The largest of the several HII regions in the arms are unresolved at the 1.5" level. Individual stars have not begun to resolve to the limit of the available plate material at about **B** = **23.**

NGC 268 **SBc(s)I-H**
CD-1557-S/Br
Aug 8/9, 1980
103aO + GG385
45 min

The thinness, order, and regularity of the arms in this distant galaxy require the early luminosity classification. The nucleus is bright and starlike at the 1" level, as in AGNV

The **redshift is v_o = 5659 km s"[1].**

NGC 2339 **SBc(s)II**
CD-688-Br
Jan 27/28, 1979
103aO + GG385
45 **min**

The bar is very weak in NGC 2 3 39, and there is no evidence for recent star formation in it. Few HII regions exist **in** the multiple-arm **pattern.** An alternate, better classification might be SBbcII.2, as in the RSA2 .

The redshift of NGC 2339 is v_a = 2229 km s^{-1}.

IC 2522 **Sc/SBc(s)I-II** **pair**
CD-198-S
Feh 8/9, 1978
103aO + GG385
40 nún

IC 2522 forms a close apparent physical pair **with** IC 2523 (ScII-III: not in the RSA) at a separation of 4.4'. A redshift is not available for IC 2 523, but the brightness of the Hll-region candidates is similar in both galaxies, suggesting equal distances.

The redshift of IC 2 522 isu_o = 2701 kms"[1]. At a redshift distance of 54 Mpc (// = 50). the projected linear separation is small at 69 kpc.

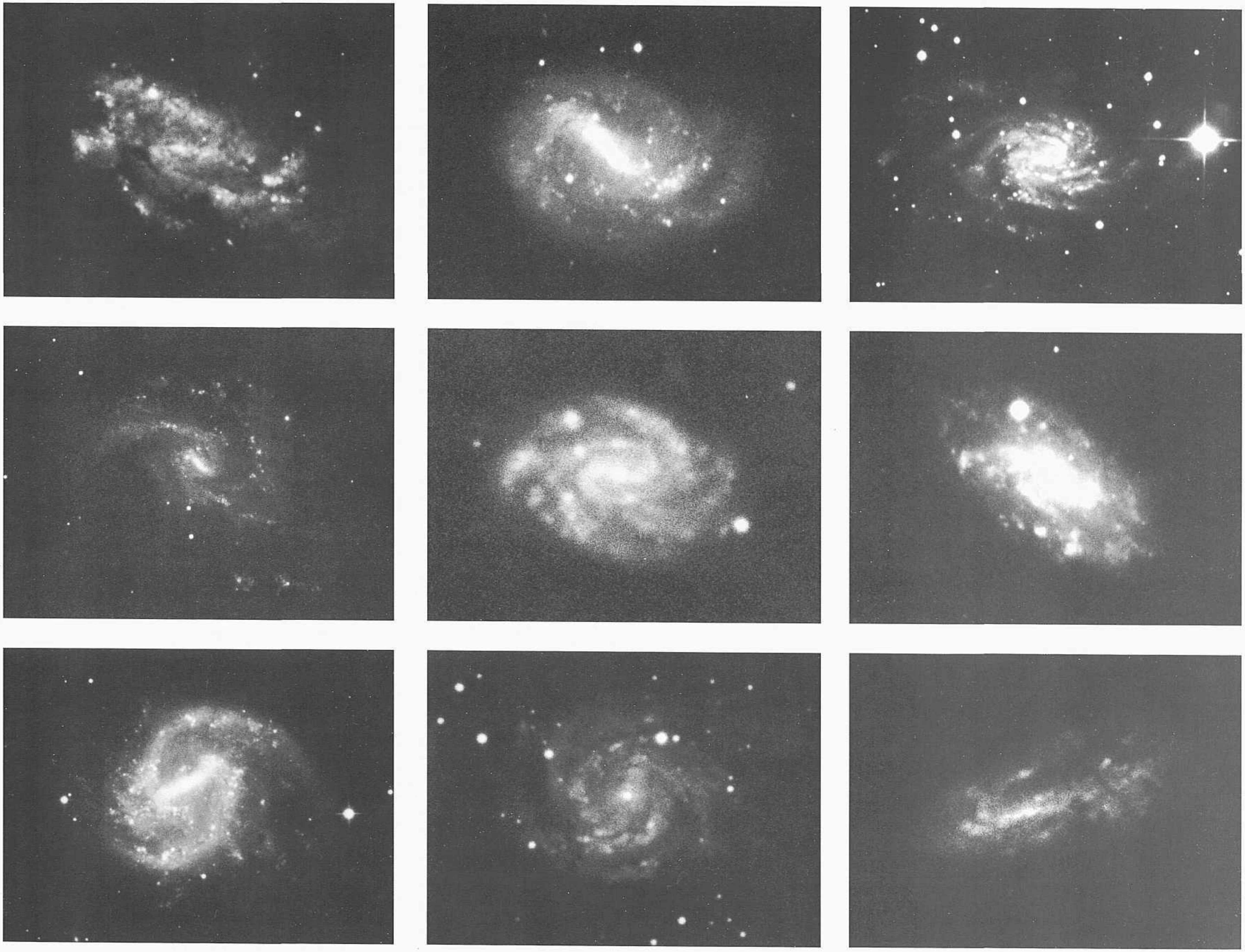
IC 1933 **SBc(s)II-III**
CD-200-S
Feb 9/10, 1978
103aO + GG385
45 **min**

The largest HII regions in IC 193 3 are complex with a combined (overlapping) diameter of about 3". Star formation is occurring in the bar as well as robustly in the arms.

The redshift of IC 193 3 is v_o = 914 km s~'.

NGC 3287 **SBc(s)II-III**
PH-8018-S
Feb **3/4, 1981**
103aO
12 min

The redshift is $v_{,,}$= 12 19 km s"'.



PANEL
299

PANEL 300

NGC **5236** **SBc(s)II** **Cen A Gr**
CD-1320-S/Hr **HA, p.** ***28***
March 12/13, 1980 **M83**
103aO + GG385 **panel 301**
45 miii

NGC **5236 is the brightest spiral in** tin-nearby group **whose brightest member is NGC 5 128 (Cen A; SO + S pec; panels 45, 46). The** mean **redshift of the group is about** $<v_o>$ **= 2 HO km** s^{-1}**. Because the group** is so **nearby, most members** are **highly resolved** and **are important** for **the calibration of the extragalactic distance** scale.

The **surface** brightness **of** iNGC 52 3 6 is **exceedingly high** in **the** arms, which are **massive in** the sense **of Reynolds** (192 7a.b) and therefore cover most **of the** disk.

The dust lanes are intricate and, in general, are closely associated with **the** luminous arms **on** the insides of these arms, as usual.

The range **of** the **surface-brightness** scale is so large that two levels of **the** image from **the** original negative are illustrated. The heavy image is on this panel: a lighter print showing **the dust** lanes and the central regions is on the following panel.

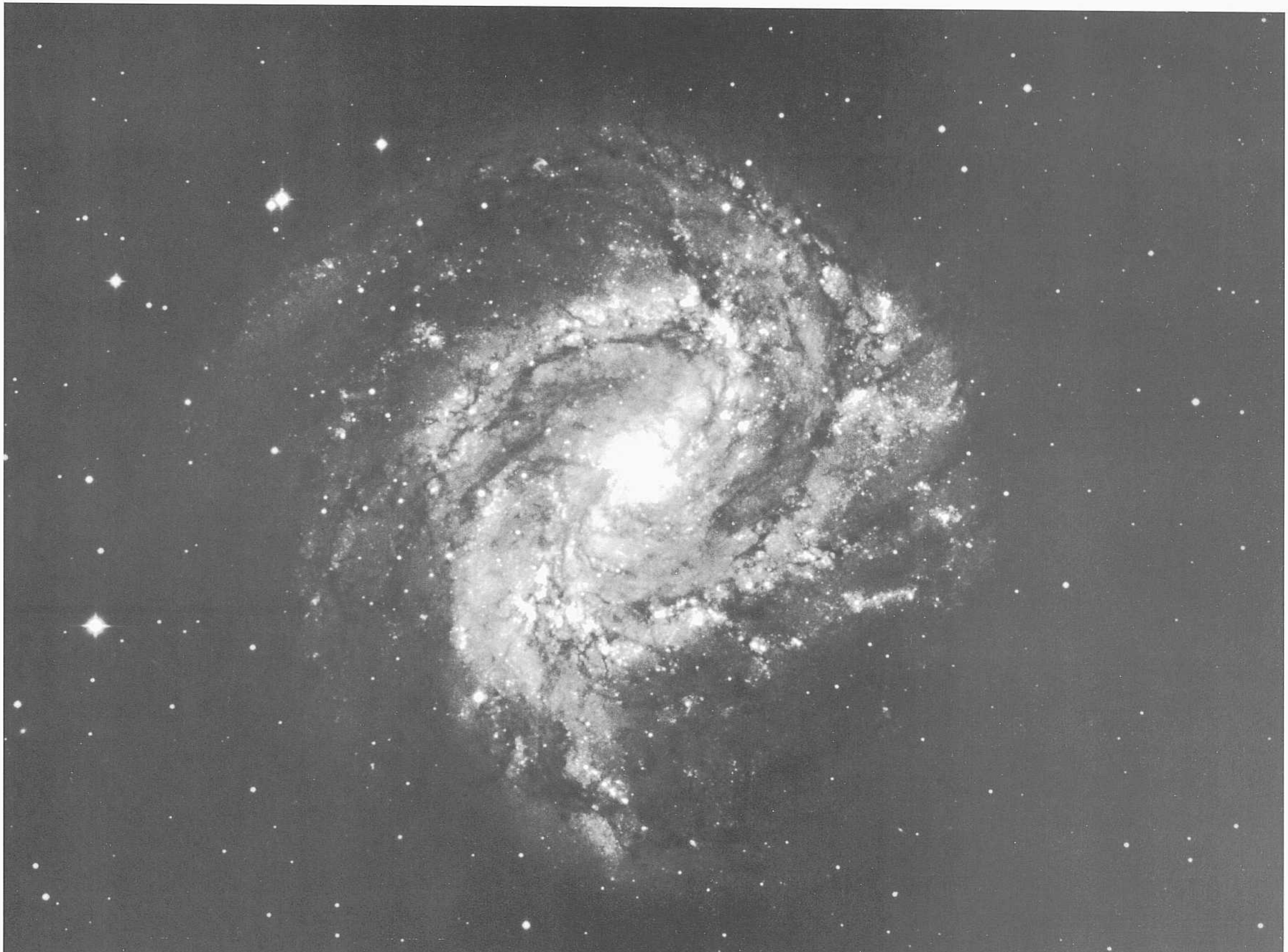
Far-outlying associations exist beyond the borders of this print. They are similar to the associations in M3 1 Field TV of **Baade and Swope** (1963), which is 96' from the center **of** M3 1 . ll is in these outlying fields, where the surface brightness of the background disk **of** M83 is **low** and the dust is negligible, that searches **for** Cepheids will be made. Several such remote associations exist; the farthest, easily visible on **the** Las Campanas 100-inch plates, **is** at **a** radial distance **of** 1 1 ' from the center, off **the** borders of this print. At the estimated distance of 6 **Mpc** for M83 **this** angular **distance** corresponds **to** n linear **distance** from the **center of 20 kpc The distance of** Field **IV** from the center **of** IYI3 1 is similar, at 24 kpc.

NGC 5236 **SBc(s)H** Cen **A Gr**
CD-1320-S/Br **HA, p.** *28*
March 12/13, 1980 M83
103aO + GG385 panel **300**
45 mill

This light **print of** M83 shows the intricate dust lanes and the central oval luminosity **distribution requiring** the barred classification. Consistent **with** this classification are the two major **thin** dust lanes in the central oval. The dust lane pattern, the signature of a bar potential, is due to the response of the interstellar gas to that potential, resulting in two hydrodynamic shock fronts that appear as straight dust lanes. The **pattern** has been discussed in many of the previous descriptions of prototypical SBb galaxies such as NGC 1300 (panels 154. S8).

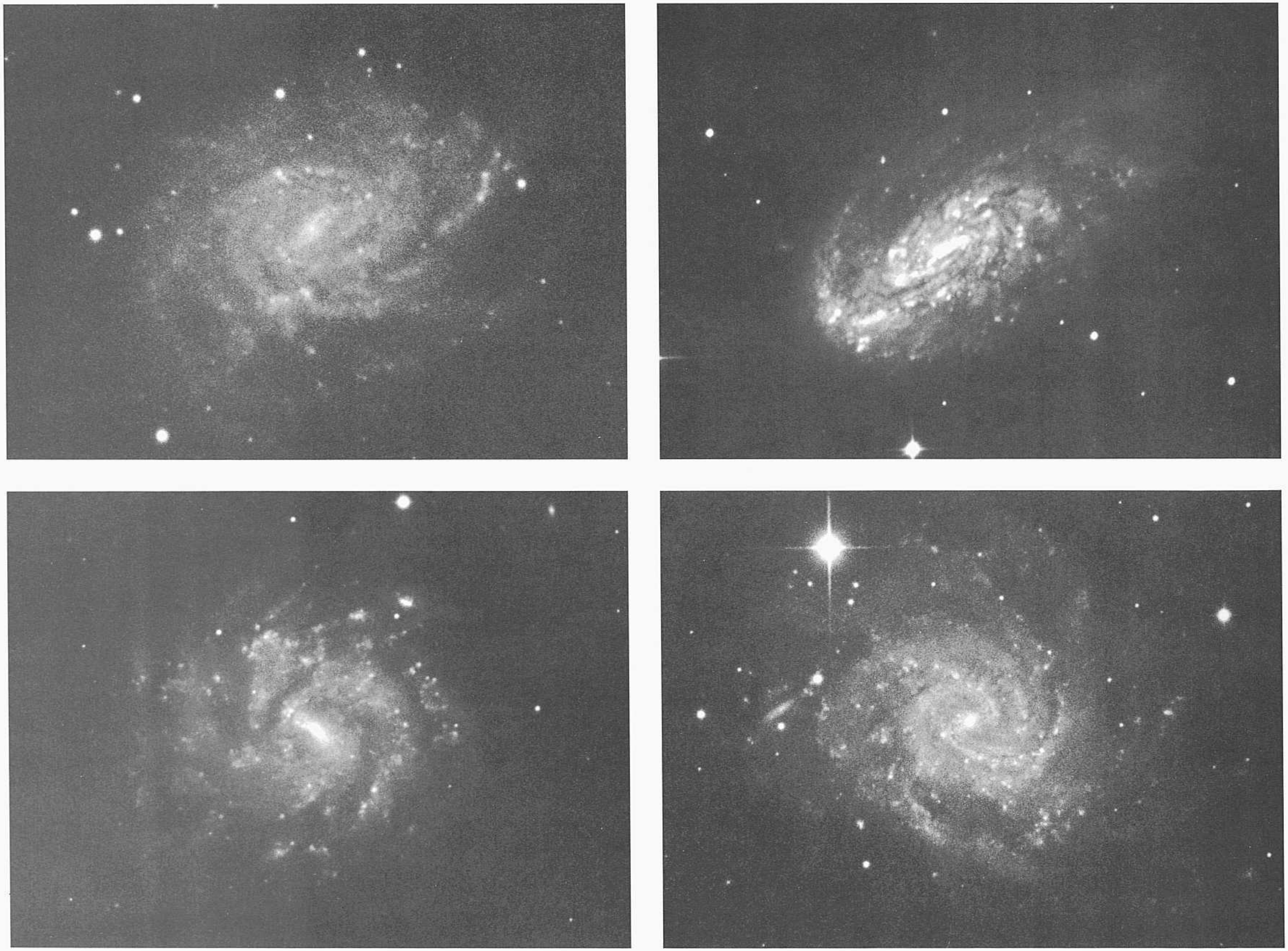
One of the central dust lanes cuts across the front of the nuclear region; the other appears to duck behind. The pattern is identical to that in the prototypical SBb galaxy NGC 5383 (panel 168).

The brightest individual stars are easily resolved throughout the image of **M83.** However, their photometry in the high-surface-brightness central regions is difficult to interpret because of the evident high internal absorption throughout the inner disk and arms. Vie estimate that the brightest stars begin to resolve at about $B = 17$.



PANEL
301

PANEL
302



NGC 5334 SBc(rs)II
CD-1514-S/Br
Aug 5/6, 1980
103aO + GG385
45 min

NGC 5334 may be IC 4338 listed in Dreyer's Second Index Catalog, although the RA positions differ by 1 5 seconds of time.

The surface brightness of NGC 53 34 is exceptionally low. enhanced in this print by contrast control in the darkroom in progressing from the original negative to the final image.

There are a few IHI-rcgion candidates in the bar and in the arms, but none are resolved at the 1.5" level. The redshift of NGC 5334 is v_0 = 123 7 km a"[1].

NGC 685 SBc(rs)II
CD-2016-Bedke/Gregory
Oct 25/26, 1981
103aO + GG385
45 min

Many individual knots are present in the bar and in the massive arms of NGC 685. These are likely to be HII regions and brightest resolved stars, but the distinctions have not yet been made (1991) by standard techniques. The resolution is sufficiently promising and the surface brightness is low enough in the arms to make NGC 685 a prime galaxy for more-detailed study of its stellar content.

The largest Fill regions probably begin to resolve into disks at about the 1" level. The redshift of NGC 685 is v_n = 1306 km s~[J].

NGC4654 **SBc(rs)II-IH** VCC 19JS7
CD-2176-S
March 28/29, 1982
I03nO
50 min

NGC 4654 is among the- 15 largest spirals considered to be members of the Virgo Cluster. Its isophotal diameter is large at *l)->r_t* = 4.7'. A comparison of its angular size with oilier large spirals in the cluster can be seen in the alias of Virgo Cluster spirals (Sandage, Binggeli, and Tammaun I 985a, panel 6).

As with the other large spirals in tin[1] cluster. NGC 4654- is in the outskirts of the cluster, away from either subcluster A or B (compare Binggeli, Tammann, and Sandage 1987). It is located 3.3° east (and slightly north) of NGC. 4486, which is associated with Virgo subcluster A.

Mil regions are present in the bar. The nucleus is brilliant and starlike at the I" level. The brightest HII regions in the arms arc abundant and have a helerochromatie blue magnitude of about B = 20. The galaxy is a good candidate for resolution into individual stars using a high-resolution telescope.

The redshift is v_o = 92 6 km s^{-1} but. being in the Virgo Cluster, this is as much a virial velocity as a distance indicator.

NGC 5885 SBc(s)II
CD-1392-S/Br
March 21/22, 1980
103aO + GG385
45 inin

NGC 5885 is a beautifully symmetric barred spiral, similar to but not quite as regular as its Sel counterpart NGC 1232 (Sc; panels 2 16. SI 3). or more closely similar to NGC. 3 184 (Sc; panels 23 7, S5) or IC 5332 (Sc; panel 2 59).

The bar is short. The two principal inner arms spring from the ends of the bar. as in NGC 1300 (SBb; panels 154. S8). They then branch into the thick multiple-armed structure in the outer regions.

Many Mil regions exist, defining the centers of the luminous arms. The regions are unresolved at the 0.7" level. The redshift of NGC 5885 is v_o = 1879 km s"[1].

NGC 3319 SBc(s)II.4
PH-7126-S
Jan 31/Feb 1, 1976
103aO + GG385
35 niin

NGC 33 19 **is a highly** resolved, nearby galaxy, **in which robust star formation is occurring in** the **high-surface-brightness,** lumpy bar. The two spiral arms spring from the ends of the **bar** in **the** (s) configuration of **the** NGC 13 00 (SBb: panels **154, S8)** type. The arms are moderately **chaotic;** hence **the** late luminosity class is shown.

Individual **brightest** stars are clearly resolved in the arms, starting at about $B = 19$, but more-precise data **require** photometry and the separation of stars from the several **bright Hll-region** candidates using standard methods.

The largest of the **HII** regions **probably** resolve into disks at the 2" level. The **redshift** of NGC 3319 is v_o = 776 **km** s"[1].

NGC 7496 SBc(s)II.8 MCL Gr #40
CD-1163-Br panel S10
Aug 22/23, 1979
103aO + GG385
45 niin

NGC 7496 is in a complex region of galaxies whose redshifts are about u_0 = 1400 km s^{-1}. The **region** has been mapped in redshift space by Maia, da Costa, and Latham (1989). They assign NGC 7496 to a group of more than 30 galaxies **for** which they have redshifts within projected linear distances of less than 2 Mpc. Among the RSA galaxies assigned to the group are IC 5325 (Se; panel 268), NGC 7462 (SBc; panel 311), NGC 7496 (here), NGC 7531 (She: panel 175). NGC 7552 (SBb; panel 156), NGC 7582 (SBab; panel 122), NGC 7590 (Sc), and NGC 7599 (Sell). The mean redshift assigned to the group by Maia. da Costa, and Latham is $\langle v_0 \rangle$ = 1390 **km** s .

HII regions are abundant in one of **the** arms near one end of the bar of NGC 7496. This is the region where the maximum shock **pressure** occurs, often seen in the hydrodynamic simulations (compare **Prendergast** 1962. 1983: Huntley, Sanders, and Roberts 1978: Huntley 1978, 1980).

A lew **individual brightest** stars are probably identifiable, starting al about /} = 2 0. The redshift of NGC 749 6 is v_0= 1444 km s"'.

IC 5273 SBc(s)II-III Grus Gr
CD-1546-S/Br
Aug 7/8, 1980
103aO + GG385
45 nuin

IC 52 7 3 has high-surface-brightness, **tightly** wound massive arms that cover most of the disk. It has been assigned to the loose, widely separated Grus Group (Sandage 19 75b) whose mean redshift is listed as $\langle v_o \rangle$ =1581 km s^{-1}. The redshift of IC 5273 is v_0 = 1296 km s"'.

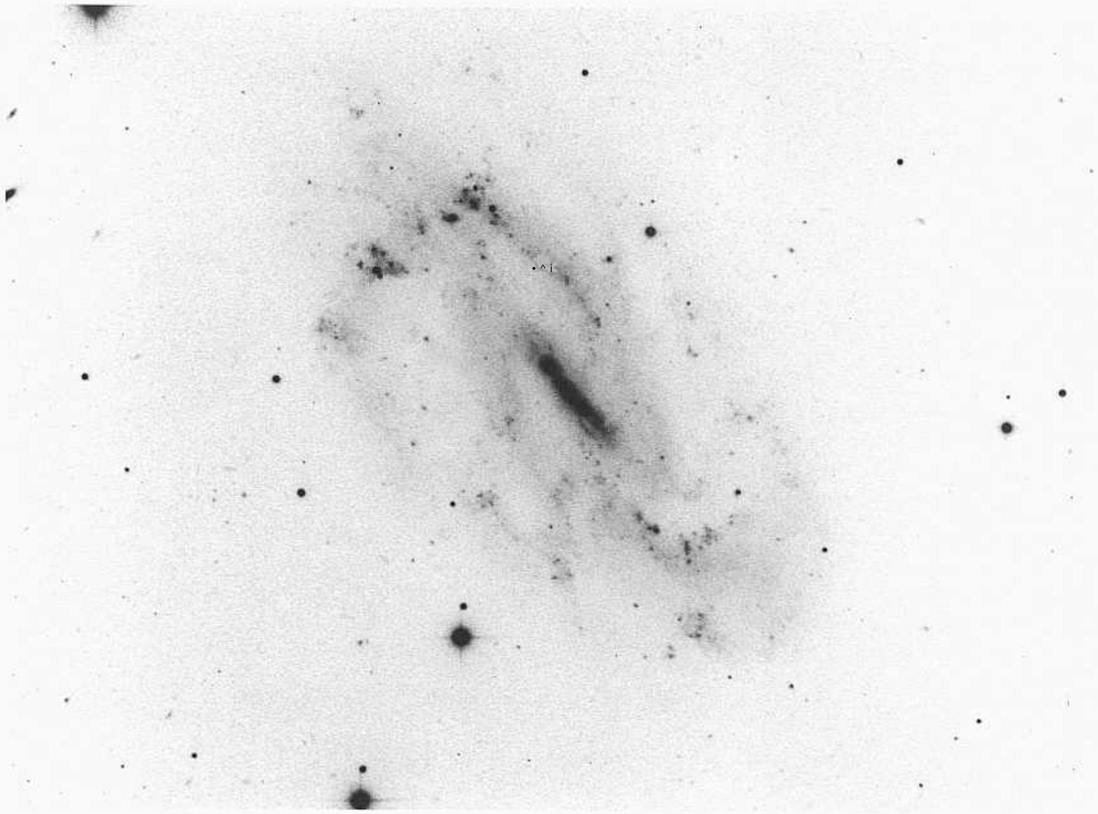
Several of the brightest **HII** regions are complex and resolve at about the 2" level.

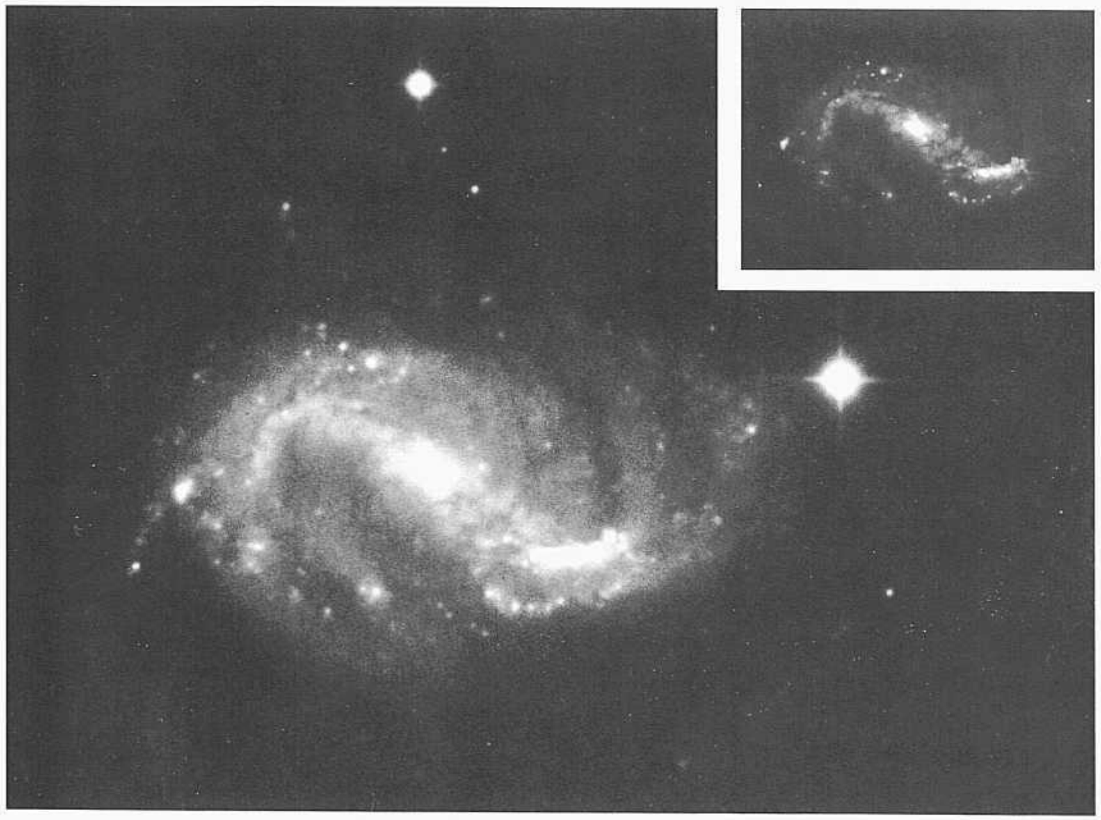
NGC **925 SBc(s)II-III HA,** ***p. 37***
PH-71-S
Dec 26/27, 1951
103aO + WG2
15 niin

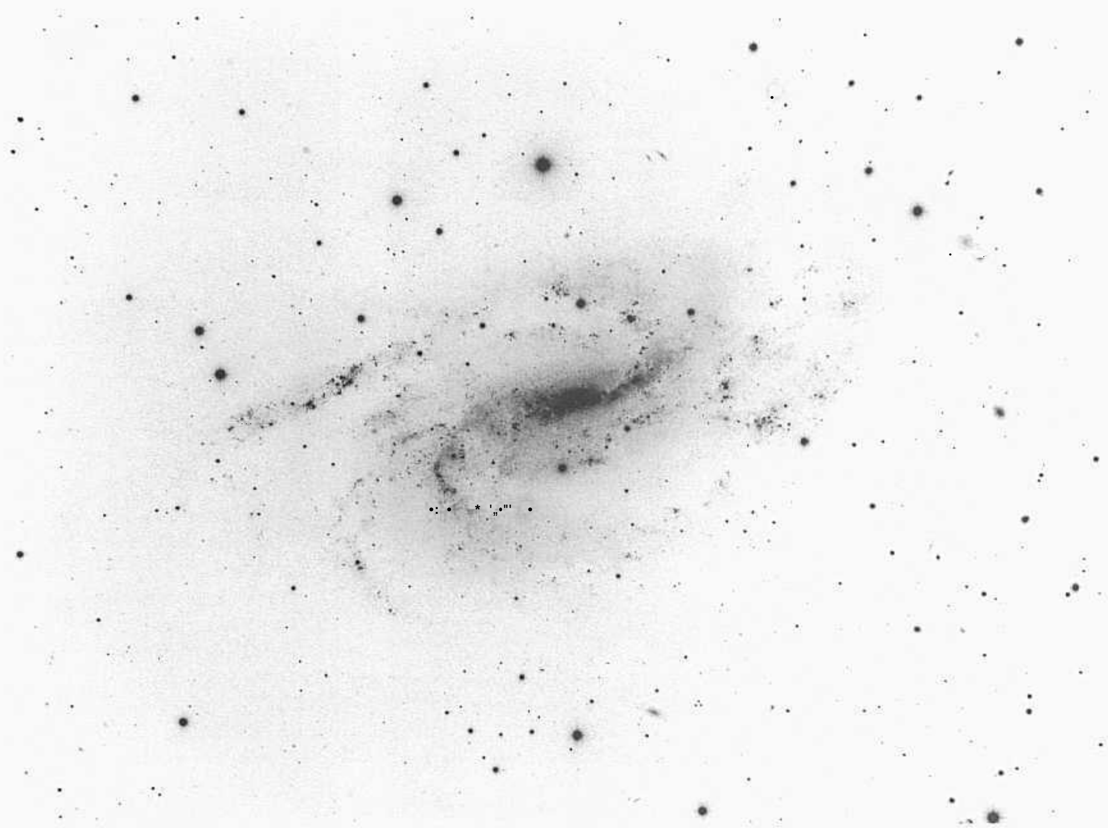
NGC 92 5 is one of the gems in the sky. It is highly resolved into individual stars starting at about $B = 20$. Numerous Hll-region complexes exist, the largest of which have angular diameters of about 5".

Stellar associations can be identified in the arms. The bar is full of **HII** regions and resolved stars. NGC 92 5 is one of the premier galaxies **not** far beyond the Local Group where studies of the stellar content will he important for the distance-scale problem. Cepheids should be easy to detect if the **photometry** can be pushed to $B = 26$.

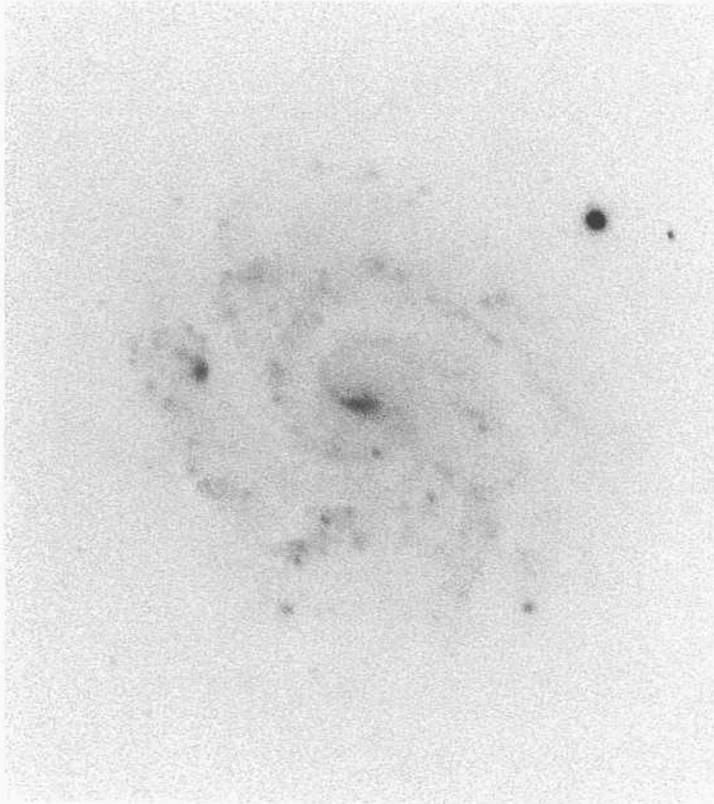
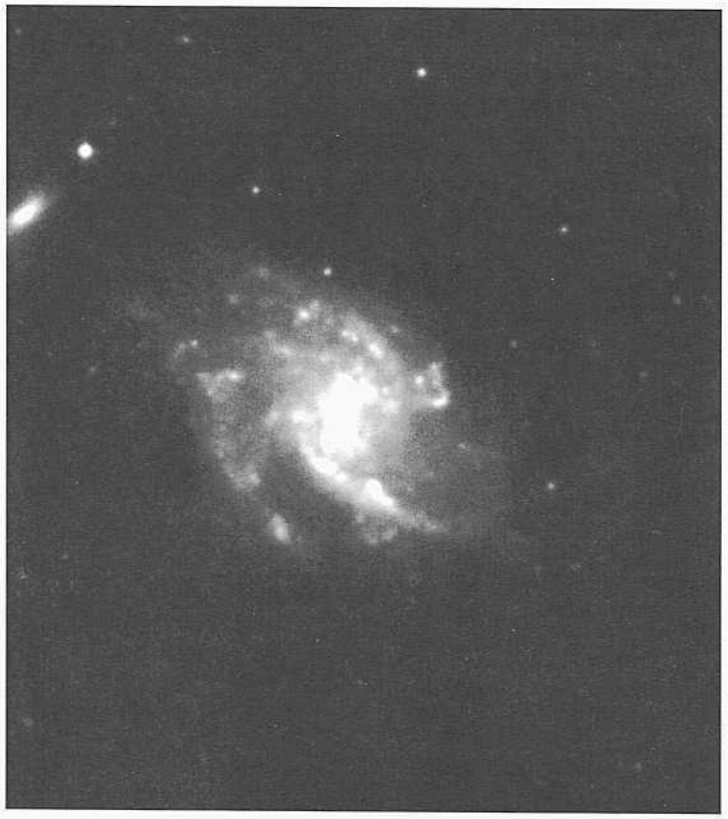
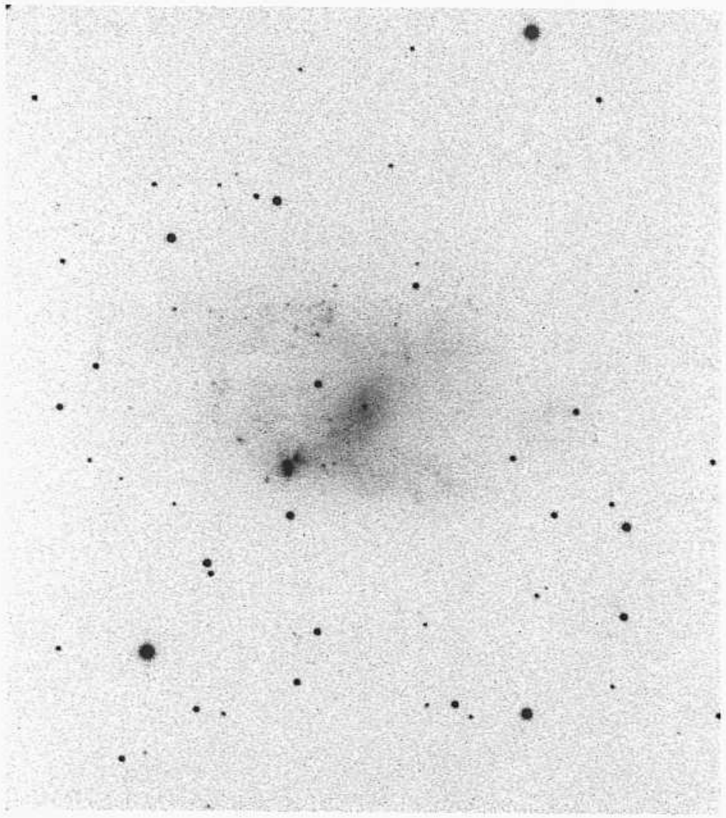
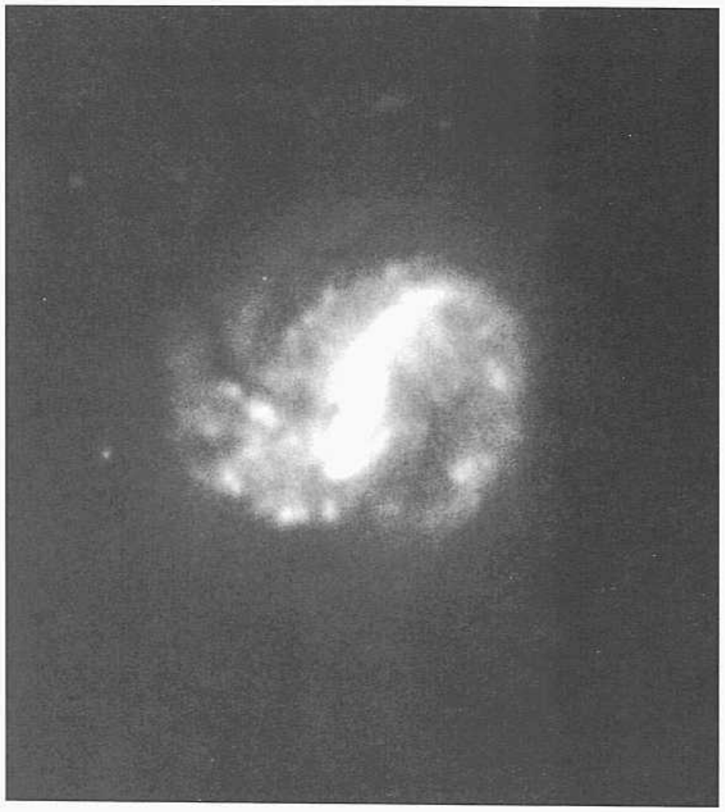
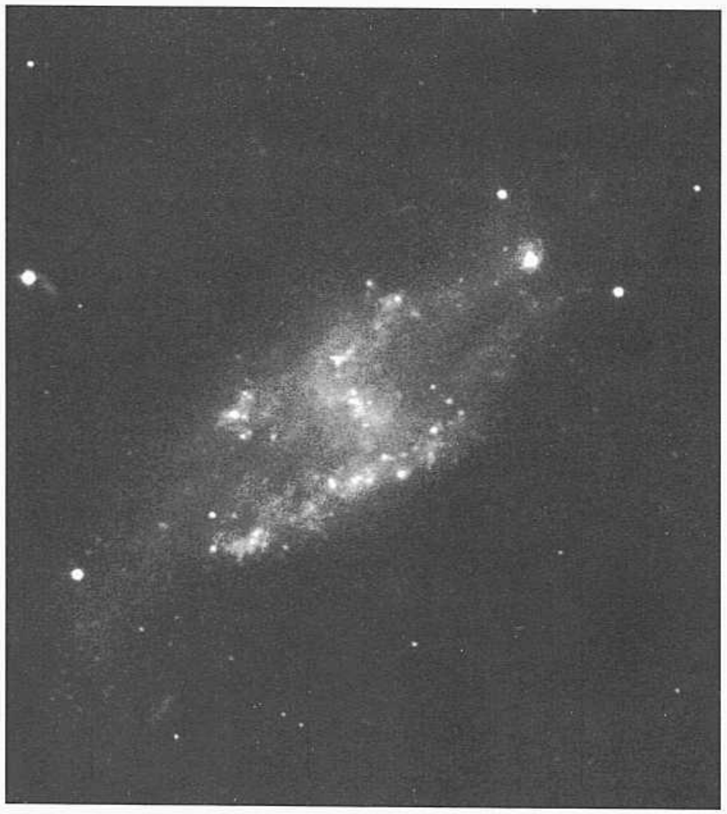
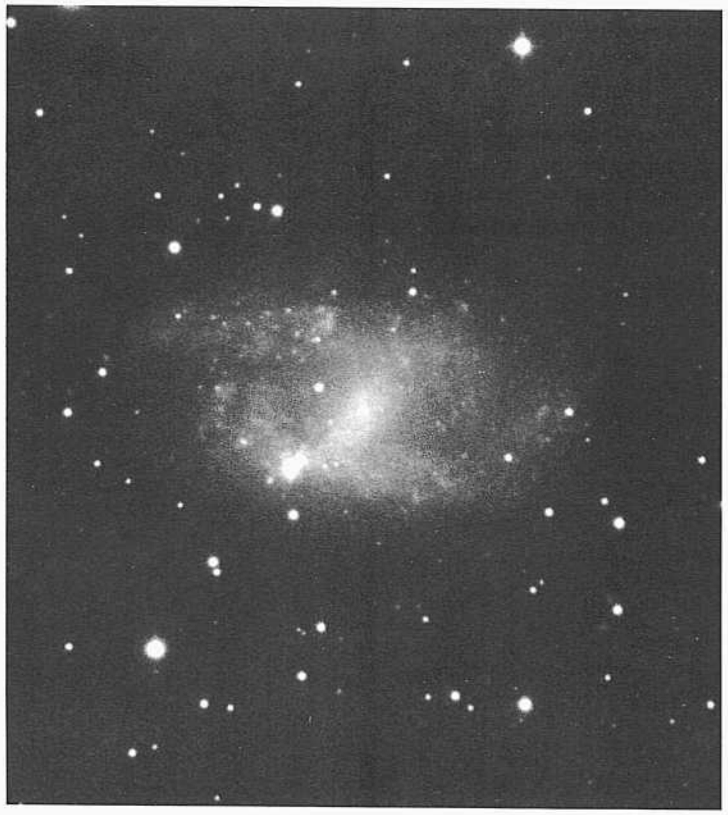
The redshift of NGC 92 5 is v_n - **792** kms"'.







PANEL
304

NGC 6412 SBc(s)/Sc(s)I-II
PH-7685-S
Sep 26/27, 1979
103aO
10 **inin**

The arms of the **multiple-spiral** pattern in NGC 6412 are thin and regular, similar to the pattern in NGC 1232 (Se; panels 216, S13); hence the early luminosity class is **required.** The surface brightness of the arm pattern is low.

The bar is short. The two principal arms near the center spring from the ends of the bar in the (s) pattern.

The largest of the several **HII** regions has a halo diameter of about 3". The redshift of NGC 6412 is $v_{,,}$ = 1568 km s^{-1}.

NGC 1341 **SBc(s)H-III** **FCC 62**
CD-1667-S
Dec **31/Jan 1, 1981**
103aO
75 min

NGC 1341 is listed as a member of the Fornax Cluster in the Fornax Cluster Catalog (Ferguson 1989). It is located 2.7° (which is 3.8 cluster core radii) southwest of NGC 1399, which is the cluster center. The redshift at v_o = 1793 km s^{-1} is high compared with the adopted mean velocity of $<v_o>$ = 1366 km s~[J] (Ferguson and Sandage 1990).

NGC **4519** **SBc(rs)H.2** VCC 1508
CD-801-S
Feb 24/25, **1979**
103aO + Wr2c
45 **min**

NGC 4519 is near NGC 4472, which is the central galaxy **of subcluster** B of the Virgo Cluster (Binggeli, Tammann, and Sandage 1987). It is **illustrated** in [he Atlas **of** Virgo Cluster Spiral Galaxies (Sandage, Binggeli, and Tammann 1985a), where it can be **compared** with other cluster members because all images are enlarged to a common scale.

The spiral pattern is similar to that in NGC 4597, below, and NGC 5398, shown in **the two** prints at the right. A central bar exists from which the arms spring, **but** the arms exist on both sides of the ends of the bar. It is the same pattern of a broken (incomplete) ring seen in earlier barred SBa and SBb(rs) types, **but** the **stellar** content is much later in NGC 4519 here and in the two remaining galaxies on this page.

Many **HII** regions exist in the bar and in the arms of NGC 4519. The largest of these resolve at about the 2" level. The redshift is v_0 = 1094 km s^{-1}, close to the adopted mean redshift of the Virgo Cluster, $<v_o>$ = 976 km s^{-1} (Sandage and Tammann 1990).

NGC 4597 **SBc(r)III:**
CD-1400-S/Br
March 22/23, **1980**
103aO
75 **min**

NGC 4597 is in the complex region once called the southern extension of the Virgo Cluster but now called the ridge-line region of the Local Supercluster, south of subcluster B of the Virgo Cluster.

The brightest parts of the stellar content of NGC 4597 are highly resolved into many **HII** regions and perhaps even brightest stars. The largest HII region, similar to NGC 604 in M33, has a core diameter of 5" and a halo diameter of 11". The redshift is v_o = 851 km s~'.

Because the disk surface brightness is low, NGC 4597 is a prime candidate for a major effort to study its bright stellar content for cab'bration purposes.

NGC 5398 **SBc(s)II-III**
CD-1364-S/Br
March 16/17, 1980
103aO + **GG385**
50 min

NGC 5398 has a **spiral-arm morphology** that is **remarkably** similar lo **that** of **NGC** 45 I[l]* at tin- left and NGC 4597. below in **the** middle **column.**

The heavy print here shows tin[1] **resolution** into stars and **1111** regions in the thick massive arms, which, **nevertheless iiave a** low **surface** brightness. The **resolution into** stars begins ;tt about /{ = 2 1 .

The largest of the many 1111 regions is complex, with a halo **diameter of** about 6". Measurement of the short-exposure plate used for the print below shows each of the components lo have diameters of about 2". The redshift of NGC 5 3 9!! is [;,, = 984 km s~\

NGC 5398 **SBe(s)II-lII**
CD-1365-S/Br
March 16/17, 1980
103aO + GG385
10 min

The bar is oval-like and is of low surface brightness. The nucleus is unresolved at the 0.7" level. It and the oval (which is the bar) **resemble** the dE,N dwarf elliptical morphology. The form would be classified as dE,N if the spiral arms were absent.

The two galaxies on this panel are the SBc prototype examples of the multiple-arm pattern seen in the Sc counterparts NGC 1232 (Scl; panels 216, S13) and M101 (Sd; panel 218).

NGC 5643 SBc(s)II-III
CD-1342-S/Br
March 14/15, 1980
103aO + GG385
40 niin

Although NGC 5643 is in low Calactie latitude (b = 15°) with tin- attendant high foreground contamination, it is nevertheless clear that robust current star formation is occurring in the nearly **circular** arms; very many **Mil-** region candidates exist. **Individual** stars also begin to resolve at about $B = 22$.

The central region is oval **rather** than bar-like. The straight, thin dust lane on one side of **the** center, characteristic of barred spirals, is evidence for strong **noncircular** motions in the neighborhood of the central oval potential; the lane is the response of the gas to hydrodynamic shocks due to these noncircular motions.

The faintness of a corresponding straight lane on the opposite side of the center may be an aspect effect: these lanes may not lie entirely in the plane of the disk, evidenced also by **their** crossing over and under the nuclear region, as is clear in NGC 5383 (SBb: Hubble Atlas, p. *46:* panel 168 here).

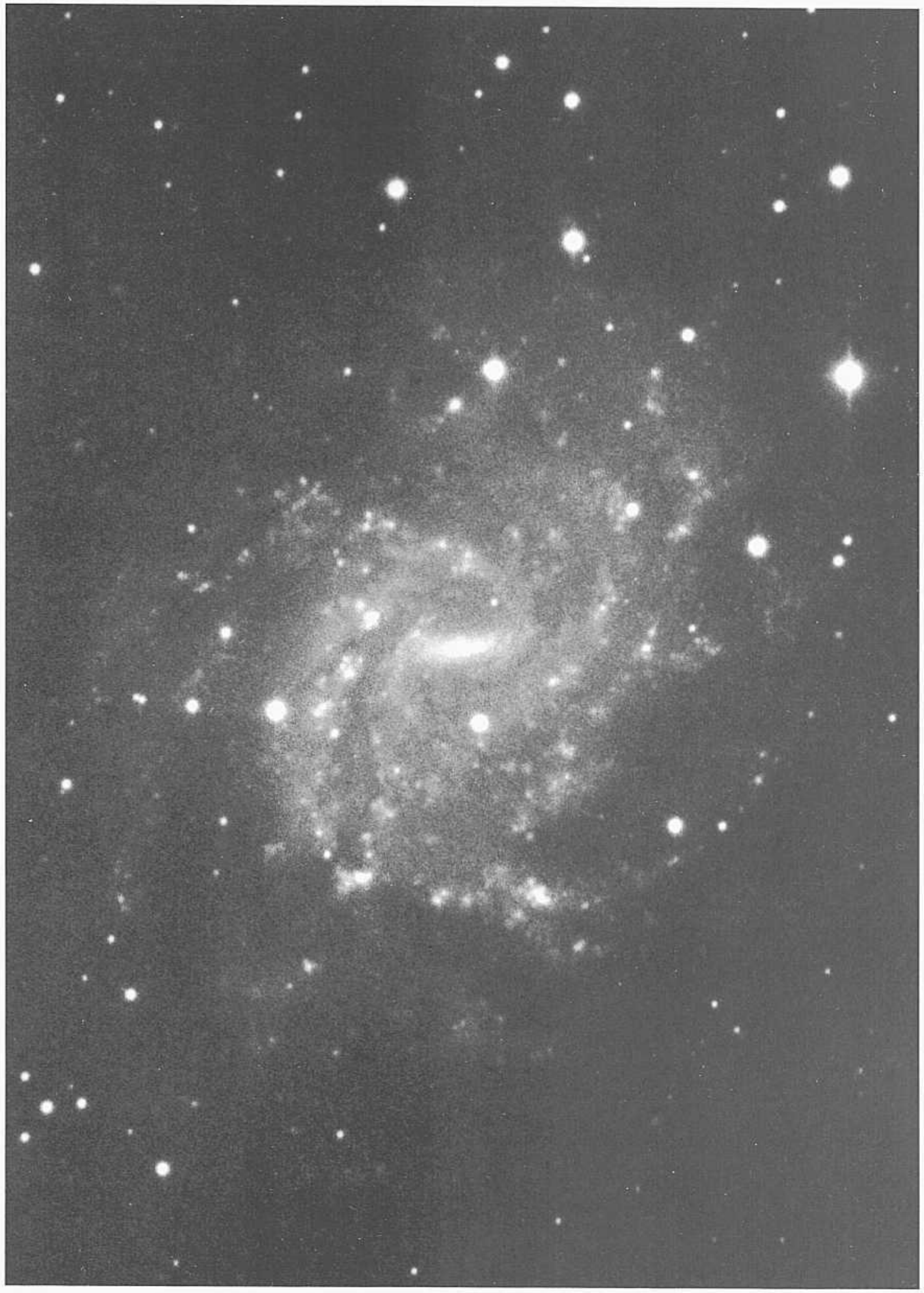
The redshift of NGC 5643 is v_n = 947 km s^{-1}.

NGC 5556 SBc(sr)II-III companions
CD-1353-S/Br
March 15/16, 1980
103aO + GG385
45 iiiin

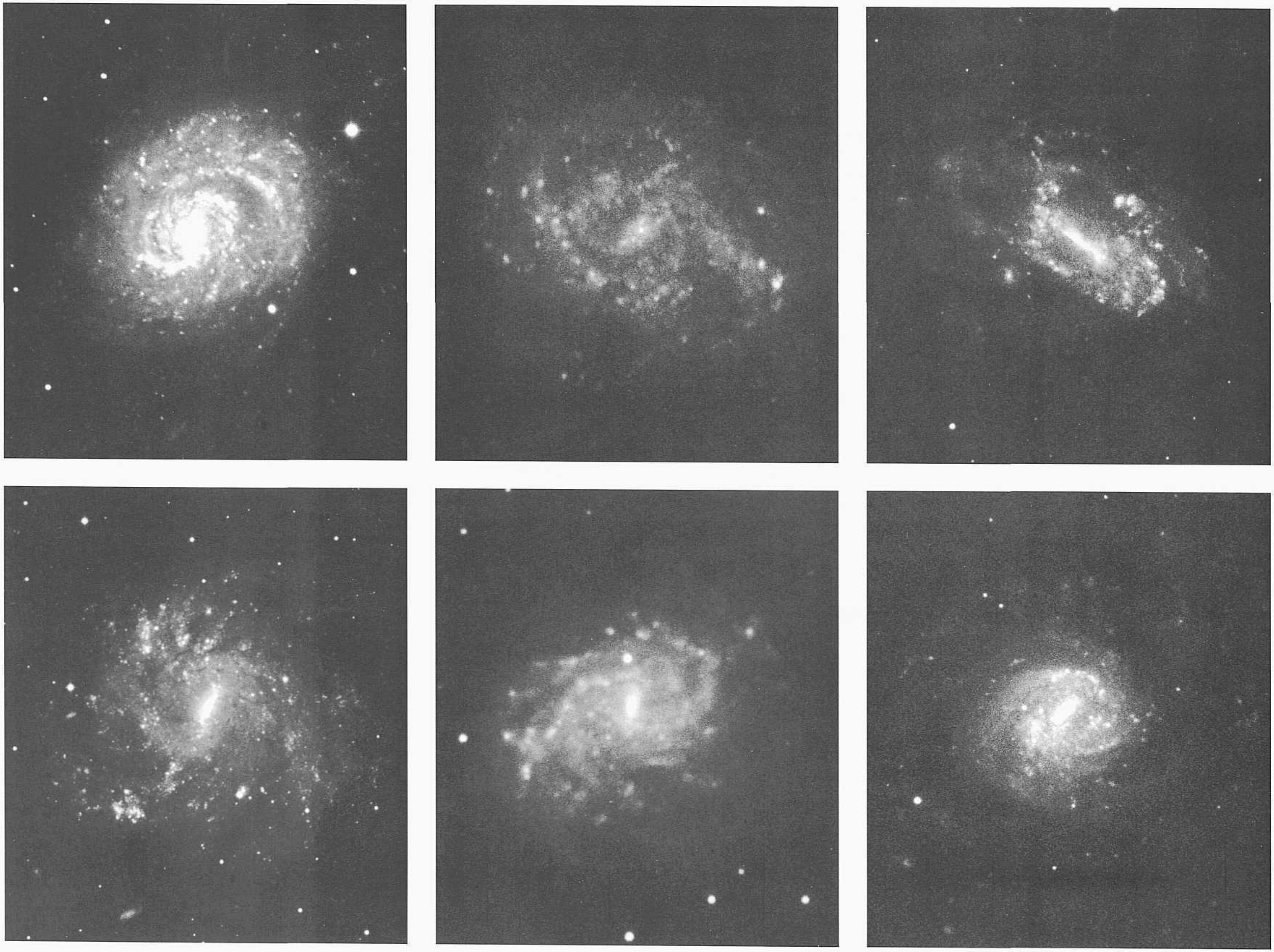
The bar in NGC 5556 is short but real. Current star formation is occurring in it. The two main inner arms spring from the ends of the bar and thereafter fragment almost immediately into the multiple-arm pattern of moderate geometrical entropy in the outer regions.

Very many **HII** regions exist in the spiral pattern, **the** largest of which begin to resolve at about the 1" level. Individual brightest stars are evident in the image beginning at about $B = 22$. The redshift of NGC **5556 is v_0 = 1163** km **s"¹.**

A likely **companion** (Anonymous: SniIII). with similar resolution of its stellar content, exists at a separation of 9.4'. The projected linear separation is 64 kpc at a redshift distance of 23 Mpc (// = 50). Several additional dwarf candidate companions exist in the immediate field. The galaxy and its companions are prime objects to study at higher resolution and brightness levels for the calibration of the extragalactic distance scale.



PANEL
305



PANEL
306

Many of the galaxies on this panel are highly resolved into individual stars, and are therefore useful for calibration studies of the extra^alactic distance scale.

NGC 1637 SBc(s)II.3 HA, p. *30*
PH-68-MH
Feb 15/16, 1950
103aO
30 niin

The central region of NGC 1637 has no bar but has an oval luminosity distribution. One nearly straight dust lane exists on one side of the center, characteristic of barred spirals.

Individual brightest stars clearly begin to resolve at *B* brighter than 22 mag, but the confusion with very many Hll-region candidates must be solved before precise data can be interpreted.

The largest HII regions resolve into disks at about the 1.5" level. The redshift of NGC 1637 is v_o = 715 km s^{-1}.

NGC 5068 SBc(s)II-III
CD-1855-HB
April 4/5, 1981
103aO
75 niin

The angular size of NGC 5068 is large at £>25 = 6.9'. It is highly resolved into Hll-region candidates and individual brightest stars that could be as bright as *B* = 18.5 but which must be individually separated from the Hll-region candidates before the data can be interpreted.

Star formation is occurring in the bar. Many classical OB associations can be identified in the arms. The largest HII region resolves at a diameter (halo) of about 4". The redshift of NGC 5068 is v_o =443 km s"'.

IC 749 SBc(rs)II-III Karachenteev 313
PH-7641-S
April 28/29, 1979
103aO
12 min

IC 749 forms a close physical pair with IC 750 (Sb?; panel 195) at a separation of 3.3'. The respective v_o redshilts are u_o(749) = 827 km s^{-1} and i?$_o$(750) = 742 km s^{-1}. The pair may be part of the extended <i'$_o$> =750 km s^{-1} group in the Ursa Major region that also contains NGC 3675 (Sb; panels 139, S4, S13, S14), NGC 3769 (SBc; panel 311), NGC 3782 (SBcd; panel 328), NGC 3949 (Sc: panel 265), NGC 4051 (Sbc; panel 180), NGC 4242 (SBd; panel 322), and others listed in Group 10 by de Vaucouleurs (1975) and called the CVn II Cloud there.

At an adopted redshift distance of 16 Mpc (77 = 50), the projected linear separation of IC 749 and IC 750 is small at 15 kpe. There is little or no evidence for tidal interaction between the pair; the true linear separation must be considerably larger than this minimum projected distance.

Many Hll-region candidates exist in the well-formed arms of IC 749. Resolution into individual stars is also present, starting probably near *B* = 22.

NGC 7070 SBc(s)H pair
CD-1155-Br
April 22/23, 1979
103aO + GG385
45 niin

NGC 7070 forms an apparent pair with NGC 7072 (Selll. high surface brightness) at a separation of 4.5'. The redshift of NGC 7070 is v_o - 2365 km s"^{1}. The redshift of NGC 7072 is unknown (c. 1990), but the resolution of its stellar content is similar to that in NGC 7070, suggesting a common distance. At a redshift distance of 47 Mpc (*H* = 50) the projected linear separation would be 62 kpc.

The arms of NGC 7070 are thin and regular. The luminosity class of II, assigned here, differs from the 11-111 class listed in the RSA.

NGC 4116 SB«(i)II-lll pair
CD-1847-HB
April 3/1, 1981
103aO
75 mill

NGC II I 6 forms a physical pair with NGC 4123 (Sm.c: panels 201. Hii) al a separation of 14'. The respective redshifts are (,',,(1116) = 1140 km s⁻' and u_o(4123) =1157 km s"^{1}. At a redshift distance of 23 Mpc (// = 50) the projected linear separation of the pair is 94 kpe.

Many Hll-region candidates exist in the bar and in the arm pattern. The nucleus in the center of the bar is starlike; it is unresolved at the 0.7" level.

NGC 255 SBc(rs)II-III
PH-7836-S
Sep 3/4, 1980
103aO
12 niin

The many Hll-region candidates in NGC 255 are unresolved at the 1" level. Individual brightest stars may begin to resolve at about *B* = 22.5. The redshift is v_o = 1726 km s^{-1}.

NGC 672 SBe(s)III Racine wedge
PH-7697-S Karachentsev 40
Sep 26/27, 1979
103aO + GG385
12 min

NGC 6 72 forms a close pair with IC 1727, shown at the right, at a separation of 8.3'. The respective redshifts are $u_o(672)$ = 647 km s^{-1} and v_o(1 72 7) = 5 76 km s^{-1}. At the mean redshift distance of I 2 Mpc (77 = 50) the projected linear separation is small at 29 kpc.

The resolution into individual stars in the arms of NGC 6 72 is easy. The brightest begin to resolve near *B* = 22. The bar also contains bright stars and several Hll-region candidates.

There are only a few HII regions in the arms and none resolve into disks at the I .5" level.

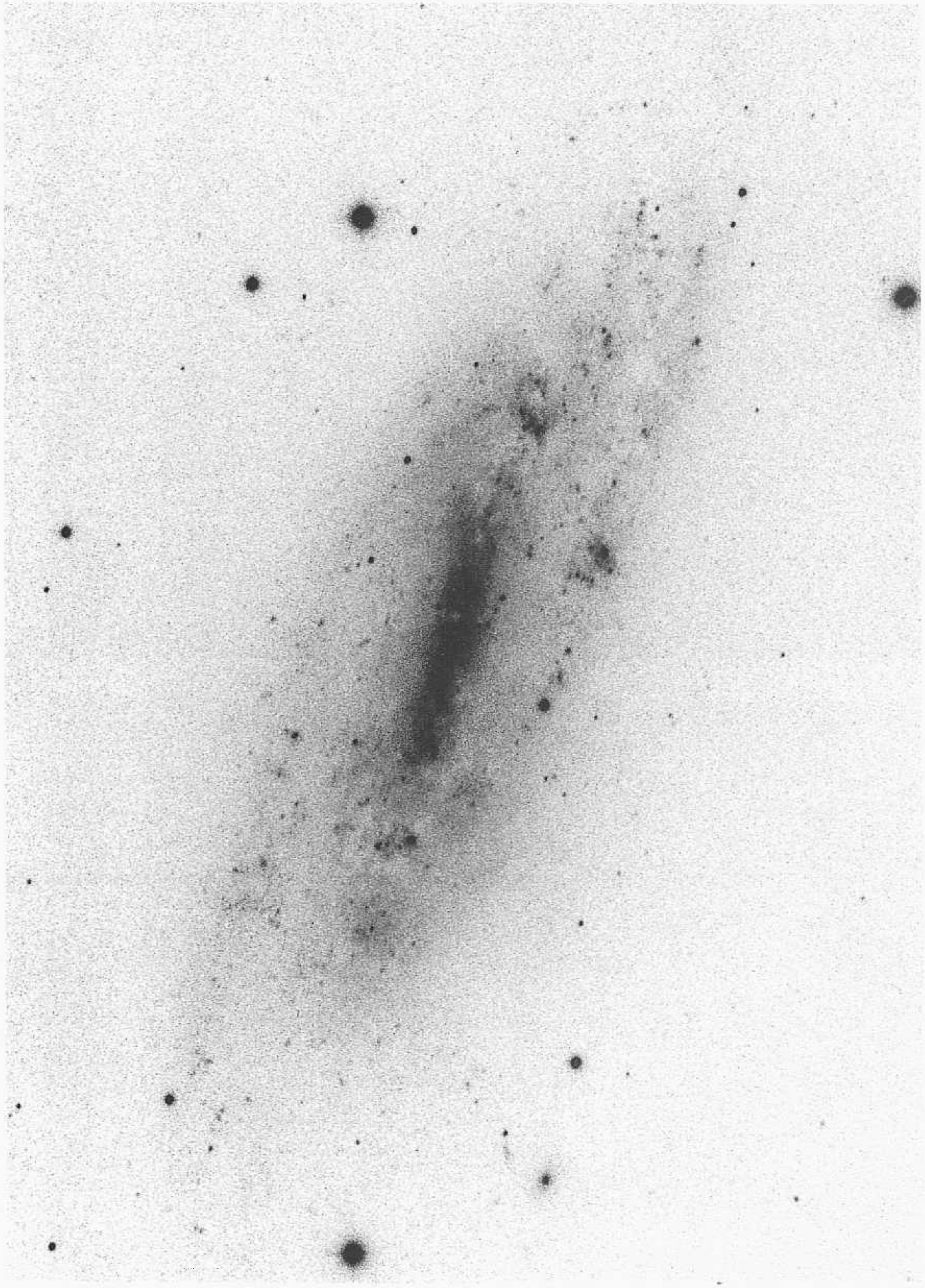
Note that the bright stars in this reproduction have Racine wedge secondary images that arc 5 mag fainter and L8" removed from their primaries.

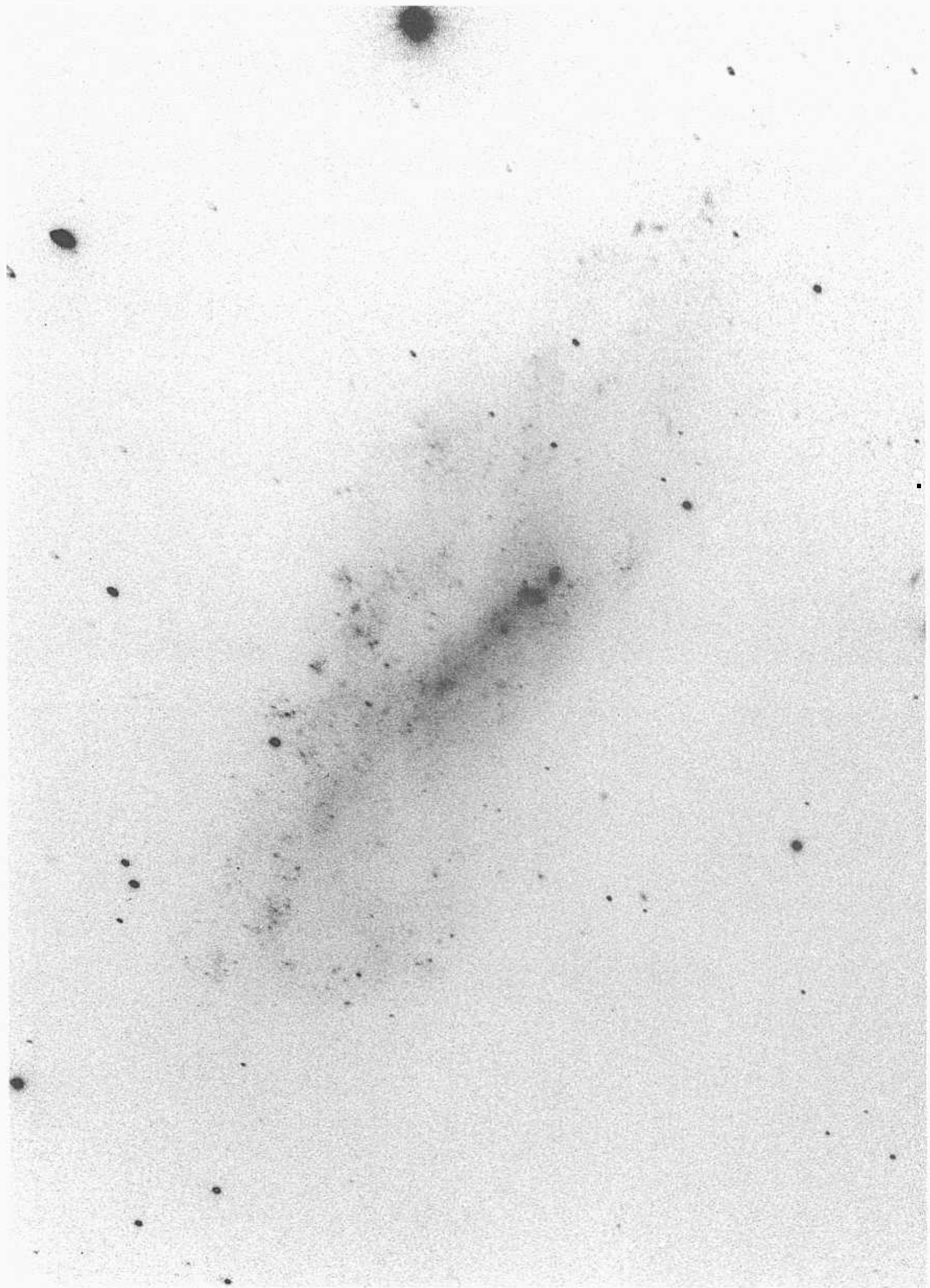
IC 1727 SBed(s)Ill Racine wedge
PH-7697-S Karachentsev 40
Sep 26/27, 1979
103aO + GG385
12 min

The resolution into individual brightest stars occurs at the same level, about *B* = 22, in IC 172 7 as in its companion NGC 6 72. shown at the left. The surface brightness of the arms and of the underlying disk is low in both IC 172 7 and NGC 6 72, making this nearby pair ideal for future studies of the brightest resolved stars, including Cepheids, useful for calibrations of the extragalactic distance scale.

The print of IC 172 7 here is made from the same Palomar 200-inch plate used for NGC 672 at the left. IC 1 72 7 is near the edge of the plate whose coma-free field is smaller than the area covered by IC 1727. The images on one side of the print show coma at this break point in the field.

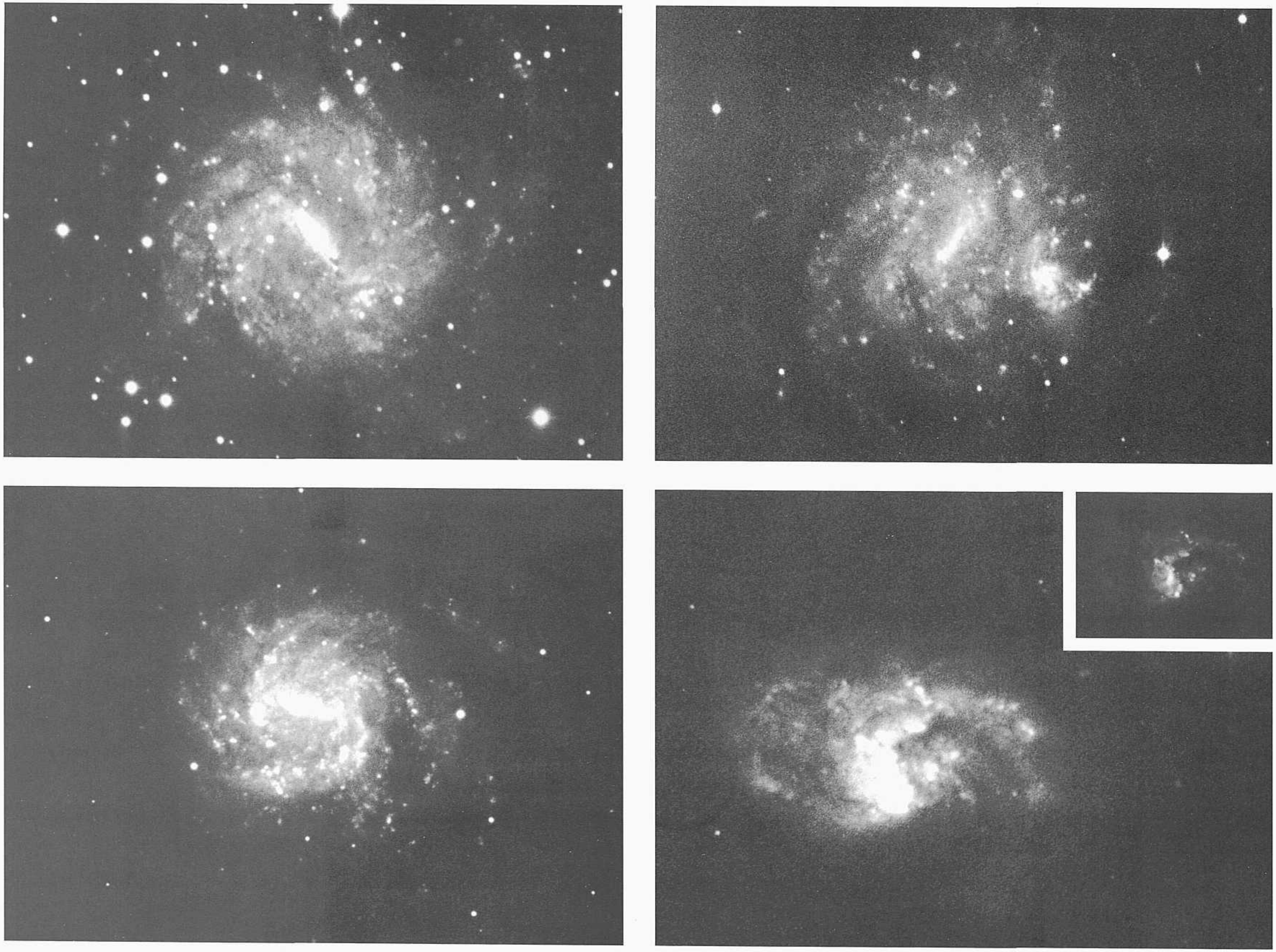
The original plate was taken with a Racine wedge, which produced secondary images to the bright, stars.





PANEL
307

PANEL
308



NGC 3059 SBc(s)III panel S9
CD-742-S
Feb 3/4, 1979
103aO + Wr2c
45 inin

The spiral arms in NGC 3059 are massive in the sense of Reynolds (1927a,b); they cover most of the disk and are of moderate surface brightness. The Galactic latitude of NGC 3059 is low (*b* = —15°), explaining tin* high density of foreground contaminating stars.

The redshift is v_o = 991 km a"[1].

NGC 1493 SBc(rs)III
CD-201-S
Feb 9/10, 1978
103aO + GG385
45min

Mi-region candidates exist throughout the bar and the multiple-arm spiral pattern. The largest of the MI candidates resolves at about the 1.5" level. Individual brightest stars are probably present starting at about *B* = 2 1.5. The redshift of NGC 1493 is v_o = 910 km s"[1].

A probable companion (Anonymous: ImlV) exists at a separation of 9.6'. The companion has two Hll-region candidates, both of which have disks whose angular diameters are about 2". At the redshift distance of 1 8 Mpc (H = 50) for NGC 1493 the projected linear separation of the pair would be 50 kpc.

NGC 4496A/149615 SBcIII-IV VCC 1375
CD-2201-S VCC 1376
March 3 I/April 1, 1982 Karachentsev 343
103aO
50min

The image of NGC 4496A overlaps thai of NGC 4496 H: the centers have an angular separation of 0.9'. The redshifta listed by Karachentsev, u,,(4496A) = 1 J!3 I km s~' and u_o(4496B) = 4509 km s^{-1}. would put the companion far in the background. This is curious because the brightnesses of the numerous I Ill-region candidates in both galaxies seem closely the same, suggesting that the two galaxies are at nearly the same distance. Additional data arc needed, but an apparent confirmation of the large redshift of NGC 4496B is given by the 21-cm redshift listed in the VCC of u_{mn} = 1548 km s^{-1} (or v_o = 4391 km s^{-1}) attributed to unpublished observations by Hoffman. Helou, and Salpeter (1984, private communication). This may be the same measurement published by Hoffman *et al.* (1989), where v_{sim} = 4546 km s'" is listed for NGC 4496B.

Both NGC 4496A and 4496B are listed in the VCC as non-members of the Virgo Cluster.

NGC 1385 SBc(s)III
CD-1741-S
Jan 12/13, 1981
103aO + GG385
30min

Vigorous star formation is occurring throughout NGC 1385, as judged by the many bright HII regions in the bar and in the arms. The detected candidates for brightest individual stars in the outer regions do not resolve brighter than *B* = 22.

The redshift is v_{n} = 1968 km s~\

NGC 1313 SBc(s)III-IV
CD-564-S
Oct4/5, 1978
103aD + Wrl2
60 niin

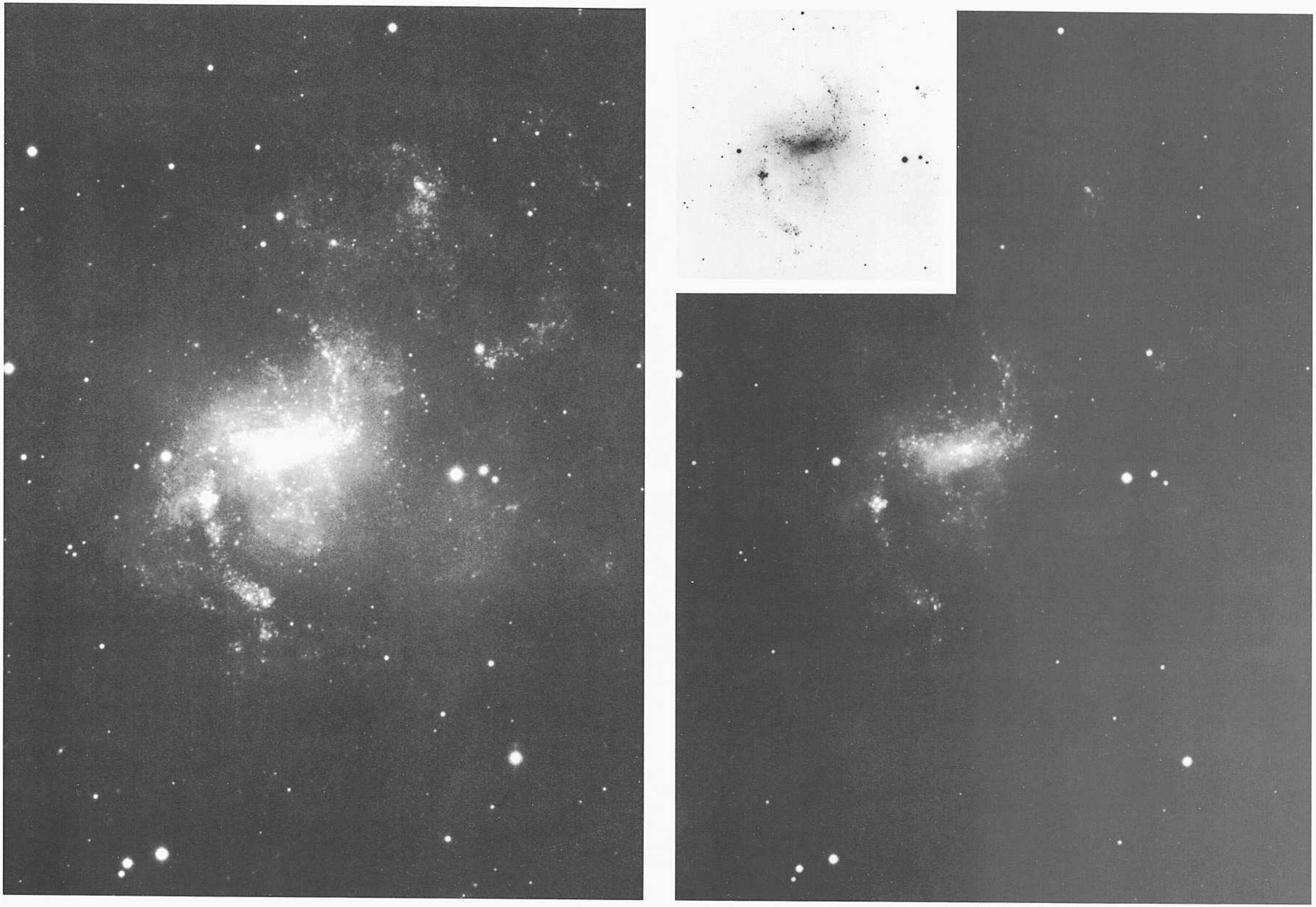
The resolution into individual stars in NGC 1313 is exquisite. Brightest stars begin to resolve at about B = 1 7, similar to the level in members of the South Polar Group such as NGC 55, NGC 247. and NGC 300 for which distance moduli of about $in — M$ = 26.5 have been **adopted.**

The brightest stars occur in the bar and in a compact association in one of the two stubby inner arms that start from the ends of the bar. These arms, and **the** resolution of stars in the bar. are seen best in the shallow print on the **right.** Both **prints** here have been made from the same original plate taken in the V photometric passband.

The chaotic nature of the outer regions of NGC 1313 is seen in the heavy print on the left. A semicircular arc near the upper border of the print, similar to Constellation III in the LMC, contains a bright association and provides good resolution into stars. Similar resolution into fainter stars continues to the plate limit over the entire face of the galaxy.

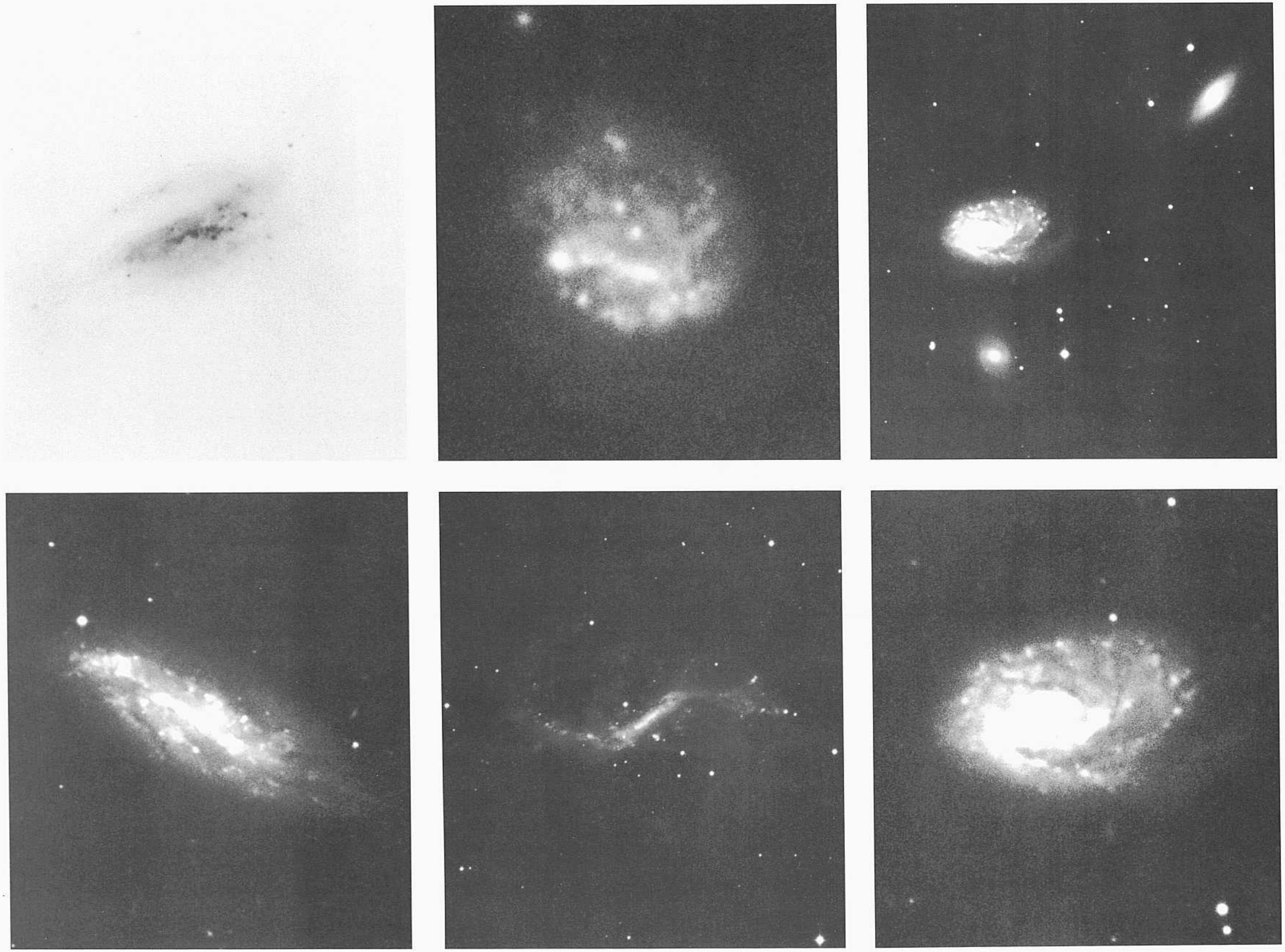
The small redshift of v_o = 261 km s^{-1} is consistent with the small distance inferred from the magnitude of B = 17 for the brightest resolved stars.

Note that the prints here have been made from a yellow-sensitive emulsion rather than blue. This tends to suppress the contrast between the young blue individual stars and the underlying older disk.



PANEL
309

PANEL
310



NGC 6239 SBcIII pee
PH-59-H
April 27/28, 1949
103aO
30 niin

The original plate from which this image was made was one of the earliest taken with the 200-inch Palomar reflector, before the prime-focus Ross corrector was installed. There is, therefore, appreciable coma extending to the center of the field because the//ratio of the primary mirror is so small. However, the angular size of NGC 62 39 is small enough (D_{2S} =2.7') to avoid much image degradation near the center, where the Hll-region candidates exist.

Current star formation is occurring in the bar but little exists in the faint arms. None of the Hll-region candidates resolve at the 1" level. The redshift of NGC 6239 is v_o = 1110 km s~'.

NGC 4294 SBc(s)IMII VCC 465 pair
CD-1318-S/Br
March 12/13, 1980
103aO
75 inin

NGC 4294 in the Virgo Cluster forms a close (probable) physical pair with NGC 4299 (Sd; panel 328) at a separation of 5 .6'. Both are in the Virgo Cluster and are located about a third of the distance between Virgo subclusters A and B.

Closeness of angular separation in the cluster region is not usually good evidence of physical association. However, the circumstance here is unusual because the redshifts of both galaxies are so nearly the same and each is far from the cluster mean redshift, showing the same (nearly 30) large virial velocity deviation from the mean. This is so improbable as to suggest that the galaxies are, in fact, a binary pair.

The redshifts are u_o(4294) = 227 km s~' and u_o(42 99) = 107 km s"[1]. At the cluster distance of 21.9 Mpc, the projected linear separation of the pair is small at 36 kpc.

Hll-region candidates exist both in the bar and in the arms of NGC 4294. However, none resolve into disks, nor is there evidence of resolution into brightest stars in the arms. This lack of resolution is consistent with membership in the Virgo Cluster, which lies at a much greater distance than that indicated by the small redshifts of the two galaxies. This is direct evidence for the large virial velocity dispersion in the Virgo Cluster because, from the stellar content, there is no question that the two galaxies are cluster members.

The pair is shown in the Virgo Cluster Atlas of Spirals (Sandage, Binggeli, and Tammann 1985a, panel 15), enlarged to a common scale for other Virgo galaxies.

NGC 4234 SBcIII.4 VCC 221
CD-2157-S
March 26/27, 1982
103aO
50 niin

NGC 4234 is in the Virgo Cluster Catalog but is listed there as a non-member. It is located in the southwestern corner of the survey area; it may be a member of the background W Cloud (Binggeli, Tammann, and Sandage 1987). Its redshift is v_n = 1981 km s"[1].

NGC 4731 SBc(s)IH(lides?) triplet?
CD-2188-S
March 29/30, 1982
103aO
46 niin

NGC 4731 forms a wide pair with NGC 4697 (E6; panels 13, 19) at a separation of 36'. It also forms a closer pair with an anonymous BCD galaxy at 10.4' that resolves into HII regions at the same brightness as in NGC 4731. The redshifts are u_o(4697) = 1033 km s~' and «O(4731) = 1303 km s"[1]. If the galaxies are at a common redshift distance of 23 Mpc *(H* = 50), their projected linear separation is 241 kpc.

The redshift of the closer BCD companion is not known (c. 1990) but there is little doubt that the pair forms a physical association. Their projected linear separation is small at 70 kpc. Many other dwarf E and Im candidate companions exist in the field of NGC 4697 and NGC 4731.

Star formation is occurring in the bar of NGC 473 1, judging by the Hll-region candidates there. The arm pattern is that of tidal plumes, perhaps due to a close encounter with the BCD companion, which also has a near (so-called) starburst morphology.

NGC 4273 SBc(s)II VCC 382
CD-1339-S/Br
March 14/15, **1980**
103aO
75 min

NGC 4-273 is in a busy region in the southwestern corner of the Virgo Cluster Catalog area. It and its companions are probably in the W cloud in the background (Binggeli. Sandage, anil Tammann 1985; Binggeli. Tammann, and Sandage 1987). The bright companion galaxies in the wide-angle view in the upper-right photograph are NGC 4277 (SBa; VCC 386; v_o = 2345 kins"') and NGC 4268 [$S0_2$(6); VCC 371 ; v_n = 2 1 64 km a"[1]]. The redshift of NGC 42 73 is v_o = 2 232 km s^{-1} . The dwarf elliptical galaxy VCC 390 (dE3) is also present in the field shown here.

NGC 4273 SBc(s)H VCC 382
CD-1339-S/Br
March 14/15, 1980
103aO
75 min

The spiral arms of NGC 4273 terminate at a sharp outer boundary whose elliptical outline is not centered on the galaxy's center. The pattern of a sharp outer termination is moderately common, shared for example by NGC 95 (panel 248), NGC 491 (panel 2 11), NGC 163 7 (panel 306), NGC 2701 (panel 271), and NGC 4647 (panels 51,278,314), among others.

The asymmetry in the arm brightness between the two sides of the major axis is not the normal pattern. Nevertheless there are numerous examples in this atlas. These include IC 1953 (panel 208), NGC 5065 (panel 246), NGC 95 (panel 248), NGC 1569 (panel 263), NCC 2276 (panel 263), NGC 2 70 1 (panel 27 1), NGC 478 I (panel 273), NGC 4298 (panel 279), NGC 4096 (panel 287), NGC 3367 (panel 293), NGC 1637 (panel 306), the prototypes of NGC 5676 (panel 245) and NGC 5678 (panel 278), NGC. 1536 (panel 313), perhaps NGC 922 (panel 3 I 3), and NGC 5474 (panel 315).

The six galaxies on this panel have moderate-to-high inclination. All feature a central bar, although the bar is less definite in the last three galaxies than in the first three.

NGC 7640 SBc(s)II: HA, p. *49*
PH-115-H
Sep 24/25, 1951
103aO
30 niin

NGC 7640 is very highly resolved into individual stars and a few large Hll-region complexes. From tile degree of resolution into stars, the distance modulus must be smaller than $m - M = 31$ hut larger than $m - M = 30$. The brightest stars begin to resolve at about $B = 21.5$. Star formation is occurring in the central region as well as in the two major arms.

The redshift is $v_0 = 669$ km s^{-1}.

NGC 4178 SBc(s)II VCC 66
CD-2100-S
March 18/19, 1982
103aO + GG385
75 niin

NGC 4178 is listed as a cluster member in the Virgo Cluster Catalog (Binggeli, Sandage. and Tammann 1985). It is illustrated on a common scale with other cluster members in the Atlas of Virgo Cluster Spirals (Sandage, Binggeli, and Tammann 1985a, panel 6). The angular diameter is large at $D_{2 \cdot 5} = 5.0'$. The redshift of NGC 4178 is $v_0 = 224$ km s~', illustrating the large virial velocity variation among the Virgo Cluster members. From the characteristics of the HII regions and the lack of individual resolved stars brighter than $B = 23$, there is no question that the galaxy is much more distant than its small redshift would indicate.

The bar consists of HII regions in a thin straight pattern. Two large IHI-region complexes exist in one of the arms. Halo diameters of these compound associations are about 5".

NGC 1249 SBc(s)II
CD-704-S
Jan 30/31, 1979
103aO + GG385
45 niin

The halo diameters of the largest of the Hll-region complexes in NGC 1249 are about 3". Resolution into individual stars is difficult but may begin at about $B = 22.5$. The redshift of NGC 1249 is $v_o = 887$ km s"'.

NGC 3769 SBc(s)II Karachentsev 294
PH-7633-S
April 28/29, 1979
103aO
12 min

NGC 3769 forms a close pair with a companion (NGC 3 769 A; Sin; not in the RSA) which is evidently at the same distance judging by its similar resolution into stars and HII regions. The separation of the pair is 1.2'. The individual v_o redshifts listed by Karachentsev are 791 km s^{-1} for NGC 3 7 69 and 845 km s~J for its companion. At the mean redshift distance of 16 Mpc *(H* = 50) the projected linear separation is very small at 6 kpc. It can be guessed from the distorted morphology that a close encounter is, in fact, in progress.

NGC 7462 SBc(s)
CD-1535-S/Br
Aug 6/7, 1980
103aO + GG385
45 min

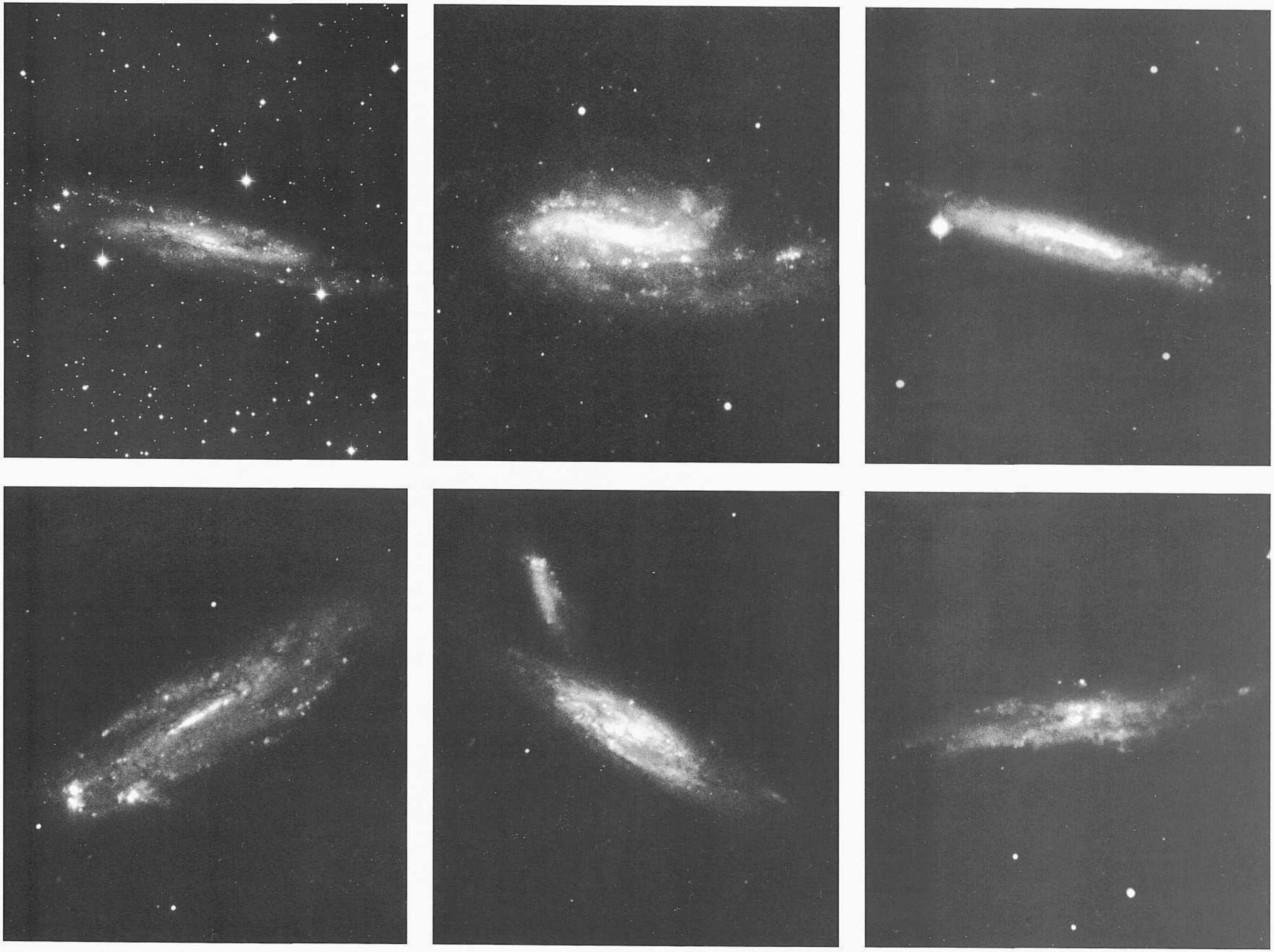
NGC 7462 is nearly on edge. The brightness distribution at the center suggests the presence of a bar, but this is uncertain. HII regions exist, most easily seen on one side of the image in the outer region of lower projected surface brightness.

The redshift is $v_0 = 1022$ km s"'.

NGC 7307 SBc(s)II
CD-1125-Br
Aug 20/21, 1979
103aO + GG385
45 min

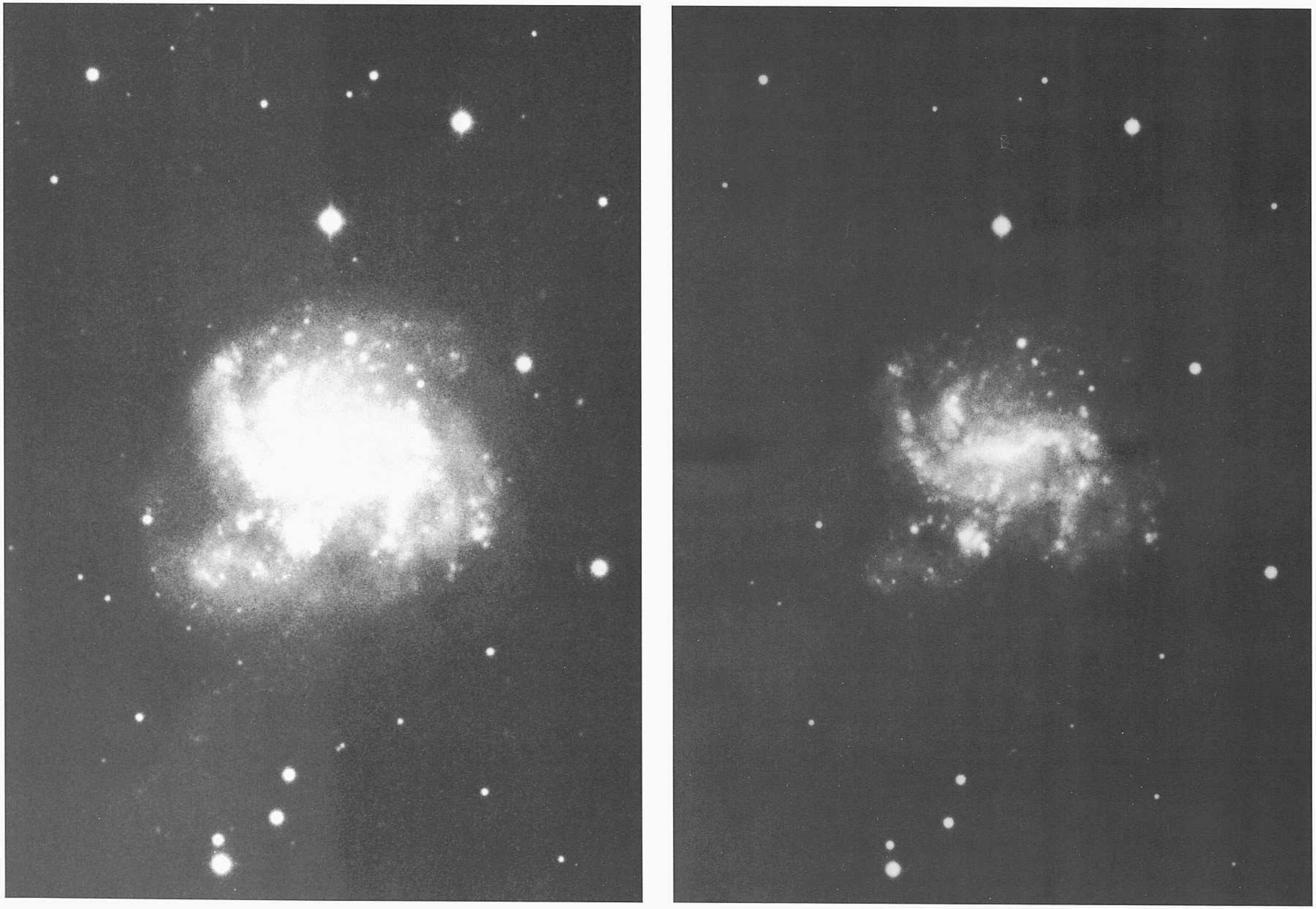
Incipient resolution into stars and HII regions exists across the high-surface-brightness face of NGC 7307, but the nearly edge on inclination to the line of sight makes this information only qualitative.

The redshift is $v_n = 1865$ km s"[1].



PANEL
311

PANEL 312



NGC2139 SBc(s)H.3
CD-766-S
Feb 21/22, 1979
103aO + GG385
15 inini

NGC 2 139 is ;i clear ruse of a merger in progress. The small satellite on one side of the larger galaxy near ils minor axis is seen besl in llir light print on the right. The nuclear region of Ihis smaller galaxy is intact, and it has many 111 [-region candidates along with evidence of robust star formation. However its outer regions appeal* to he tidally disrupted.

The main galaxy is also generally inlact. having a strong, chaotic bar and massive spiral arms in which robust star formation is occurring. I[owever, there is a low-surface-bTightness straight (tidal?) plume extending about one galaxy diameter beyond the main body of the large galaxy, starting near the apparent point of overlap of the two respective central regions.

The stellar content is about equally well resolved in both galaxies.

The redshift, presumably of the central region of the larger galaxy, is v_o = 1 688 km s^{-1}.

The nine galaxies on this panel complete the SBc section of the classification. Most are moderately inclined to the sight line and/or are peculiar in some moderate fashion.

NGC 1796 SBc(s)III
CD-221-S
Feb 12/13, 1978
103aO + GG385
45 min

The disk of NGC 1796 is covered with star-producing regions, causing the high surface brightness over the entire image. A central bar is present; HII-region candidates exist in it as well as in the tightly wrapped arms.

The redshift is $v_o = 771$ km s^{-1}.

NGC 4668 SBc(s)III pair
CD-1411-S/Br
March 23/24, 1980
103aO
75 min

NGC 4668 forms a close pair with NGC 4666 (Sbc: v_0 = 1474 km s^{-1}; panel 194) at a separation of 7.8': it also has a wider association with NGC 4632 (Sc: v_0 = 1557 km s^{-1}: panel 288) at a separation of 52'. The redshift of NGC 4668 is v_0 = 1530 km s^{-1}. At the mean redshift distance of 30 Mpc (/"/ = 50) the projected linear separations of NGC 4666 and NGC 4632 from NGC 4668 are 68 kpc and 454 kpc, respectively.

Many HII regions exist over the face of NGC 4668, which is small and chaotic but has a high-surface-brightness disk. The resolution into HII regions is at the same level as in the close companion NGC 4666 and in NGC 4632. There is little question that all three galaxies are at the same distance.

NGC 3912 SB late pec
PH-7607-S
April 3/4, 1979
IIIaJ + GG385
30 min

The bar and parts of one of the arms of NGC 3912 are filled with HII regions. The redshift is v_o = 1733 km s^{-1}.

NGC 1536 SBc(s) pec
CD-2040-Bedke/Gregory
Nov 1/2, 1981
103aO + GG385
45 min

The bar and the region of each arm just beyond the ends of the bar contain many HII-region candidates. The disk is covered with very broad, massive, ill-defined arms nearly devoid of HII regions. The arms are not symmetrical about the bar: one side sweeps out more widely than the other, but there is no evidence for tidal interaction by a companion. NGC 1536 is isolated; its redshift is v_o = 1168 km s^{-1}.

NGC 5074 SBc(s)II
PH-8092-S
Feb 6/7, 1981
103aO
12 min

NGC 5074 has a small angular diameter (D_{25} = 1.0') and moderately high surface brightness in its inner region. This region contains a bar and two bright arms that start from the ends of the bar. One arm remains bright for about one-quarter revolution; the other remains bright only for a short stub of a beginning. A fainter, low-surface-brightness outer arm surrounds the inner region.

The redshift of NGC 5074 is v_0 = 5675 km s^{-1}; the absolute magnitude is bright, at M_B = -21.3.

NGC 4064 SBc(s):
H-2213-H
May 17/18, 1942
103aO
60 min

NGC 4064 is difficult to classify because it is seen nearly edge on, but the existence of a bar is certain. HII regions define the bar in the same way as in NGC 1536 at the top of this column, in NGC 4731 (panel 310), and especially in NGC 4178 (panel 311).

Dust patches exist on either side of the major axis. The galaxy may resemble NGC 4389, at the upper right, if it were viewed from an angle about 10° less nearly edge on.

The redshift of NGC 4064 is v_o = 937 km s^{-1}.

NGC 4389 SBc(s)III pec
PH-8059-S
Feb 4/5, 1981
103aO
12 min

NGC 4389 has a bright bar filled with discrete HII regions. Its spiral pattern is difficult to trace because of the large inclination angle. Its morphology may be similar to that of NGC 4178 (panel 311), NGC 3059 (panels 308, S9), NGC 4116 (panel 306), NGC 3319 (panel 303), and NGC 4654 (panel 302), all of which are shown in this SBc section and all of which have less-steep inclination angles.

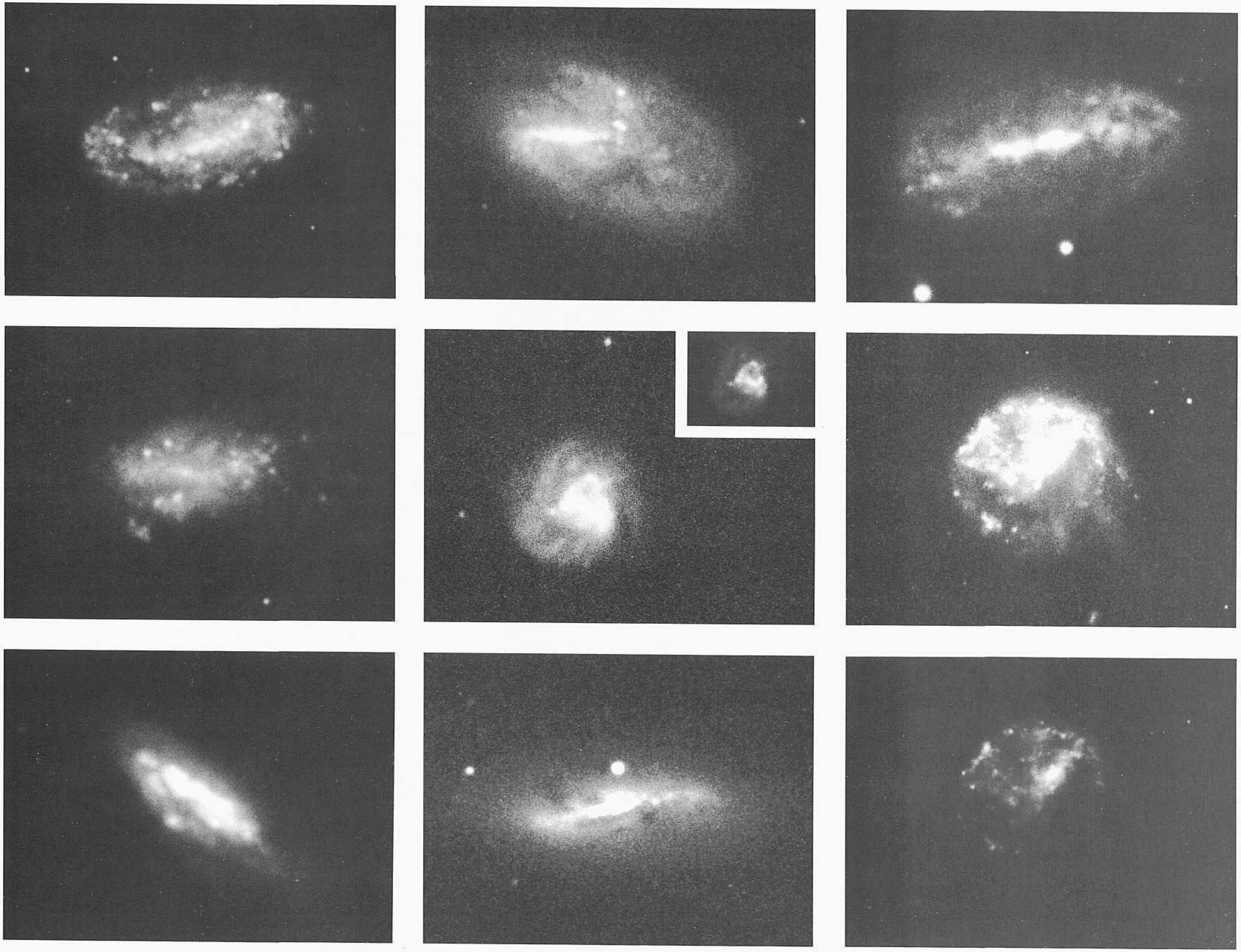
The redshift of NGC 4389 is v_o = 767 km s^{-1}.

NGC 922 SBc(s) pec
CD-1600-S/Br
Aug 12/13, 1980
103aO + GG385
45 min

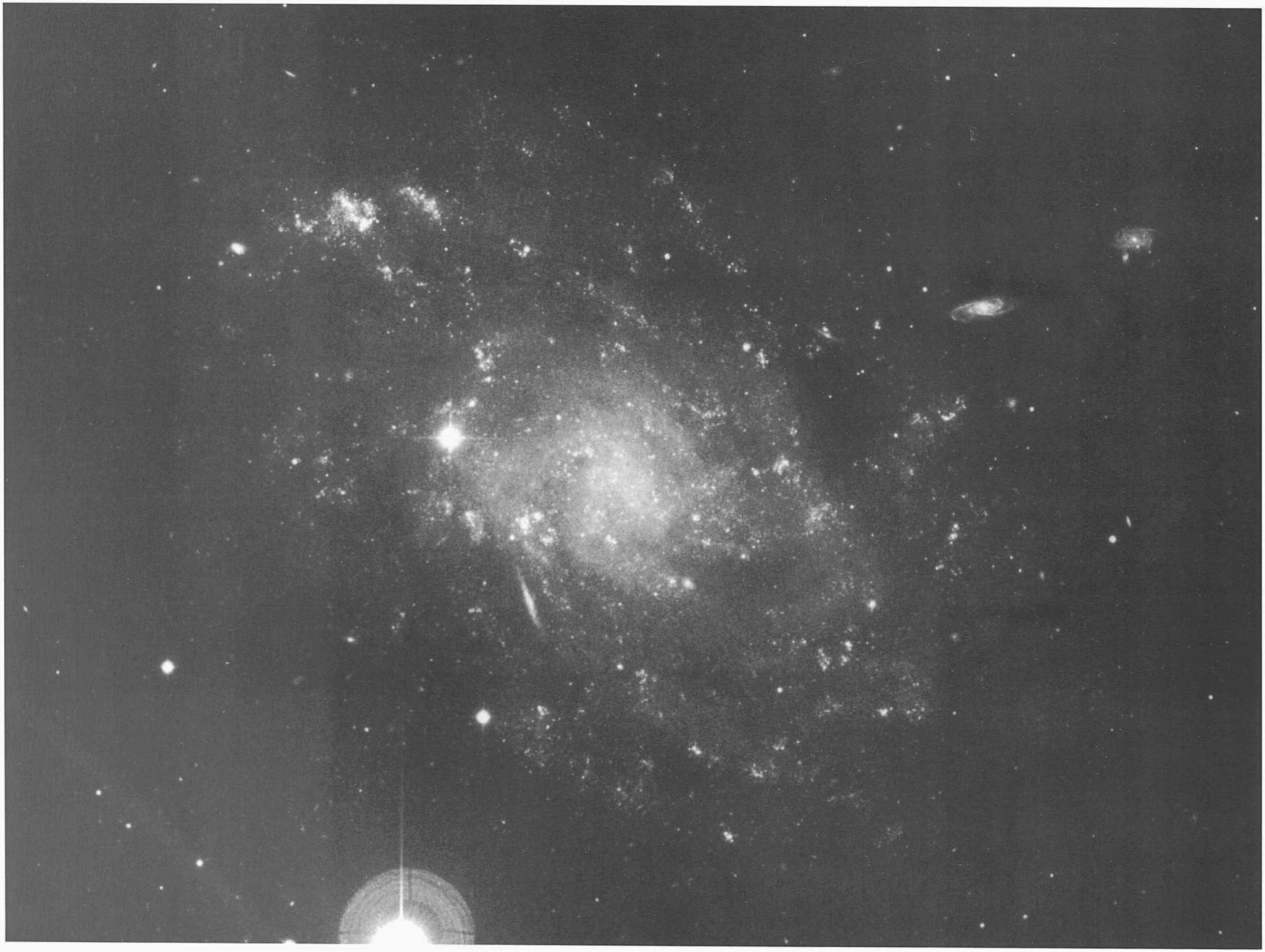
The morphology of NGC 922 is so peculiar as to be outside the classification system. It would be called a sport by nineteenth-century animal breeders. The reason for its inclusion in this section is because it appears to have a central bar from which spiral fragments are attached, primarily on one side. These fragments spiral outward at very large pitch angles, abruptly stopping at an edge. HII regions exist throughout this half of the image. The other half is devoid of high-surface-brightness features, although smooth, low-luminosity plumes exist there.

Two prints of NGC 922 are shown here. In the heavy print above, the smooth, low-surface-brightness features are easily seen. The light print below, made from the same original plate, shows well the HII-region candidates in the bar and in the high-surface-brightness parts of the image.

NGC 922 has no evident companion at the same distance that can be blamed for the peculiar morphology from a supposed close encounter. The redshift of NGC 922 is v_0 = 3061 km s^{-1}. The absolute magnitude of the galaxy is bright at M_B = -21.7.



PANEL
314



The Scd and SBcd Classification Sections

NGC 45	**Scd(s)III**	**HA, p.** ***37***
CD-540-S		**panel S6**
Ocl 1/2, 197«		
103aO + GG385		
45 inin		

NGC **45 is very highly** resolved **into individual** stars **starting at about** $V = 19.5$. **This** level is **only slightly fainter than the brightest** stars in MI **01 (Sandage** and **Tammann 19**74c. **Sandage L983b), but is** 2 mag **fainter** than the brightest stars in NGC 300. **NGC 55,** and NCC 247 in the South **Polar Group. The estimate that** NGC 45 is located about two times the distance **of** the mean of the South Polar **Group,** based on the magnitude of the brightest stars in each (V = 17.5 in the SPG; **K=19** for NGC 45), is consistent with the **redshifts.** NGC 45 has i_0 = 533 km s"[1]; the mean of the SPG is $\langle v_o \rangle$ = 201 km s~[l] **for** the five group members NGC 55. NGC 247. NGC 253. NGC 300. and NGC 7793.

The morphology of NGC 45 is similar to **that** of NGC 300 (Sc; panels 26 1. S6) and NGC 598 (M33, panel 2 62) although it is later in the classification sequence than the latter. The surface brightness of the inner disk of NGC 45 is lower than in **M33.** As in M33 and NGC 300. many associations exist in the multiple arms. The largest of these has an angular diameter of 30" which, at a distance of 6 Mpe (m - M = 29). corresponds to a linear diameter of 900 psc.

The **resolution** into stars is so complete, the crowding so small, the surface brightness of the disk so low, and the dust content so nearly negligible as to make NGC **45** an ideal galaxy **in which** to measure **photometrically** its brightest stars and to search for **Cepheids** for calibration studies of the extragalactir distance scale.

NCC 1494 Scd(s)II
CD-711-S
Jan 31/Feb 1, 1979
103aO + GG385
4-5 niin

The surface brightness of the disk and arms in NGC 1494 is higher than in NGC 45 shown on the preceding panel. The redshift is larger, at v_0 = 95 7 km s̄^{1} , consistent with the lack of resolution into individual stars at a level brighter than about V = 22. Brightest stars begin to resolve at about this level, but confusion with the numerous IIII regions that, are both brighter and fainter than this level is serious; the two types of objects must be discriminated from one another by standard methods before their photometry can be interpreted.

No nucleus or central bulge is seen on the available plate material. The arms are moderately well formed and are easily traced: hence the relatively high luminosity classification is required.

NGC 5474 Scd(s)IV pec M101 Gr
PH-82-B
June 9/10, 1950
103aO
30 min

NGC 5474 is one of the five late-type dwarf companions to Ml 01. The others are NGC 5204 (SdIV: panel 324), NGC 5477 (not in the RSA; panel 326 here). NGC 5585 (SdIV; panel 323), and Ho IV (not in the RSA or this atlas), all shown together for comparison, as enlarged nearly to a common scale (Sandage and Tammann 1974c. Fig. 1).

NGC 5474 is well resolved into individual stars beginning at V = 20.5. This is about 2 mag fainter than in Ml 01, which is at the same distance. This magnitude difference for the brightest stars illustrates the dependence of M (brightest star) on the absolute luminosity of the parent galaxy.

Many Mil regions exist across the disk. The largest several are complex and have total (halo) diameters of about 1 0".

The asymmetrical pattern of the multiple-armed system may be due to tidal interaction with M10] . at an angular separation of 44'. At the distance of 7.2 Mpc (m - M = 29.3) the projected linear separation is small at 92 kpc.

NGC 4790 Scd(s)II group
CD-1848-HB
April 3/4, 1981
103aO
75 niin

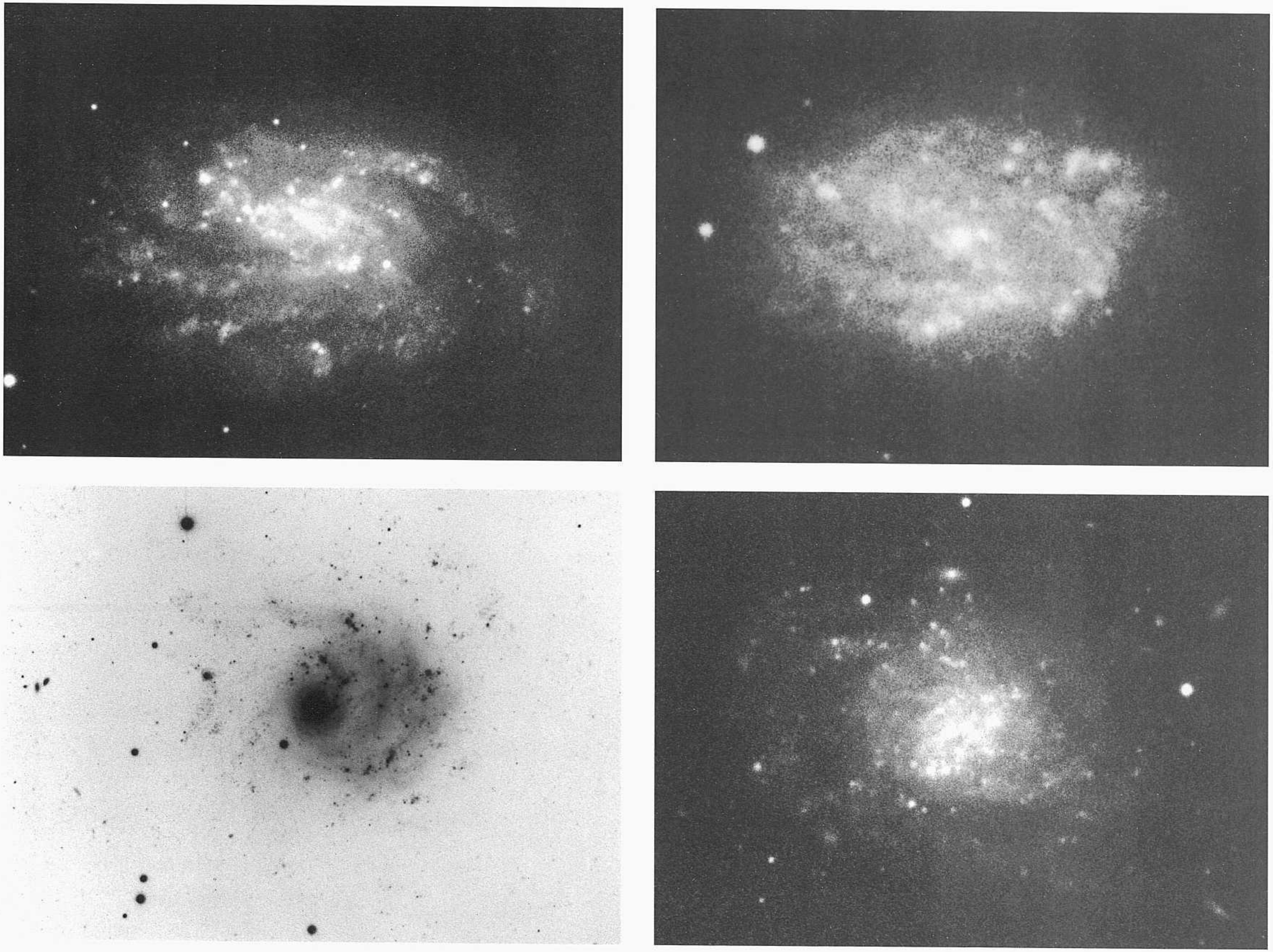
NGC 4790, with v_o = 11 54 km s"^{1}, is in a complex field that also contains NGC 4742 (E4; panel 10; v_o = 1114 km s^{-1}) at a separation of 47', NGC 4781 (Sc; panel 273; u_o = 689 kins"^{1}) at a separation of 18'. and NGC 4760 (SO or cD: panel 30: v_o = 4451 km s~^{J}), which obviously is in the background. Although the redshift difference between NGC 4790 and NGC 4781 is large at 465 km s^{-1} , suggesting different distances, the stellar contents of each resolve into individual stars at about the same level beginning near V = 2 1 .5 : further, the IIII regions in each are of about the same brightness, and the largest Mil regions in each resolve at about 3" diameter. In addition, there is a dwarf SmIII-IV galaxy between NGC 4790 and NGC 4781, separated from NGC4790 by only 13.3'. It has HII regions at the same brightness level as the other two galaxies of the pair.

If NGC 4742 (E4), NGC 4781 (Sc), NGC 4790 (Scd), and the SmIII-IV dwarf arc in a group at a mean redshift of <i'$_o$> = 98 6 km s~^{1}, giving a redshift distance of 20 Mpc *(H* = 50), the respective projection linear separations from NGC 4790 are 273 kpc for NGC 4742, 105 kpc for NGC 4781, and 77 kpc for the SmIII-IV dwarf, all smaller by a factor of four than the diameter of the Local Group.

NGC 941 ScdHI group
CD-494-S
Sep 26/27, 1978
103aO + GG385
45 niin

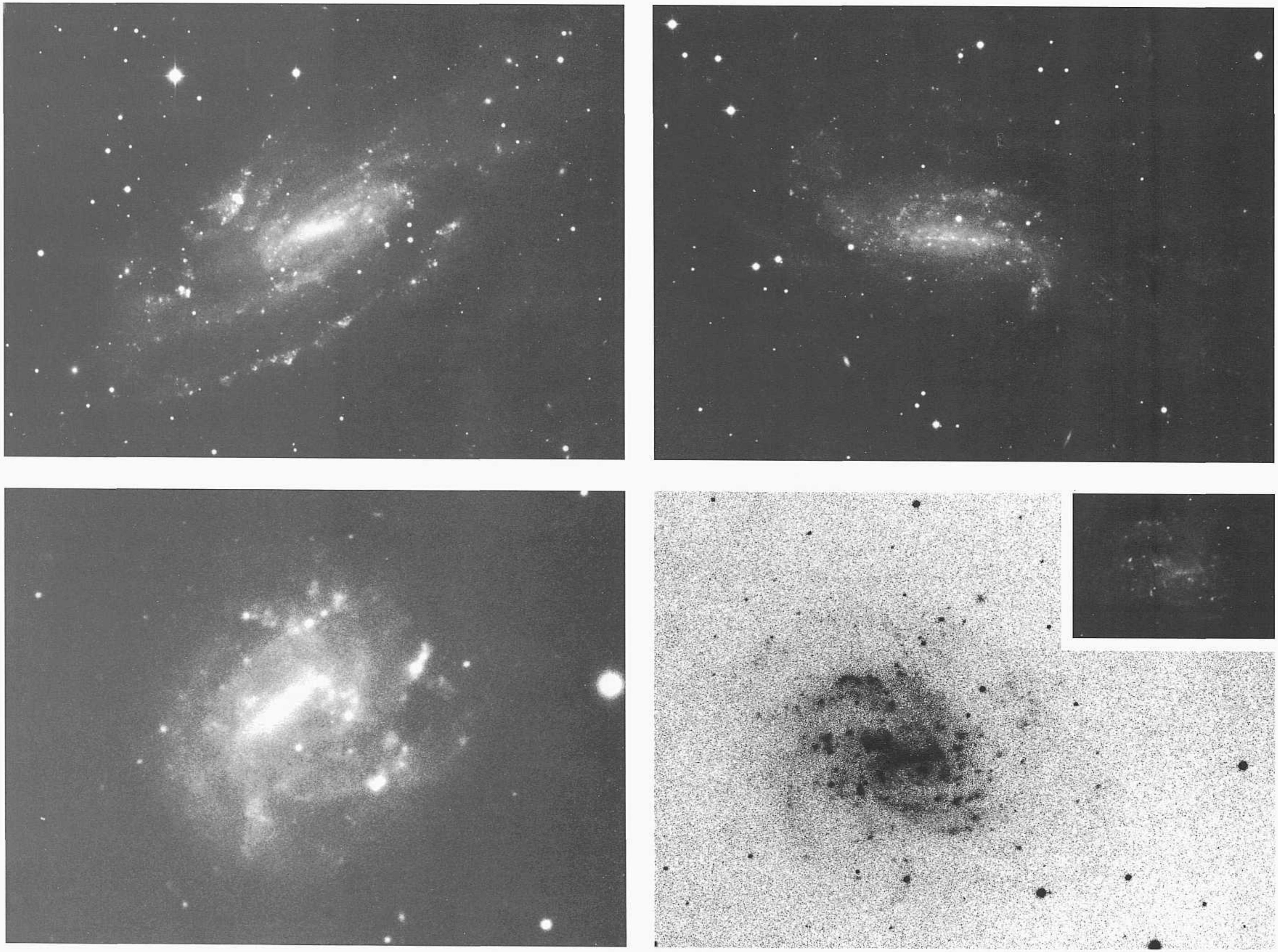
NGC 941 is in an apparent group with NGC 936 ($SB0_{2/3}$/SBa; panels 90, 106, S9) at a separation of 12.6'. and with an anonymous SBcd at a separation of 12.3' whose stellar content resolves at the same level as in NGC 941, and as a wide pair with NGC 955 (Sb; panel 150) at a separation of 3 1'. The redshifts are U_O(936) = 1512 km s̄ \ i>$_o$(941) = 1717 km s~', and u_o(955) = 1641 km s~^{J} . At the mean redshift distance of 32 Mpc (// = 5 0), the respective projected linear separations from NGC 941 are 1 17 kpc for NGC 936. 288 kpc for NGC 955, and 1 I 4 kpc for the anonymous SBcd companion. These separations are all smaller than the radius of the Local Group.

Individual stars may begin to resolve in both NGC 941 and the SBcd companion at about V = 22: discrimination and individual identification of the stars and the numerous Mil regions will be necessary by the standard methods.



PANEL
315

PANEL
316



IC5201 SBcd(s)II panel S10
CD-1533-S/Br
Aug 6/7, 1980
103aO + GG385
45 inin

The multiple thin arms are clearly resolved into individual stars beginning at about B = 21.5 . and the arms are also filled with a multitude of Mil regions, the largest of which have diameters of about 5". The redshift from Huchtmeier and Richter (1989) is v_0 = 875 km s~\

NGC 7107 SBe(s)/SBmIH-IV
CD-529-S
Sep30/Oct 1, 1978
103aO + GG385
45min

There is clear evidence of a bar containing HII-region candidates, indicating recent star formation. The spiral structure is not well defined, resembling more the pattern in the LMC than in a regular spiral; hence the mixed classification is required.

The redshift is v_{n} = 2446 km s"[1].

NGC 1744 SBcd(s)II-III
CD-1334-S/Br
March 14/15, L980
103nO + GG385
60min

Brightest stars begin to resolve in abundance in NGC 1 744 about I mag above the plate limit, which is near *H* = 23. The very brightest star may have *ii* = 20.5, but the numerous IIII regions must be separated from the stellar candidates before the brightest-star data are secure. Star-formation and IIII regions exisl over the centra] oval and inner disk.

The redshift is v_{ti} = 639 km s^{-1}. The resolution into stars is not as pronounced as in NGC 45 (two panels back), which has a smaller redshift by a factor of I .2. If the redshift-distance relation were noiseless, the magnitude difference between the brightest stars in NGC 1744 and NGC 45 would be 0.4 mag. However, the observed difference in the resolution level of the brightest stars is about 1 mag, suggesting noise in the velocity field of about ±100 km s^{-1}. Such a random velocity about the Hubble flow is. of course, small. This method has important promise and can be used out to distances of about three-fourths the distance to the Virgo Cluster.

New 3 = A 1246-09 SBed(s)II.2
CD-1883-HB
April 11/12, 1981
103aO
60nün

The surface brightness of New 3 is very low. which is the reason it was not included in the NCC listing. A small bar exists from whose ends the multiple-arm pattern begins.

Many IIII regions cover the face of the disk. A few exist in the bar.

The redshift of New 3 is i-$_{o}$= 1 1 05 km s~'.

NGC 4485/4490 S(tidal) Karachentsev 341
H-1458-B ScdIII pec
May 24/25, 1944
103aO
75 niin

Both components of this obviously interacting pair show massive, robust star formation over each of their faces. Individual stars begin to resolve at about V = 18 in each galaxy, but the surface brightness is so high over most of their disks as to make the photometry of individual stars difficult. Also there is much dust over the face of NGC 4490, the brighter of the pair.

The redshifts listed in the RSA2 are ::o(4485) = 817 km s~' and u_o(4490) = 601 km s^{-1}. The plate used for the heavy exposure at the top left was taken by Baade with the Mount Wilson 100-inch Hooker reflector.

NGC 4485/4490 S(tidal) Karachentsev 341
S-657-B ScdIII pec
March 3 I/April 1, 1938
E40
60 min

The light print of the NGC 4485/4490 pair at the bottom left was made from an original plate taken by Baade with the Mount Wilson 60-inch reflector.

The morphologies of the galaxies are abnormal, presumably due to the close encounter.

NGC 3691 Scd(s)HI
CD-2135-S
March 22/23, 1982
103aO + GG385
45 niin

NGC 3 691 is small (D_{2S} = 1.3') and is not well resolved into stars or Hll-region candidates. Its surface brightness is low.

Deeming that a weak spiral pattern is traceable, we have classified the galaxy as an Scd, but an Inilll classification would also be possible.

The redshift is v_0 = 947 km s^{-1}.

NGC 3274 ScdIII
PH-7934-S
Nov 7/8, 1980
103aO
12 min

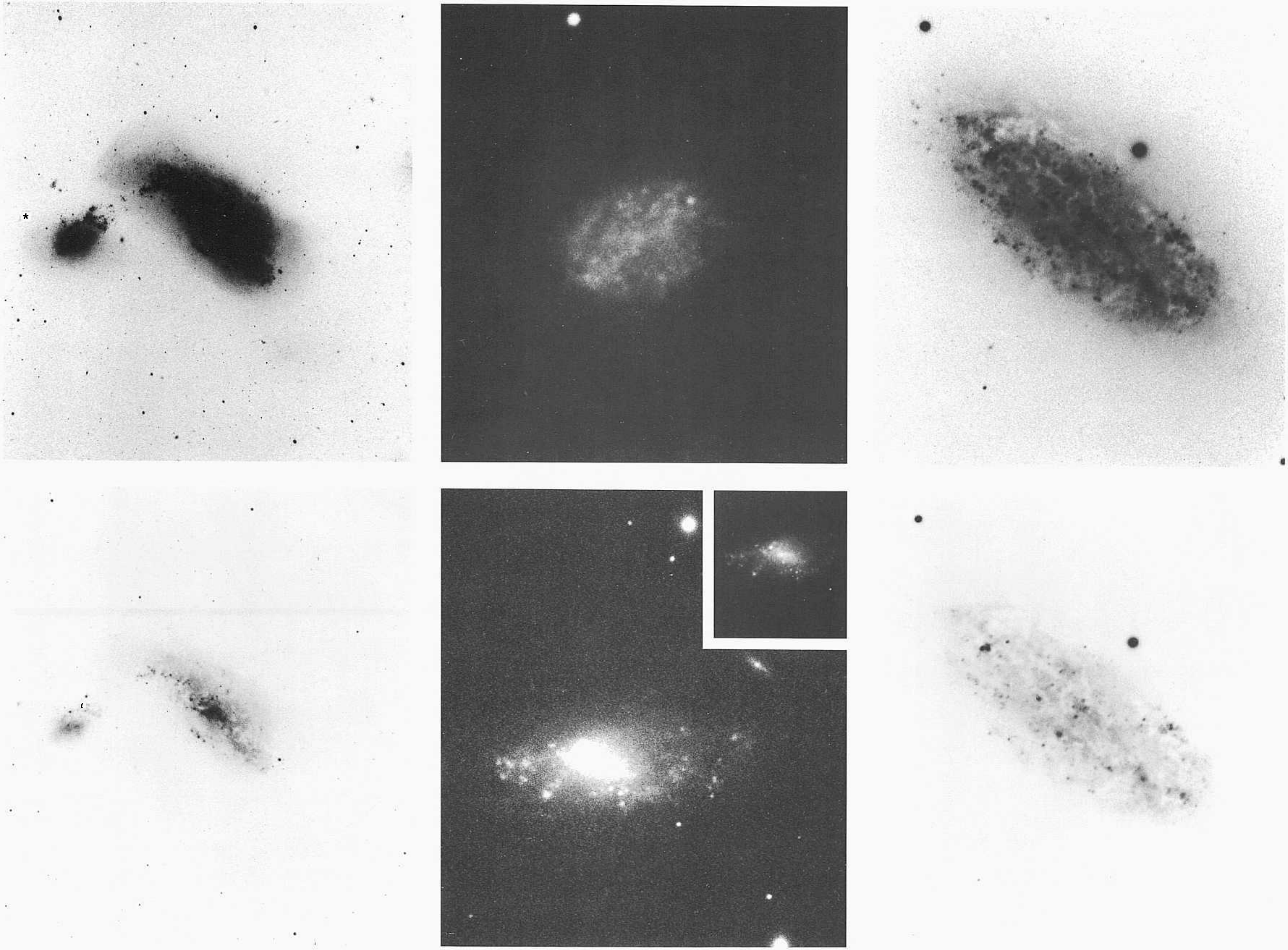
NGC 32 74 is resolved into individual stars beginning at about B = 19. However, discrimination of the stars from the Hll-region candidates is necessary before secure photometry of the stars can be done.

The redshift is v_n = 486 km s^{-1}.

NGC 2976 SdHI-IV M81 Gr
PH-470-S
March 17/18, 1953
103aO + GG385
10 min

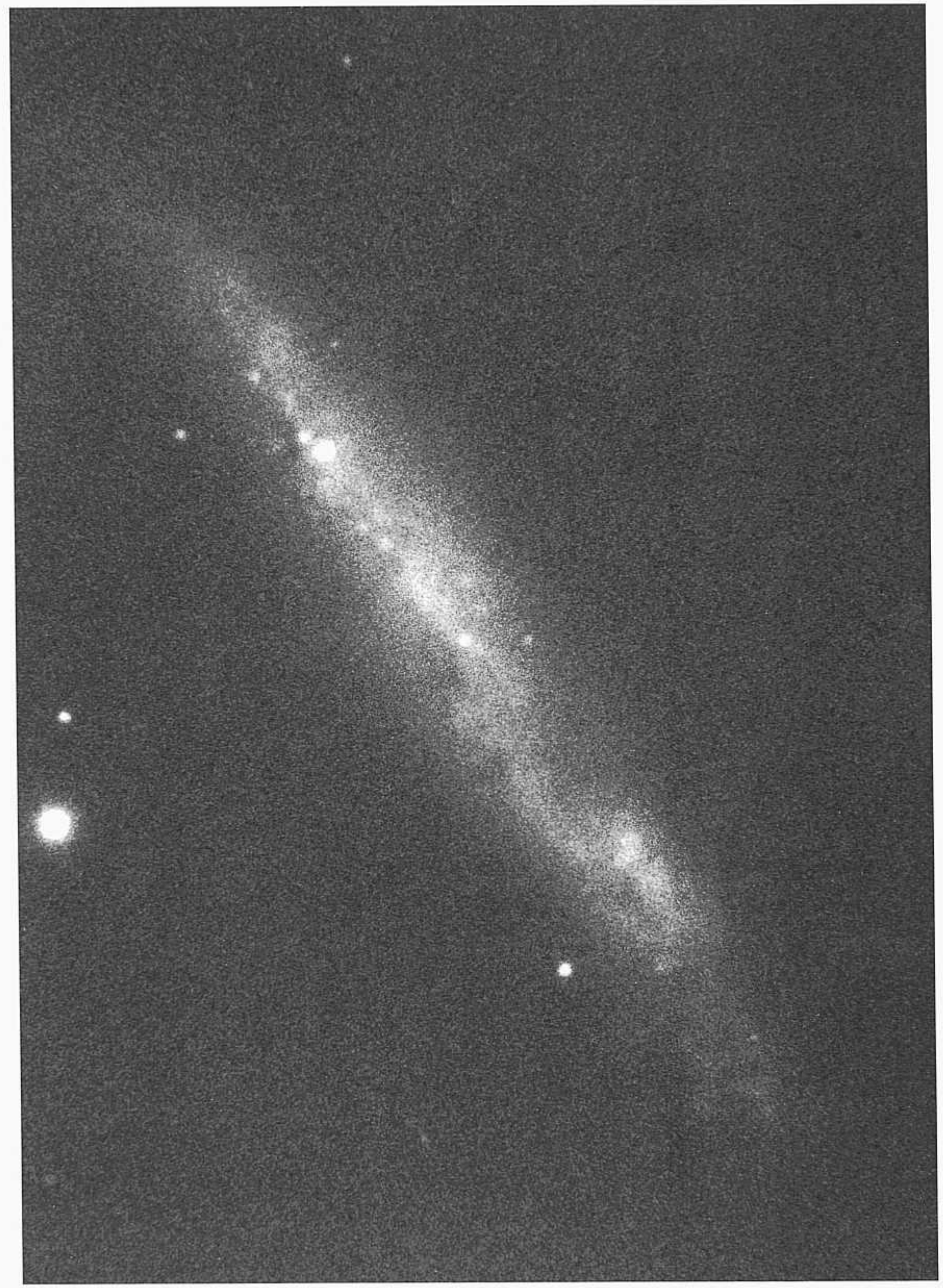
NGC 2976, long considered a member of the M81/NGC 2403 Group (Holmberg 1950), has a large angular diameter (D95 = 4.9') and a small redshift, v_0 = 168 km s~^{1}, consistent with membership in the Group, whose mean redshift is <u_o> = 240 km s~', as listed in the RSA2.

Both prints on the facing panel have been made from the same short-exposure blue plate taken at Palomar with the 200-inch reflector. The surface brightness is high, making photometry of the individual stars difficult, although they begin to resolve as individuals at about B = 18.5. A spiral pattern is difficult to trace but it does exist; hence the Sd classification is required.



PANEL
317

PANEL
318



The 14 galaxies on this and the nexl two panels are nearly edge on. All are classified as Sc. Sed. or Sd. based cm the absence of evidence for a nucleus and central bulge and. for the Sod and Sd types, by the lack of a discernible spiral pattern, often indicated in earlier on-edge Sc types by the particular luminosity distribution at the ends of the disk.

NGC 55 Sc South Polar Gr
CD-556-S
Oct4/5, 1978
103aO + GG385
45 niin

NGC 55 is very highly resolved into individual stars, about equally well as other galaxies of the South Polar Group such as NGC 247 and NGC 300. The resolution is also similar to that in the nearby galaxy NGC 3 109. where Cepheid variables give a modulus of m - M = 26.4 (Sandage and Carlson 1988). This is nearly the same value measured by Graham (1984) for NGC 300. also using Cephcids.

The brightest stars in NGC 55 begin to resolve at about B = 17.5. The redshift is v_o = 115 km s~[1]. Evidently, NGC 55 is just beyond the Local Group and has the small cosmological expansion redshift characteristic of galaxies with distance moduli near m - M = 26 (Sandage 1986a).

NGC 1507 **Sd(on edge)**
PH-7845-S
Sep 3/4, 1980
103aO
12 niin

NGC I 507 is seen on edge and. therefore, is of uncertain morphological type. The Sd classification is made because of the absent....f both a nucleus and a central bulge, and because of the lack of the characteristic hooks at the ends of the edge-on image; such hooks are often seen in edge-on Se galaxies that have strong spiral patterns.

The redshift is v_0 = 898 km s"[1]. A few Hll-region candidates are present.

NGC 4144 ScdIII CVn II Gr
PH-7147-S Raeiiie wedge
Feb 1/2, 1976
103aO + GG13
30 niin

NGC 4144 is very nearby, judged by the easy resolution inlo individual stars beginning at about $B = 20$. The galaxy is in the complex Ursa Major region wherein at least three separate Kroups can be identified. The mean redshift is about $<v_o> = 285$ km s^{-1} for the CVn I Group, as named by de Vaucouleurs (1975), where he lists five members. The group is called 134 by Kraan-Korteweg and Tammann (1979), where they list 21 members, including NGC 4144.

The second group in the Ursa Major region, called the CVn II Cloud by de Vaucouleurs (1975), has $<v_o>$ of about 750 km s^{-1}. It contains such galaxies as NGC 3675 (Sb; panels 139, S4, SI 3. SI 4) and NGC 4051 (She; panel 180) as listed by de Vaucouleurs (1975). It also contains others such as NGC 4242 (SBd: panel 322), IC 749/750 (SBc; Sb?; panels 195. 306), NGC 3782 (SBcd; panel 328). and NGC 3949 (Sc: panel 265). The third aggregate in the region is the loose Ursa Major Cluster, with $<v_o>$ of about 980 km s~'.

The redshift of NGC 4144 is small at 316 km s~^{1}. The galaxy is clearly in the nearby B4 (or CVn I) Group.

The spiral pattern can be discerned by the characteristic hooks that bend in opposite directions at the ends of the nearly edge on image.

Note that the plate was taken with a Racine wedge; the bright stars have secondary images 5 mag fainter at 18" separation.

NGC 2188 ScdIII
CD-141-S
Feb 1/2, 1978
103aO + GG385
50 niin

Individual stars are beginning to resolve at about $B = 21$ in this nearly edge on galaxy, but tile high-surface-brightness of the image will make photometry difficult.

The redshift is $v_n = 555$ km s^{-1}.

NGC 4592 ScdIII
H-2271-H
May 5/6, 1946
103aO
40 niin

NGC 4592 resolves easily into fill-region candidates and brightest stars that begin to appear individually at about $B = 20$. This is brighter by about 2 mag than the resolution level of the spirals associated with the Virgo Cluster (NGC 4321, NGC 4535, NGC 4303. NGC 4254, etc.). The mean redshift of the Virgo Cluster of <>,,> = 976 km s~^{1} is similar to the redshift of $v_o = 903$ km s~' of NGC 4592 here, yet the level of resolution of the stellar content is different, suggesting velocity perturbations in the expansion field in the direction of NGC 4592.

The region is complex (NGC 4592 is in the southern extension of the Virgo Cluster), and the redshifts there are not good distance indicators. From the resolution level in NGC 4592 one surmises that the distance modulus to this galaxy is about $m - M = 30$ on the scale of $m - M = 31.7$ adopted for the Virgo Cluster.

NGC 4244 ScdIII CVn I Gr
PH-124-MH HA, p. 25
March 20/21, 1950
103aO
30 min

NGC 4244 is a member of the very nearby CVn I Group (de Vaucouleurs 1975), which is the B4 Group of Kraan-Korteweg and Tammann (1979) in the Ursa Major complex. The redshift of NGC 4244 is $v_a = 249$ km s~'.

The galaxy is highly resolved into individual stars beginning at about $B = 18$. However, study of its stellar content will be difficult because the galaxy is almost exactly edge on.

NGC 4244 ScdIII CVn I Gr
H-2507-H HA, p. *25*
March 5/6, 1948
103aO
30 min

The image of NGC 4244 in the light print at the bottom of the column was made from a different original plate than was used for the heavy print above it.

The dust lane nearly bisects the very thin plane, showing that the galaxy is closely edge on. There is neither a central bulge nor a luminous halo. H1I regions arc present, the largest of which resolve at the 5" level.

The angular diameter of the NGC 4244 disk is large, at D25 = 16'.

NGC 3044 Scd(on edge)
CD-1460-S/Br
May 10/11, 1980
103aO + GG385
45 nin

NGC 3044 is nearly edge on. It has neither a central bulge nor luminous halo. A few individual knots are either HII regions or individual brightest stars. The magnitude of the brightest of these is about B = 21.5. The largest HII region resolves into a disk at about the 2" level.

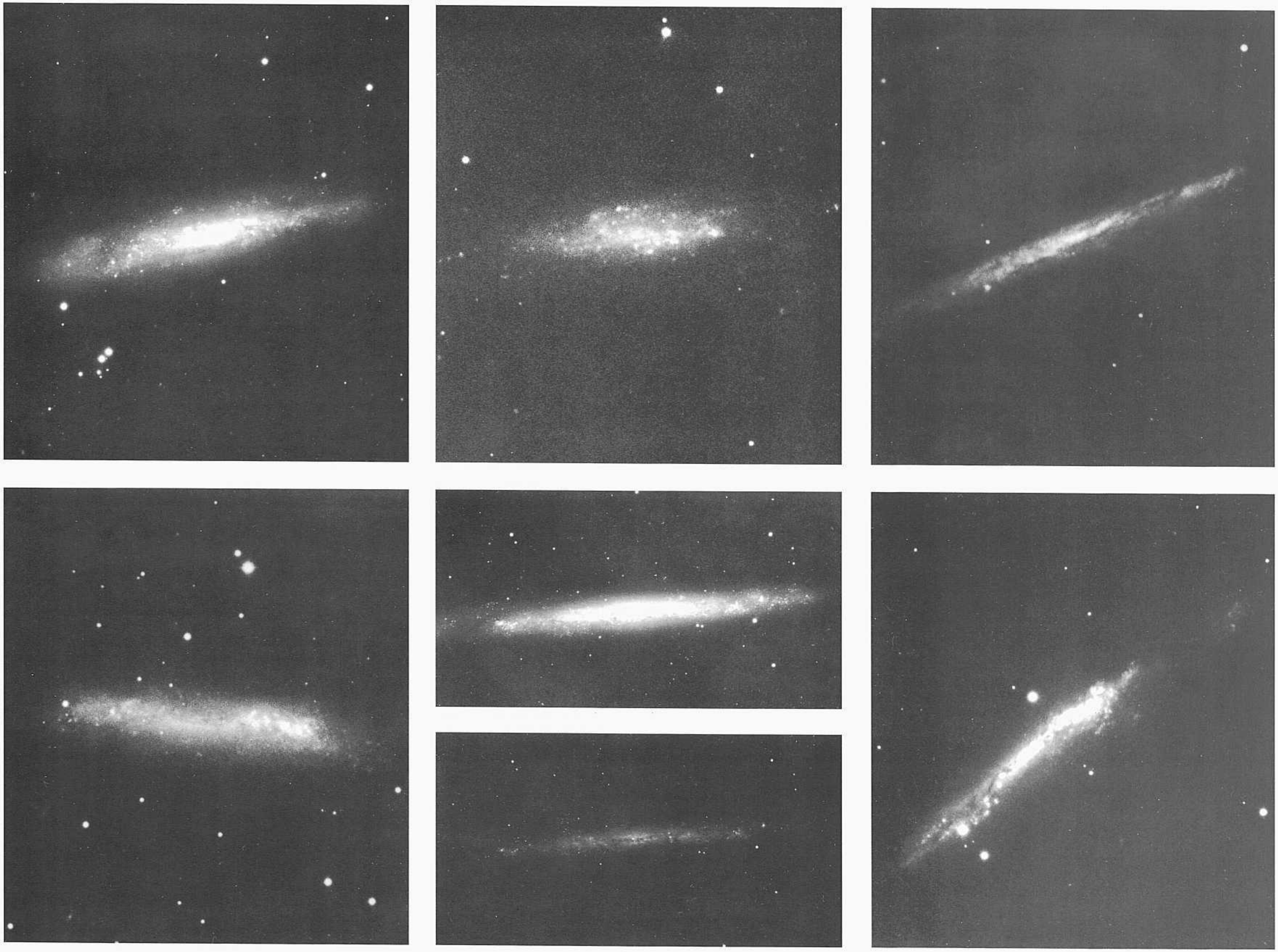
The redshift is $v_0 = 1206$ km s^{-1}.

NGC 3432 Scd(on edge) NGC 3368 Gr
PH-8077-S Racine wedge
Feb 5/6, 1981 panel 320
103aO
5 niin

Robust star formation is occurring in the high-surface-brightness disk of NGC 3432. High-surface-brightness HII knots dominate the image. Individual stars probably begin to resolve at about $B = 21$.

A large, very-low-surface-brightness dwarf with an unresolved nucleus exists at a separation of 3.1'. It resembles the huge dE.N type in the Virgo Cluster, illustrated elsewhere (Sandage and Binggeli 1984) and listed in the VCC, Table XIV.

NGC 3432 is listed by de Vaucouleurs (1975) as a member of the NGC 3368 Group, whose mean redshift is about $<v_o> = 750$ km s^{-1}. The redshift of NGC 3432 itself is $v_o = 607$ km s^{-1}. At a redshift distance of 15 Mpc, the projected linear separation of the companion from NGC 3432 is small at 14 kpc.



PANEL

319

PANEL
320

The six galaxies on this panel complete the illustrations of edge-on late-type Sod, Sd, and Sm galaxies in the RSA.

NGC 7064 Scd(on edge)
CD-509-S
Sep 28/29, 1978
103aO + GG385
45 inin

Hll-region candidates begin to appear across the image of NGC 7064 at about B = 1 9.5. Individual stars are definitely present at *B* - 21, but still-brighter stars are undoubtedly confused with HII regions and must be separately identified before conclusions as to the upper stellar luminosity are secure.

The redshift is v_0 = 722 km s^{-1}.

NGC 4183 Scd(on edge) Ursa Major Cluster
PH-8088-S Racine wedge
Feb 6/7, 1981
103aO
4 niin

The brightest individual Hll-region candidates in NGC 4183 begin to appear at about *B* = 20. The two largest probably resolve at about the 1.5" level. Individual stars at least as bright as *B* = 22 begin to resolve.

The redshift is v_n = 968 km s^{-1}.

NGC 3432 Scd(on edge) NGC 3368 Gr
PH-8077-S Racine wedge
Feb 5/6, 1981 panel 319
103aO
5 min

The image of NGC 3432 is repeated here from the previous panel, taken from the same original plate.

The redshift is v_0 = fi0 7 km a^{-1}.

NGC 4700 Se or Sin panel 291
CD-1444-S/Br
May 6/7, 1980
103aO + GG385
45 min

The surface brightness of NGC 4700 is so high as to mask most of the resolution into numerous HII regions seen on the original plate. The galaxy is also illustrated in the Sc section on panel 291.

The redshift is v_n = 1193 km s^{-1} .

1C5052 Sd(on edge)
CD-489-S
Sep 26/27, 1978
103a(> + GG385
45 mill

The small redshifl o_0 = 140 km s^{-1} listed in the RSA is evidently incorrect because one of the redshifts used in calculating that mean is grossly wrong. An accurate observed 2 I-cm redshift of v_{sun} = 595 km s^{-1} listed by Huchtmeier and Richter (1989) leads to v_0 = 428 km s~'. This larger redshift is consistent with the level of resolution into stars and HII regions, while the smaller velocity is not.

The largest of the several HII regions resolve at the 2" level. The brightest stars begin to resolve at about *B* = 2 1 .

NGC 5984 SBcdlll Racine wedge
PH-7487-S
May 11/12, 1978
103aO + GG13
20 min

The linear pattern of Hll-region candidates in the center of the image is the characteristic that suggests the barred morphological classification.

The redshift is v_0 =1122 km s^{-1}.

The Sd and SBd Classification Sections

C

vXalaxies of types Sd and SBd at the very late end of the spiral sequence, together with galaxies that are late-type dwarfs of types Sm and Im are shown on the next 12 panels. A spiral pattern can still be traced in the Sd and SBd types, but it is more disorganized than in the earlier morphological boxes of the sequence. A spiral pattern is even less obvious in the Sm types, whose prototype is the Large Magellanic Cloud. All traces of a spiral pattern have disappeared in the Im dwarf class.

NGC 7793 **Sd(s)IV** **South Polar Gr**
CD-510-S **panel S6**
Sep **28/29, 1978**
103aO + **GG385**
45 **nlin**

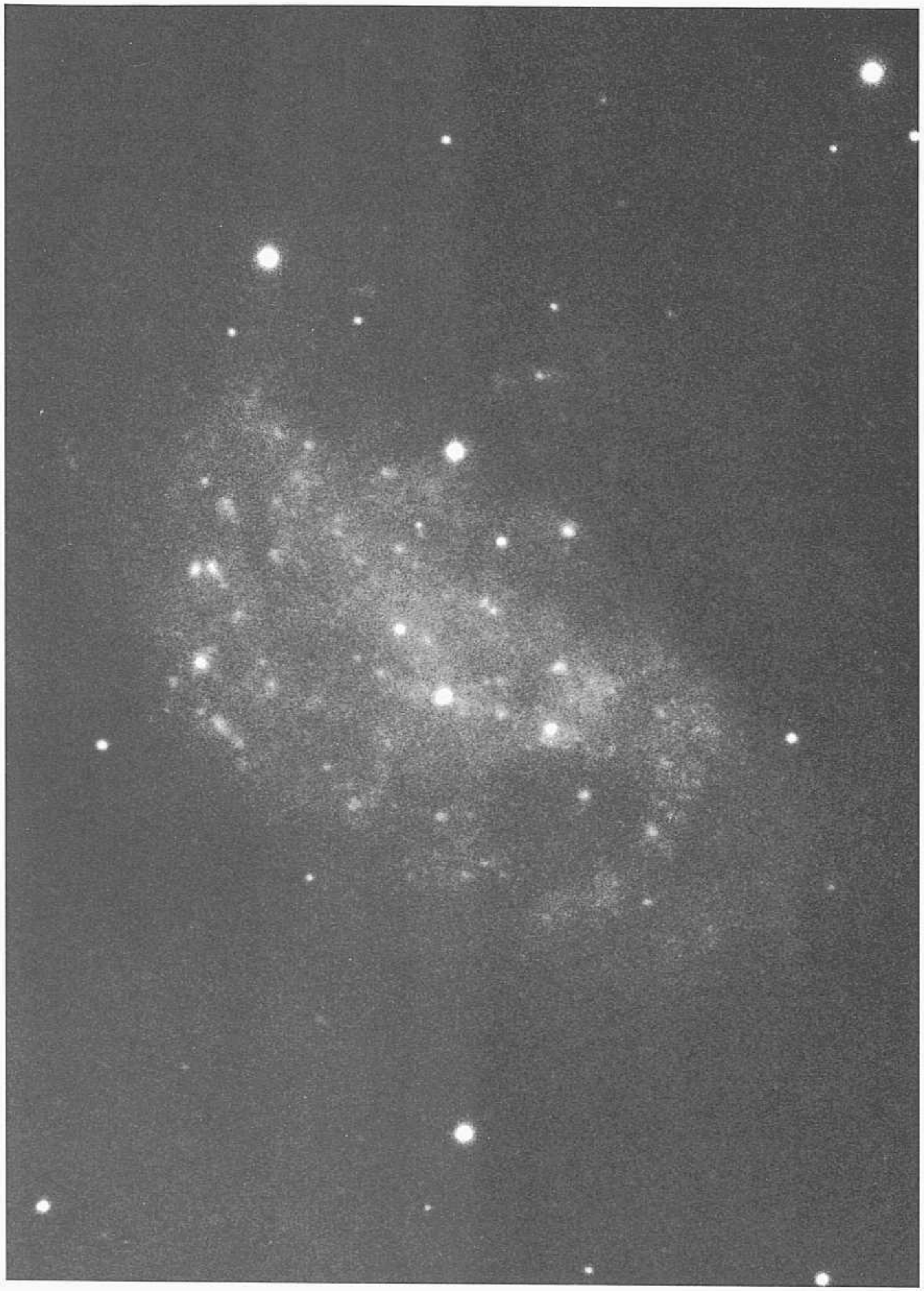
NGC 7793 is highly resolved into individual stars beginning at about B = 18. A spiral pattern can be discerned, but it is more disorganized than in M33 or NGC 300, which are earlier examples of the same type of massive-armed spiral features.

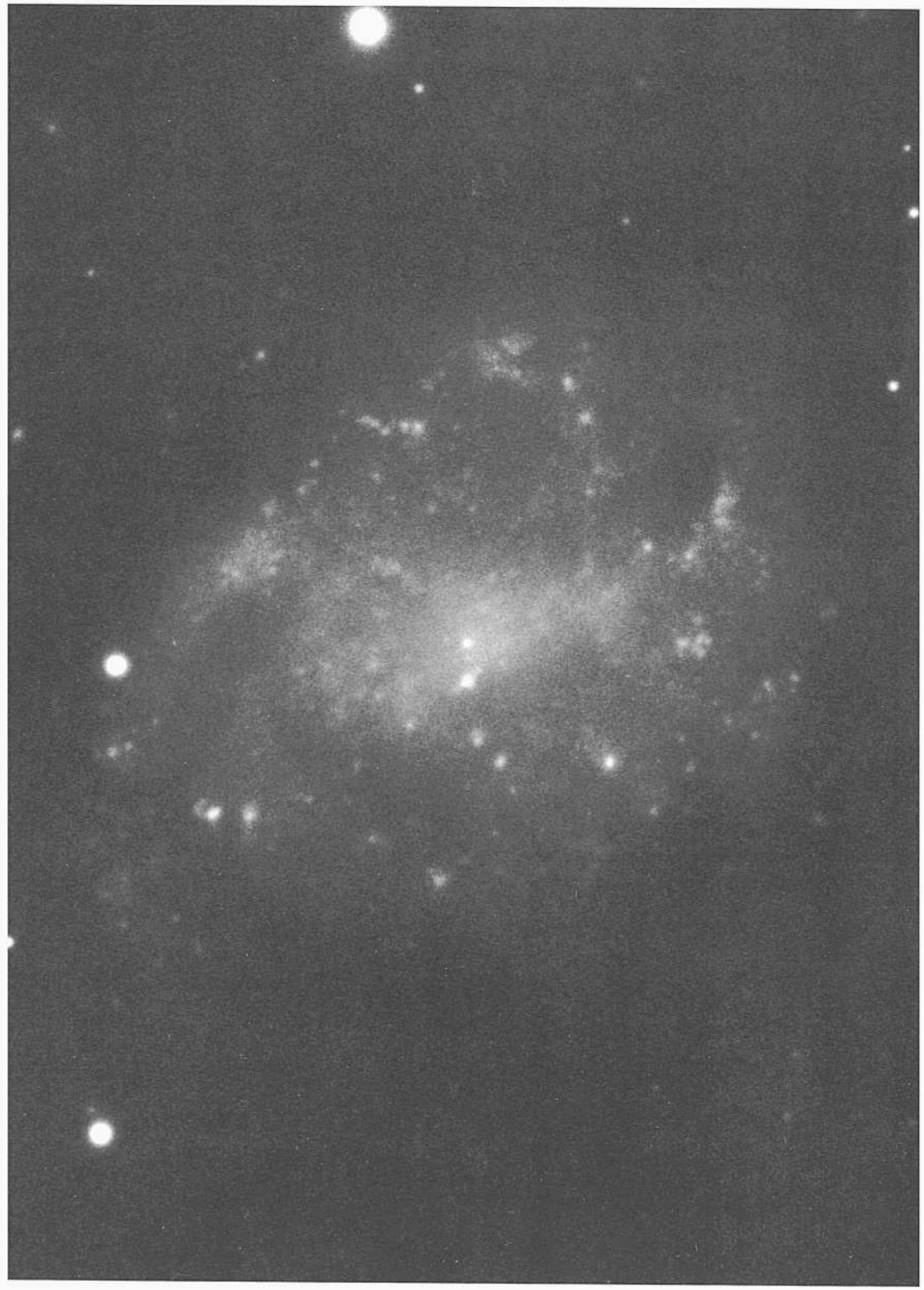
Associations of early-type stars are evident in the arms, similar to those in M33 and NGC 300.

The brightest stars may resolve starting about 0.5 mag fainter than the brightest stars in NGC 55, NGC 247, and NGC 300, also in the South Polar Group. From the characteristics of the Group set out in Table 2 in the introduction to the RSA2, NGC 7793 and NGC 253 are said to be more distant than NGC 55, NGC 247, and NGC 300. The **redshift** of NGC 7793 is v_0 = 241 km s~\ The v_o redshifts of NGC 55, NGC 247, NGC 253. and NGC 300 are 115 km s~\ 227 km s^{-1} ,2 93 km s^{-1}. and 128 km s"l .respectively. The **order** nf the luminosity level of resolution **into** stars in these galaxies is the same as the order of the redshifts, showing the extreme quietness of the local expansion velocity field and the extension of the South Polar Group in the line of sight. The velocity dispersion about an ideal linear velocity flow is at a level of only a few tens of km s^{-1} in this region immediately beyond the Local Group. The same conclusion, based on other data for galaxies extending more than halfway to the Virgo Cluster, has been discussed elsewhere (Sandage 1986a).

PANEL 321

PANEL
322





NGC 2552 **Sd(s)III** **group**
PH-7924-S Ratine wedge
Nov 7/8, **1980**
103aO
15 inin

NGC 2552 is a member of a **low-redshift** loose **group** whose members include NGC 2500 (Sc; panel 262), NGC 2537 (Sc; panel 275). and NGC 2541 (Sc; panel 264). The **respective** v_0 redshifts of **the** three companions are 615 km s^{-1},513 **km** s^{-1}, and 646 km s^{-1}. The **redshift** of NGC 2552 is i;„ = 607 km s"'. The diameter of the circle that encloses these four galaxies is about 5° on the sky.

At a mean redshift **distance of** 12 Mpc (// = 50) the linear diameter of this circle is 1 Mpc, which is closely the diameter of the Local Group.

The face of NGC 2552 is covered with HII-region candidates that begin at about B = 19. None are resolved at **the** 1.5" level. Individual stars are clearly present at a B magnitude of about 2 1 and probably brighter, but they have **not** been discriminated separately from the MI regions by the standard methods.

A weak spiral pattern is present.

NGC 4242 **SBiIIll** **CVn II Cloud**
PH-7665-S
April 29/30, 1979
103aO
I 2 mill

NGC 4242 is probably a **member** of **the intermediate redshift group with** $<r_{fl}>$ **= 7f>() km** s^{-1} **in** the **Ursa** Major **complex region,** discussed in **the description** of **NGC II II** (Scd: **panel** 3 19). The group is called **the CVn II Cloud** by **de Vaiicouleurs** (1975). Oilier **members** of **the group** include NGC 3675 (panels **139**, S.I. **S13, S14),** NGC 3769 **(panel** 3 **1** 1). **NGC** 3782 **(panel** 328). NGC 3949 (panel 265). IC 749/750 (panels 195. 306).

NGC 4242 is covered **with 1111 regions** starting at **about** li = 19. Individual **stars** arc clearly **present at** H = 2 **1** and **perhaps** brighter. **There is an unresolved (pointlike** at 0.8" resolution) nucleus. The redshift **of** NGC 4242 is v_0 = 564 km s"[1].

NGC 5585 Sd(s)IV M101 Gr
PH-76-B
June 8/9, 1950
103aO
30 niin

NGC 5 585 is one of the four well-resolved satellite companions to M101 at a distance modulus of $m - M = 29.3$ $(D = 7.2$ Mpc). The four dwarf satellites, originally discussed by Holmberg (1950), are NGC 5204 (SdIV; panel 324), NGC 5474 (ScdIV pec; panel 315), NGC 5477 (Sd:)(nol in the RSA; panel 326 here), and NGC 5 5 85 here. The redshift of NGC 5 5 85 is v_o = 441 km s^{-1}. A discussion of the Ml 01 Group has been made by Sandage and Tammann (1974c).

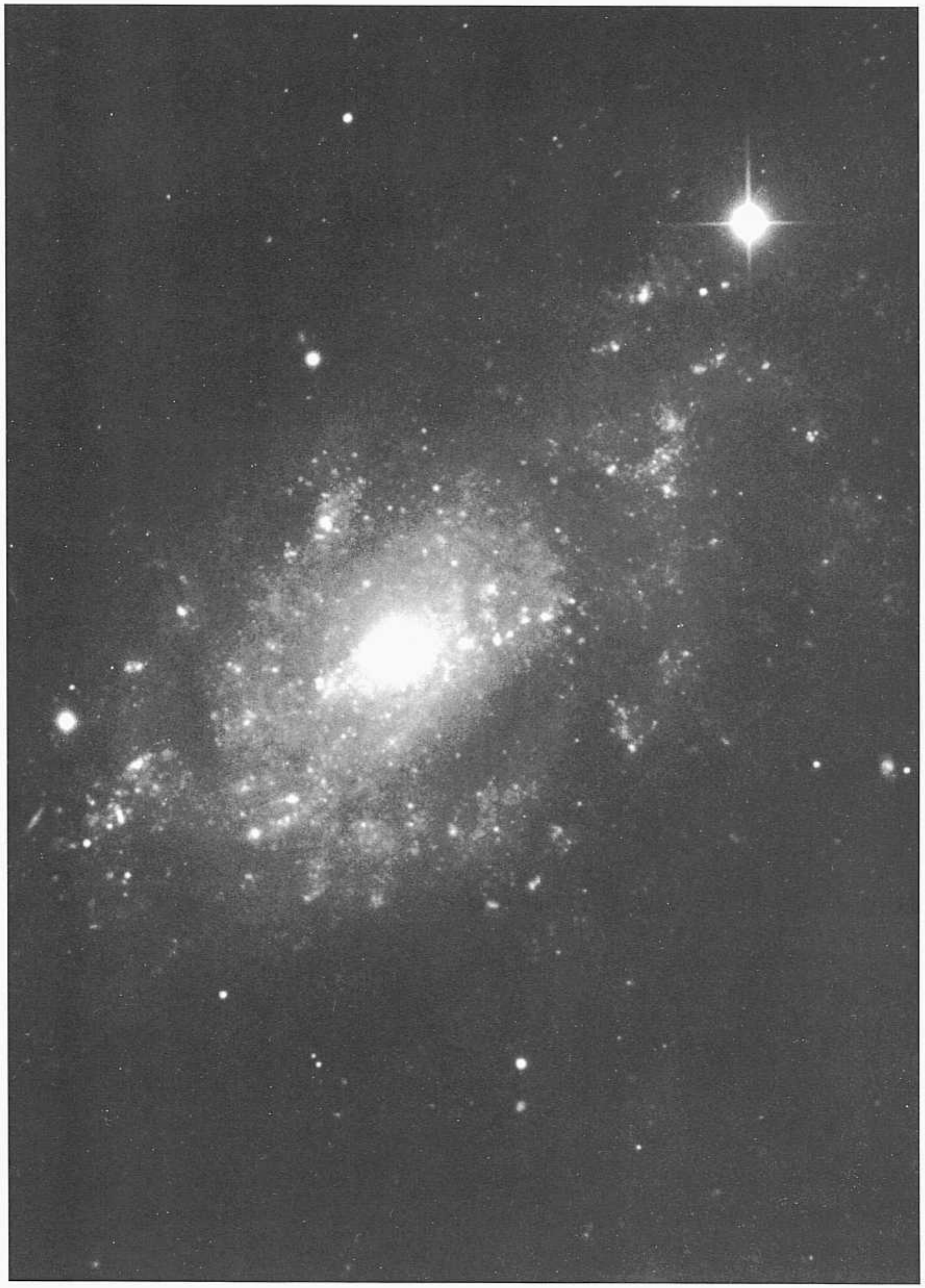
NGC 5585 is highly resolved into individual stars and HII regions. The largest HII regions resolve into disks at about the 2" level. The brightest stars are at least as bright as $B = 20$ and may be brighter, but a study is necessary to separate the stars from the HII regions by standard methods.

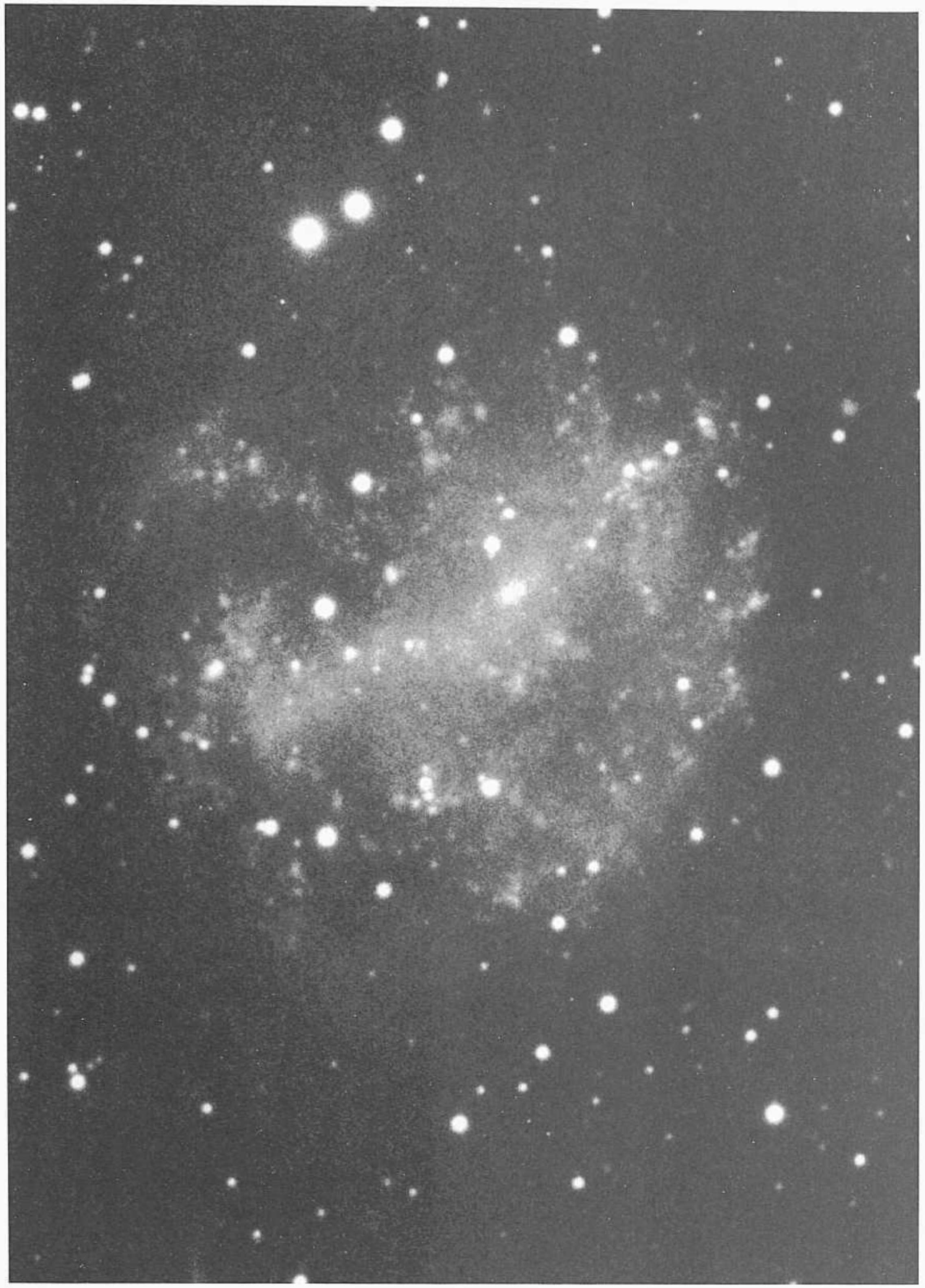
IC 4710 SBd(s)IV
CD-1472-S/Br
May 10/11, 1980
103aO + GG385
45 niin

IC 4710 is similar in appearance to NGC 4242 and NGC 2552 on the preceding panel. Each is of low surface brightness. Each has a central, pointlike nucleus. Each has an ill-defined spiral pattern that is not entirely chaotic.

Stars begin to appear in IC 4710 at about *11 = 21.* The redshift of the galaxy is v_o = 508 km s^{-1}.

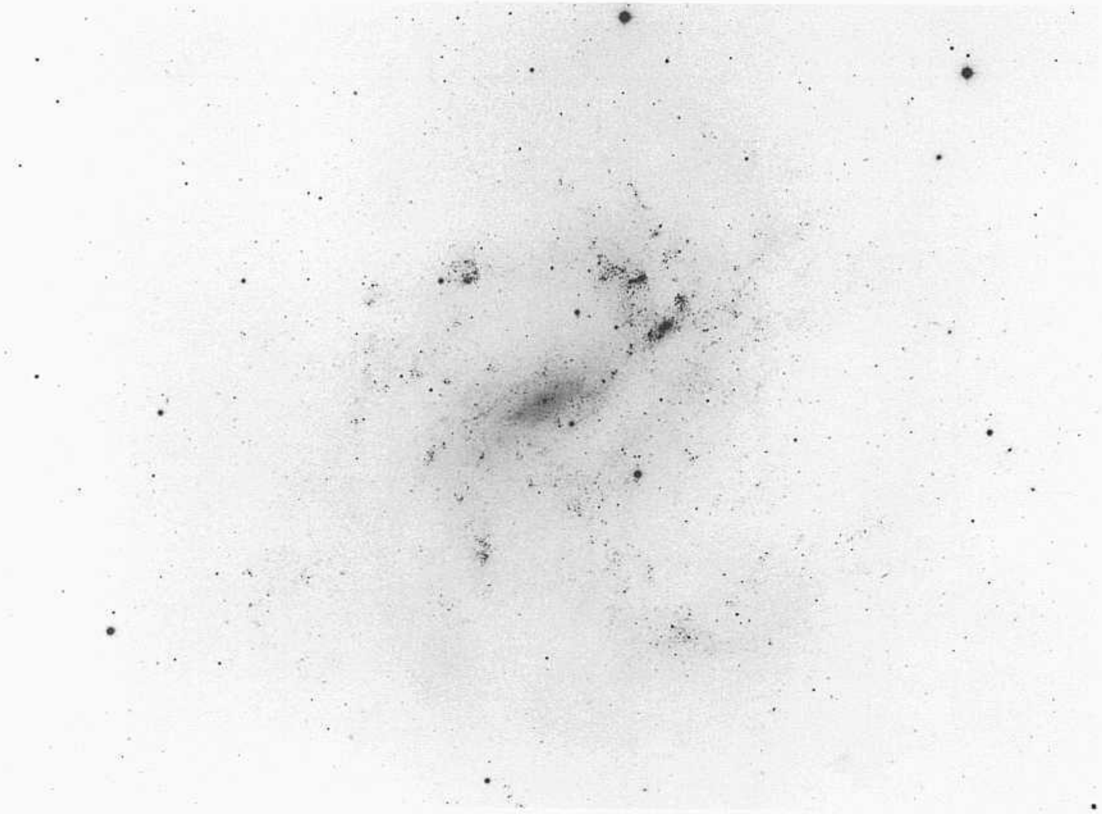
A probable companion (Imlll) is separated by 4.5'. It shows about the same degree of resolution into stars and Hll-region candidates as IC 4710. At a redshift distance of 10 Mpc $(H = 50)$ the projected linear separation from IC 4710 is small at 13 kpc.

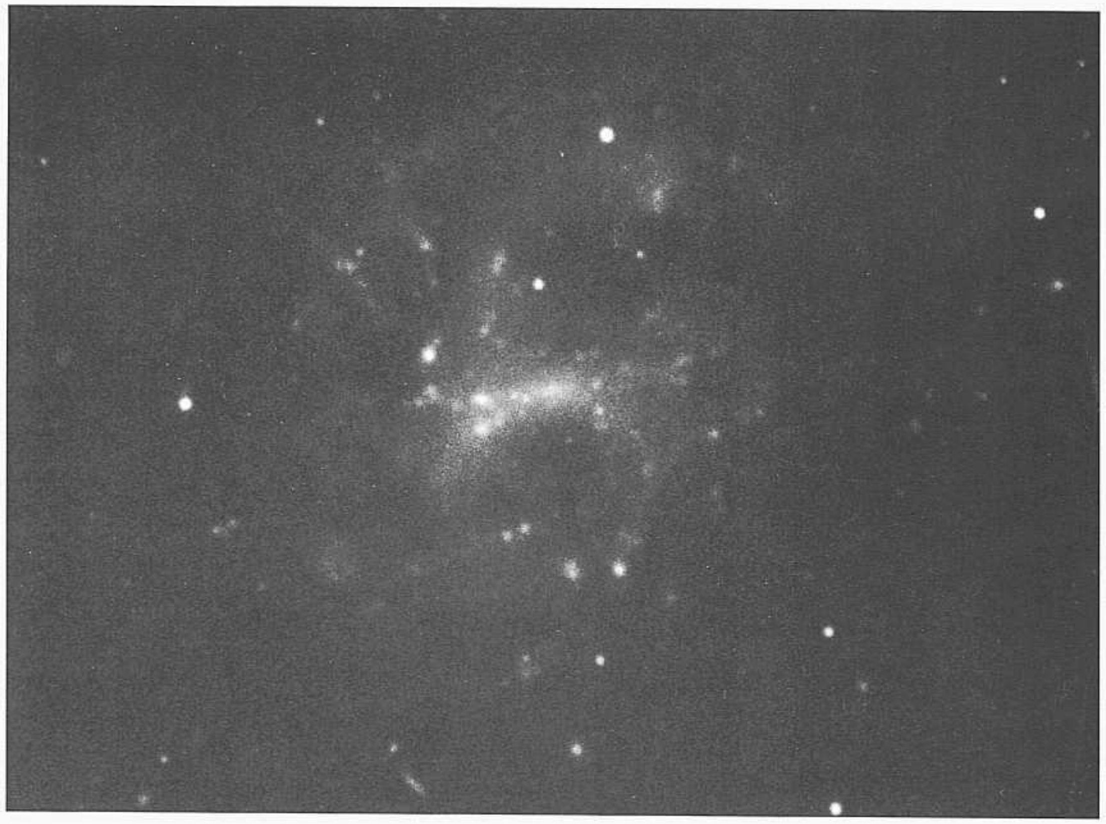


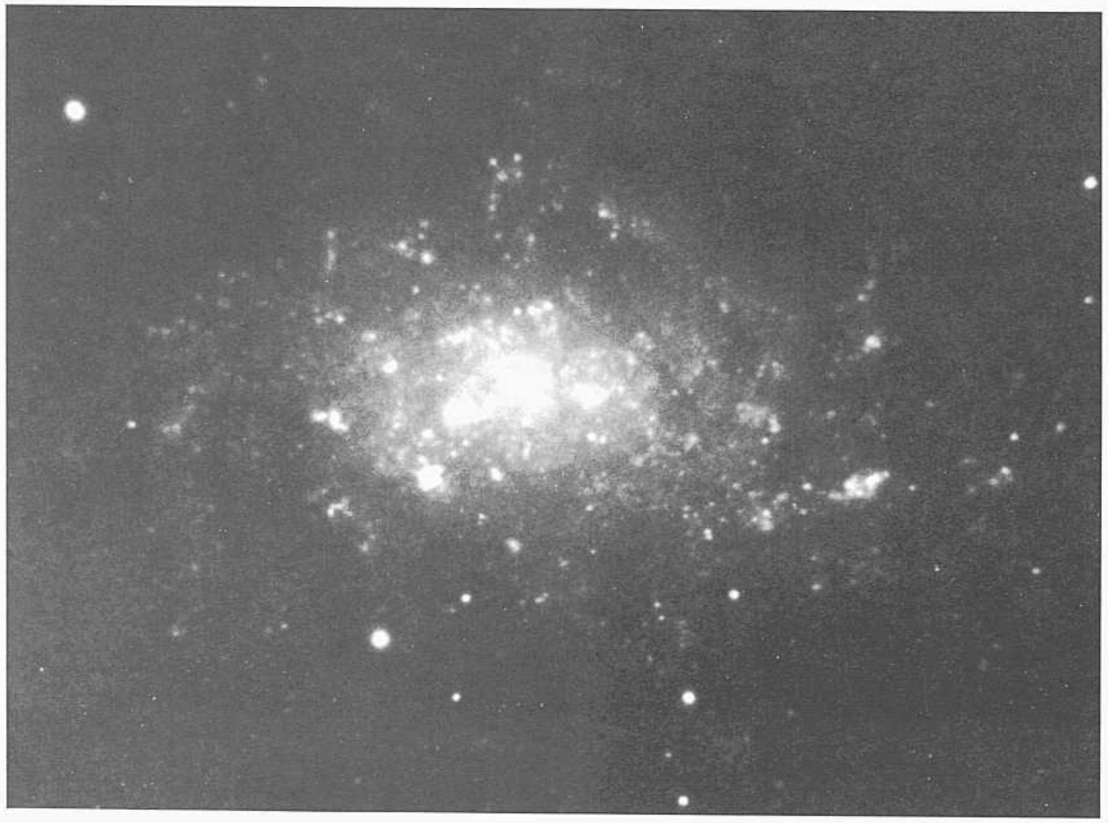


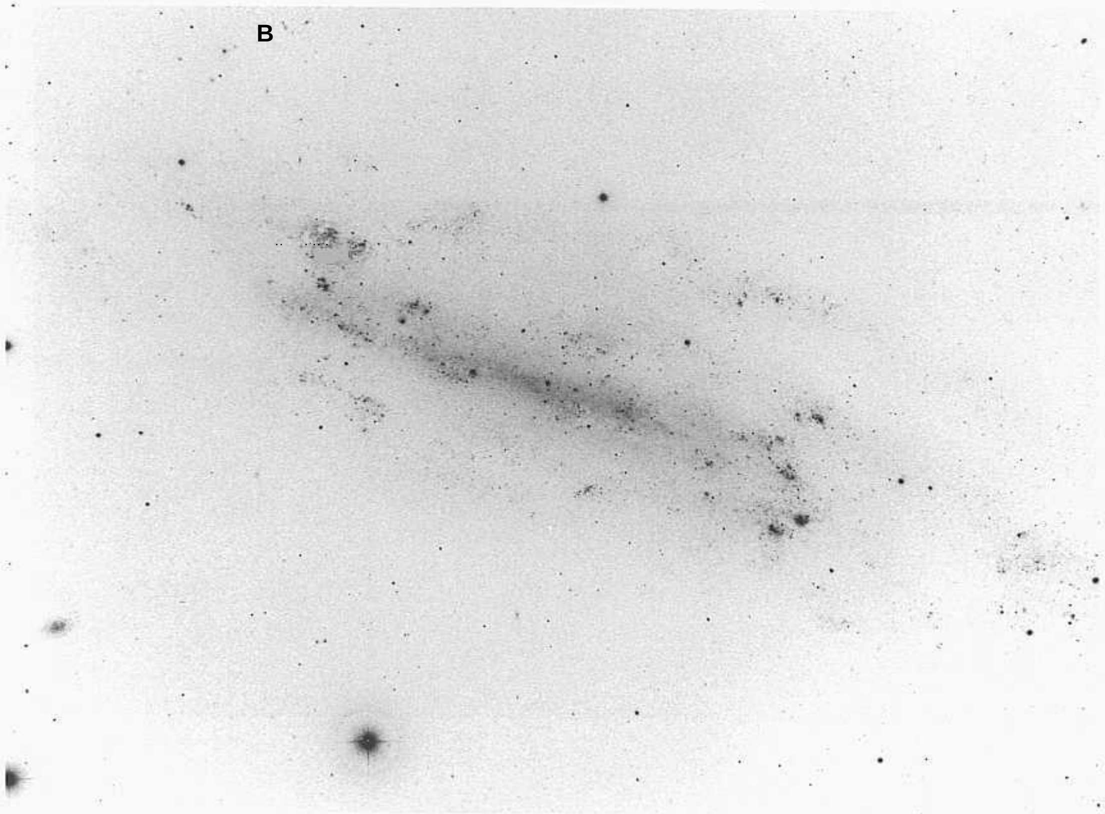
PANEL
323

PANEL
324









NGC 4395 StiIII-IV B4 Gr
PH-7145-S HA, p. *37*
Feb 1/2, 1976 Racine wedge
103aD + GGll panel S6
45 inin

Parts of this single galaxy were catalogued separately as NGC 4395, NGC 4399, NGC 4400, and NGC 4401 in the Dreyer NGC Catalog. The moderately high surface brightness center was given one NGC number; the several separate bright associations in the loose spiral pattern were the other three. The entire complex is called NGC 4395 here.

The galaxy is in the nearby, low-redsbift group in the complex Ursa Major region called Group B4 by Kraan-Korteweg and Tammann (1979) and CVn I by de Vaucouleurs (1975). The group is important for the distance scale problem because it contains NGC 4214 (SI3m; panel 330) and IC 4182 (not in the RSA or this atlas), both of which produced supernovae whose absolute magnitudes can be calibrated once precise (Cepheid) distances to these galaxies are known.

The brightest stars in NGC 4395 begin to individually resolve at about *B* = 18. Many associations of bright young stars exist in the several arms, similar to the pattern of the associations in NGC 3 00 and in M3 3.

The nucleus is bright *(S* about 16) and is starlike at 0.8" resolution.

The redshift of NGC 4395 is v_o = 304. The distance modulus is estimated to be about *m* - *M* = 2 8 .5 on the scale where *m* -*M* = 2 9 .3 for Ml 01 and *m* — *M* « 31.7 for the Virgo Cluster core.

The bright stars show secondary images from the Racine wedge that are 5 mag fainter than the primaries and are separated by 18".

NGC 5204 SclIV M101 Gr
PH-18-H HA, p. *37*
Jan 31/Fel) 1, 1949
103aO
30 min

NGC 5204 is one of the four well-resolved late-type companions of MI 01. The others are NGC 5474 (ScdIV pec; panel 3 15), NCC 5477 (Sd:) (panel 326), and NGC 5585 (SdIV; panel 323). The M10I Group was mapped first by Hohnberg (1950). Photometry, kinematics, and illustrations of the group members are set out in Sandage and Tammann (1974c).

NGC 52 04 is highly resolved into individual stars starting at about *B* = 2 0.5.

The original plate from which the reproduction here is made was one of the earliest taken with the Hale 200-inch telescope, before the Ross prime-focus corrector, which eliminates the coma aberration over a 15' field, was in place.

A description of NGC 5204 and the circumstances of the first scheduled observing run with this telescope is given by Hubble (1949). This start of the routine observing program followed more than a year of testing and adjustment of the Palomar telescope by Dr. I. S. Bowen, Director of the Mount Wilson and Palomar Observatories. Bowen's heroic effort to complete the 200-inch commissioning before astronomers had access to the telescope was highly successful but is largely unknown. The unfortunate tone of Hubble'a article should be noted in that regard.

The redshift of NGC 5204 is v_{n} = 329 km s^{-1}.

NGC 7162A SBod(s)III triplet
CD-1584-S/Br not in RSA
Aug 11/12, 1980
103aO + GG385
45 mill

NCC 7 162A forms a physical triple! with NGC 7 162 (She: panel 190) at a separation of 14.5'. and NGC 7166 (SO,: panel 34) at a separation of 14.9'. The- redshifts are u_D(7 I 62A) = 2238 km s^{-1}. 1.,,(7I62) - 2253 km a''', and u_o(7166) = 2376 km s~^{1}. Al the mean redshift distance of 46 Mpc *(H* •• 50), the projected linear separations from NGC 7 I 62 A arc 194 kpc for NGC 7 I 62 and I 99 kpc for- NGC 7 I 66.

NGC 4236 SBdIV M81 Gr
PH-45O6-S panel S 10
April 13/14, 1964
103aO
20 min

NGC 4236 is a highly resolved nearby galaxy that Holmberg (1 950) placed just outside the border of his M81/NGC 2403 Croup. The resolution into stars in NGC 4236 is at the same high level as in those members of the group agreed upon by all. Both the RSA, anil Kraan-Korteweg and Tammann (1979) consider NGC 4236 to be in the group. The level of resolution into stars shows the distance to he nearly the same as that of NGC 2403, NGC 23 66. IC2574. and other members of the group at *m* - *M* = 2 7.6 (Tammann and Sandage 1968).

The brightest stars begin to resolve at about *B* = 19. The largest HII regions have (halo) diameters of 14". The angular diameter of the galaxy itself is large at D_25 = 19'.

The redshift is u_0 = 157 km s^{-1}. consistent with the very high level of resolution into stars and a nearly noiseless Hubble expansion flow just beyond the Local Group (Sandage 1 986a).

The Sm, SBm, and Im Classification Sections

The Large Magellanic Cloud is the prototype galaxy of the Sm and SBm morphological type. In galaxies of this type there is cither a very weak spiral pattern or some other indication of weak regularity, rather than general chaos. Whatever regularity is present in galaxies of this type is undoubtedly associated with the observed small but finite rotational velocity. Such a kinematic field is needed to set up a shear velocity field that imparts regularity to the pattern, no matter how weak: the stronger the field, the greater the regularity.

The Sm and SBm galaxies in the RSA are illustrated on this and the next five panels. Galaxies with no indication of regularity in a coherent spiral pattern are in the final morphological box of the Im type, shown on panels 329-332.

LMC **SBmlll** **HA,** p. *38*
Bex-164-Henize
Nov4/5, 1951
103aE + Red Plexiglas
240 niin

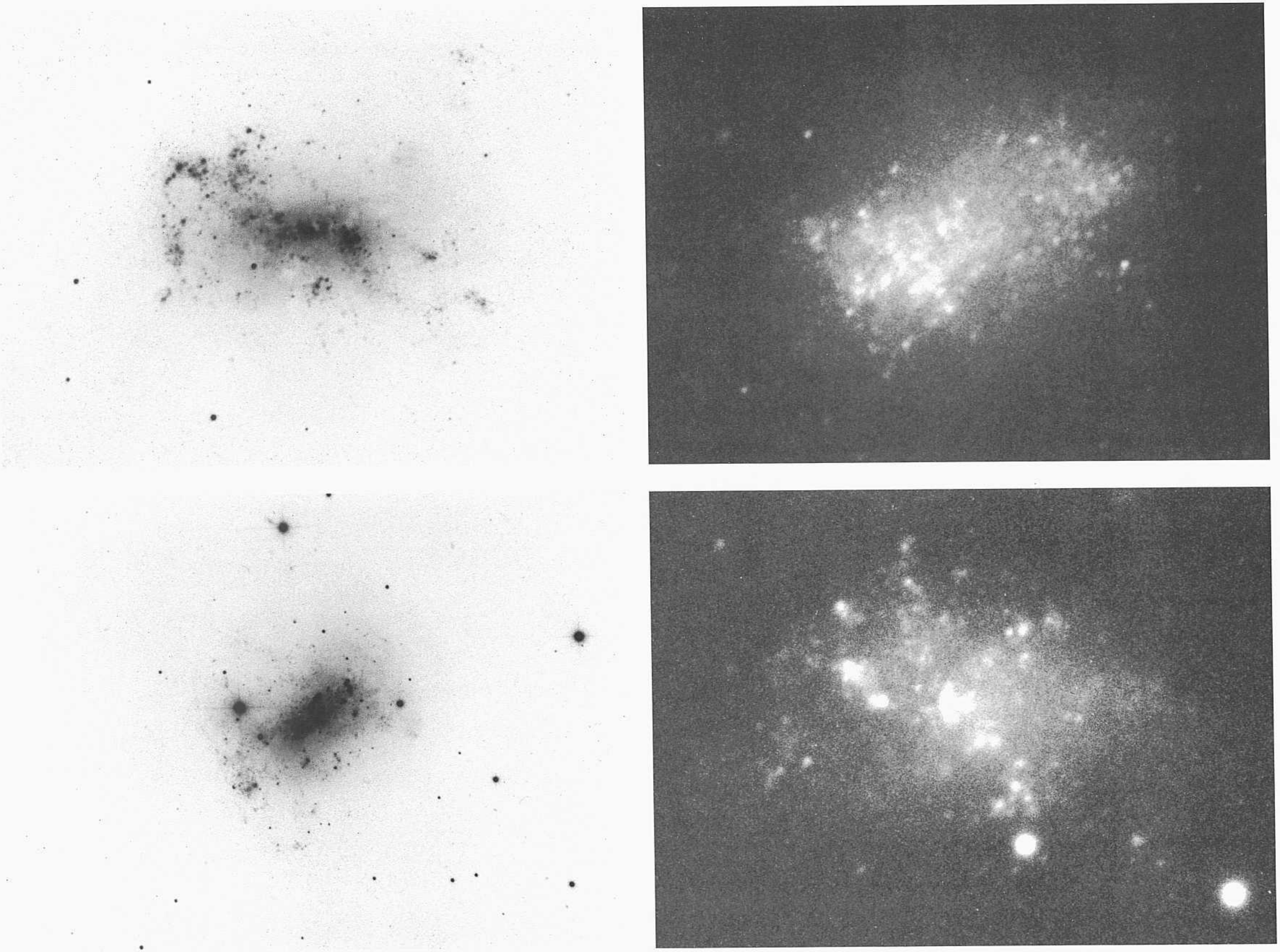
The print of the LMC here is made from an original Ha plate taken by Henize with the Mount Wilson 10-inch refractor. This telescope had been set up by Henize in South Africa in a cooperative arrangement between the Carnegie Institution, the University of Michigan, and the South African Science Research Council.

The **LMC** is a satellite of our own Galaxy at a distance modulus of $m - M = 18.5$ ($D = 50$ kpc), determined from **Cepheids.**

Weak spiral features exist (de **Vaucouleurs** 1955). The galaxy is also rotating with a peak velocity for young disk objects of 40 km s^{-1} (reviewed by Andrews and Evans 1972, and by Freeman, Illingworth, and **Oemler** 1983 with references to previous data). The smallness of the rotational **velocity is** presumed to be the reason that the spiral **pattern** is **so** poorly developed **(compare Kennicutt 1981).**

PANEL
325

PANEL
326



NGC 4449 SmlV CVn I Cloud
H-523-B B4 Gr
June 26/27, 1935 HA, p. *40*
Imp. Eel. panel S6
20 min

NGC 4449 is a member of the very nearby B4 Group (Kraan-Korteweg and Tammann 1979: hereafter KKT), also called the CVn I Cloud by de Vaucouleurs (1975). The group, described earlier on panel 324 with NGC 4395. has $<v_o>$ of about 250 km s"[1]. It includes NGC 4144. NGC 4190 (at the right on this panel). NGC 4214, NGC 4244. IC41H2. and a number of Im dwarfs listed in KKT.

The surface brightness of NGC 4449 is abnormally high. The face of the galaxy is covered with bright Mil regions and undoubtedly very bright stars which have not yet (199 1) been distinguished from the IHI-region candidates. Brightest individual stars resolve out of the background at a magnitude at least as bright as B = 19.

The face of the galaxy is covered with Hex streamers and filaments. Its morphology is mildly similar to that of the Amorphous types, such as NGC 625 (panel 336), NGC 1569 (panel 336), and NGC 3034 (M82; panels 333, 334), sometimes called starburst galaxies.

The redshift is v_0 = 2 50 km s^{-1}.

NGC 1156 SmlV HA, p. *39*
PH-1078-S
Aug 25/26, 1955
103aO
30 min

NGC 1156 is a well-resolved dwarf galaxy of the Magellanic Cloud type. Its brightest stars begin to resolve at about B = 2 1 . Very bright I III regions exist, confusing the identification of the brightest stars. The largest of these regions have diameters (halo) of about 3".

The redshift is $v_{(>}$ = 5 58 km s^{-1}.

NGC 1190 SmlV B4Gr
PH-7664-S
April 29/30, 1979
lO.iaO
1 0 mill

NGC I 1 9(1 is highly resolved into individual stars beginning al aboul *It* = 20.5. The surface brightness of the disk is also moderately high, indicating a relatively high recent star-formation rate.

NGC 4190 is a member of the nearby B4 Group, also known as the CVn I Cloud (compare the paragraphs on NGC 1119 al the left).

The icdshii't is ,;, = 231 km s '.

NGC 5177 Sd: Ml01 Gr
PH-102-B not in I!SA
July 1 1/12, 1950
103aO
30 min

NGC 547 7 is the hist of the lour highly resolved satellites of MIDI to be shown. The other three satellites are NGC 5 17 1 (ScdIV pec: panel 3 15). NGC 5204 (SdIV: panel 32 4). and NCC 5585 (SdIV: panel 323).

The brightest stars begin to resolve in NGC 5477 at about B = 20.5.

The redshift is v_0 = 442 km s^{-1}.

NGC 4656/4657 Im pair
H-3633-S HA, p. *40*
Feb 18/19, 1963 panel S6
103aO + GG13
27 niiii

The complex system of NGC 4656/4657 is listed as two galaxies in the Dreyer NGC Catalog. It may be a single galaxy in the process of (or having just completed) a close encounter with NGC 4631 (Sc on edge; panel 290), which is 31' distant. NGC 4631 is obviously at the same distance, shown by the near equality of the redshifts and the nearly identical levels of resolution into individual brightest stars. The redshifts are v_0 = 606 km s'" for NGC 463 1 and v_o = 624 km s^{-1} for NGC 4656/4657. The galaxies resolve well into brightest stars beginning at about B = L9.

The largest II11 region in NGC 4656/4657 is complex and has an angular diameter (halo) of 1 1". At an assumed disLance of 5 Mpc (Sandage and Tammann 19 74a) the linear diameter of this HII complex is about 2 70 psc. At this distance the projected linear separation of the NGC 4656/4631 pair is small, at 44 kpc. The 2 1-cm content of the pair has been measured by Weliachew, Sancisi, and Guélin (1978). A model of the tidal interaction is discussed by Combes (1978).

The resolution into individual stars is so pronounced in part of NGC 4656/4657 as to make this ualaxy a prime candidate for detailed study of its stellar content.

NGC 4532 SmIII VCC 1554
CD-2111-S
March 19/20, 1982
103aO + GG385
50 niin

NGC 4532 is listed as a cluster member in the Virgo Cluster Catalog. It is located about 1 .5° south of the center of subcluster B centered on NGC 4472 . It is illustrated on the same enlargement scale as other galaxies in the Virgo region in the Atlas of Virgo Cluster Spirals (Sandage, Binggeli, and Tammann 1985a, panel 11).

The surface brightness of the nearly edge on disk is very high, making reconnaissance of the stellar content difficult. Robust star formation is evidently occurring. One particularly bright region with a complex of candidate HII regions has an apparent diameter (halo) of 8". Individual stars are not seen, but the surface brightness is so high on the available plate material as to overwhelm the image here.

The redshift is v_0 = 1858 km s~\ hut redshifts of individual Virgo Cluster galaxies are dominated by large virial velocities rather than by cosmological expansion velocities.

NGC 4861 SBmlH
PH-8033-S
Feb 3/4, 1981
103aO
12 nùn

NGC 4861 is similar to NGC 2366 below. It is highly resolved into individual stars beginning at about B = 21. The most unusual feature of the stellar content is the enormous Hll-region complex (similar to that in NGC 2366, but much larger here) at one end of the image. Its angular diameter (halo) is about 12".

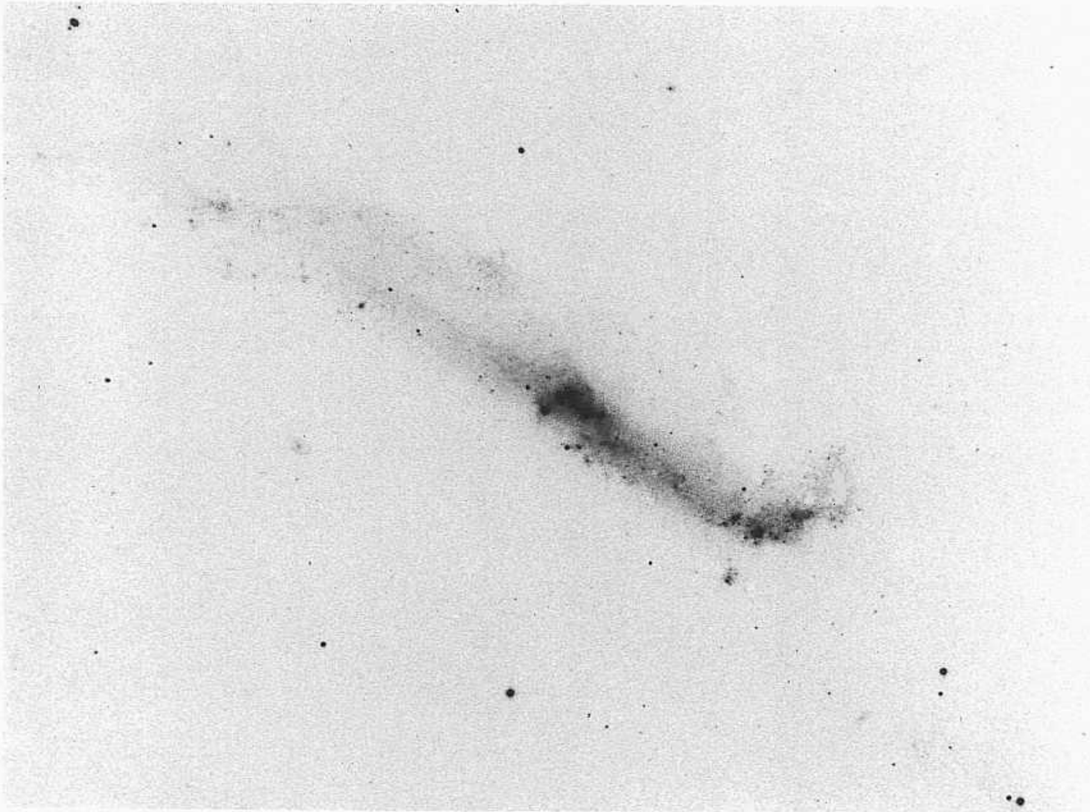
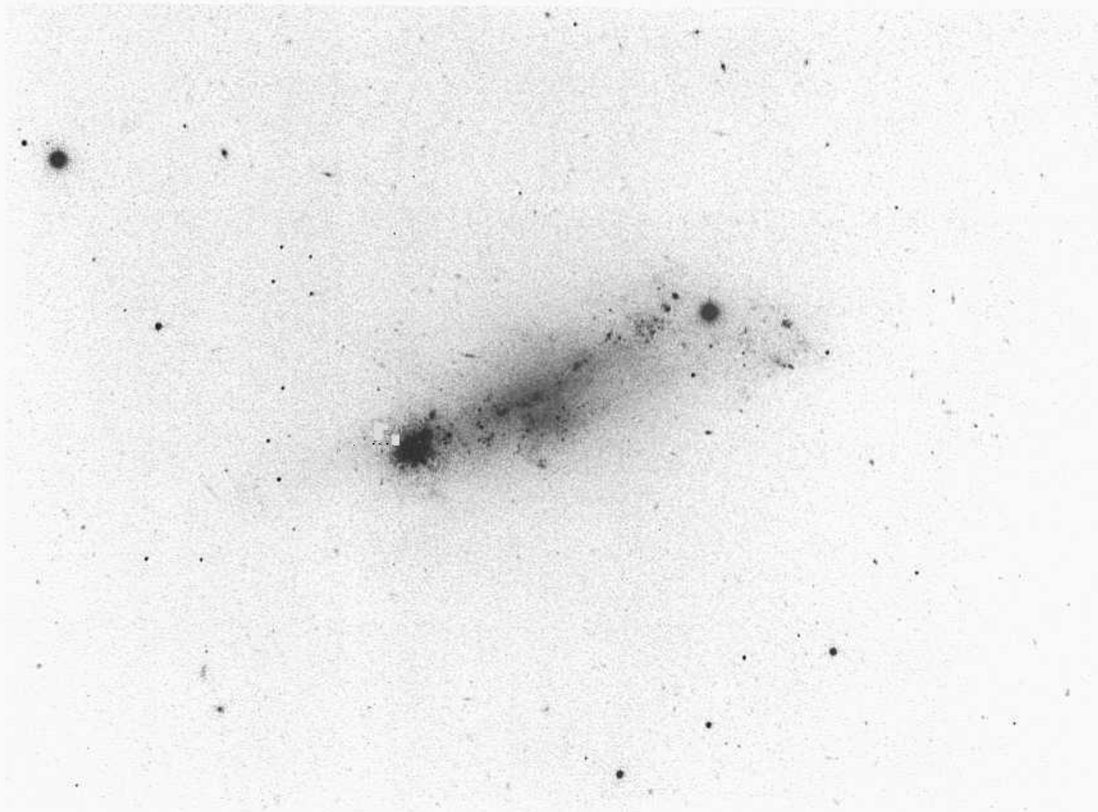
The redshift is v_0 = 83 6 km s"'. At the redshift distance of 1 7 Mpe the linear diameter of this complex is large, at 1000 psc. It is one of the largest Hll-region complexes known.

NGC 2366 SBmlV-V HA, p. *39*
PH-555-B M81/NGC 2403 Gr
Oct 31/Nov 1, 1951
103aO + GG1
30 min

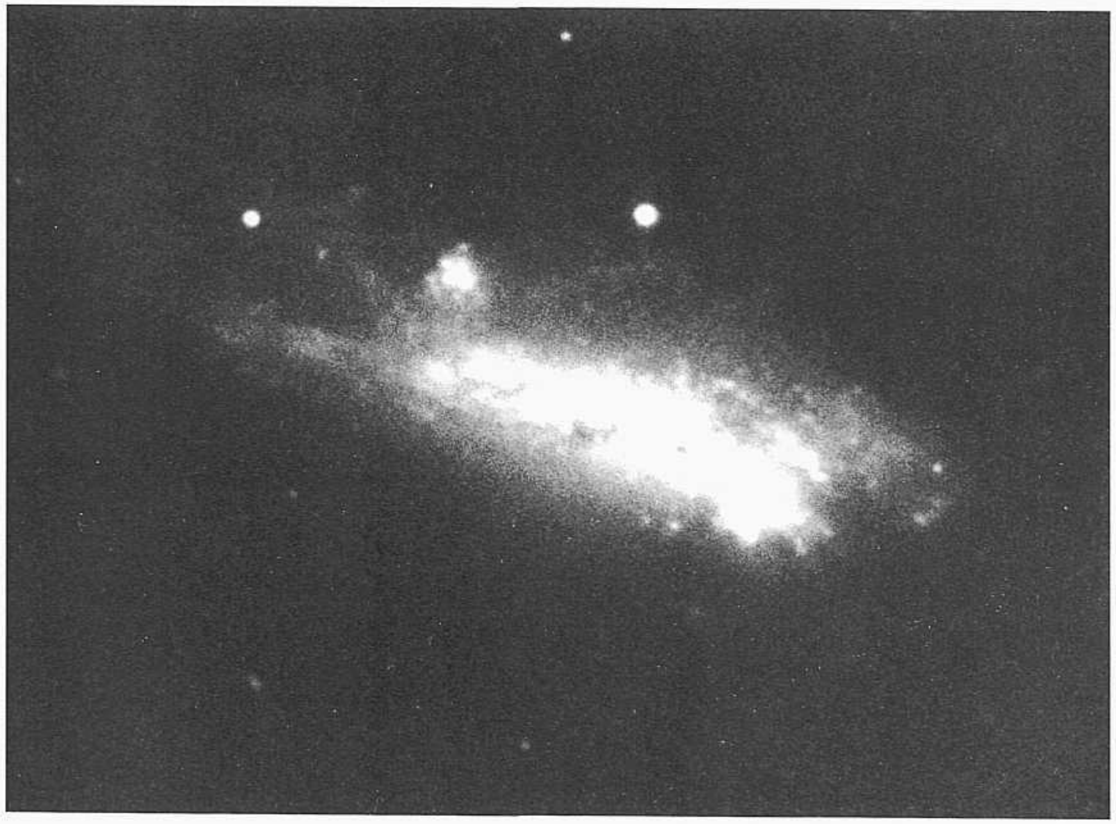
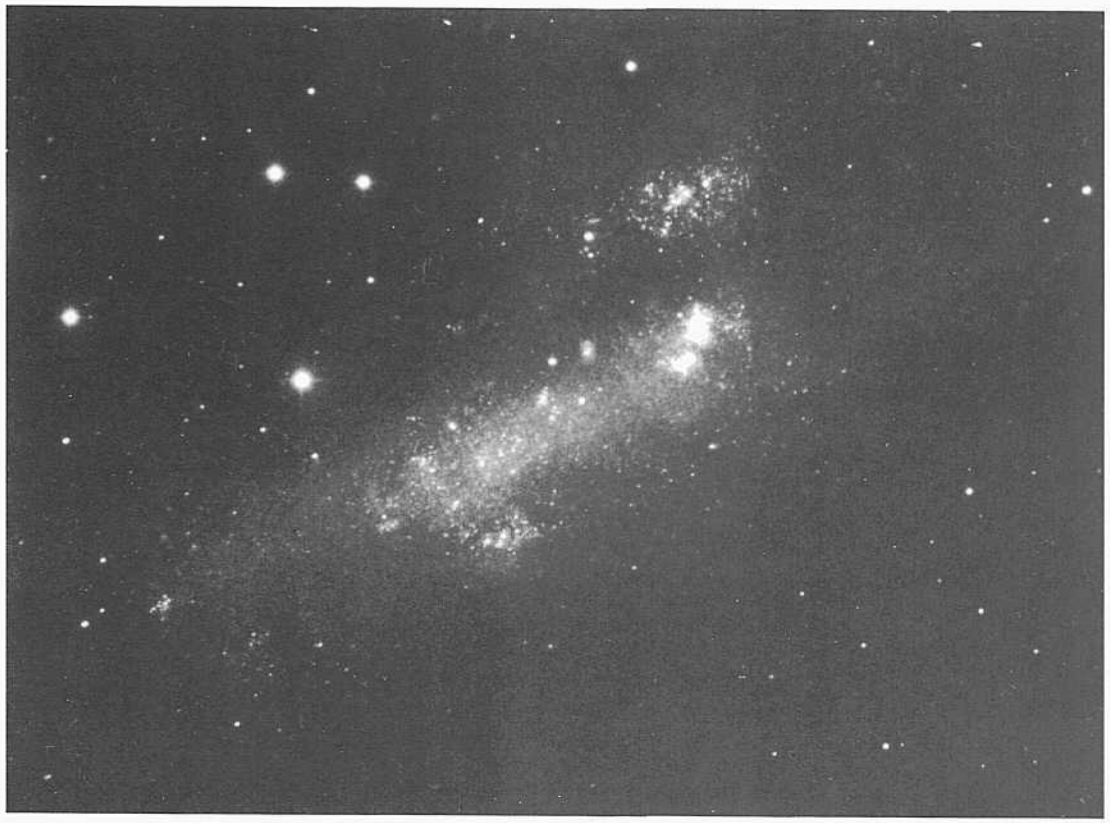
NGC 2366 is a member of the M81/NGC 2403 Group, as originally defined and catalogued by Holmberg (1950). It resolves into stars as easily as other members of the group, such as NGC 2403, M81, IC 2574. Hoi, HoII, and NGC 4236. The brightest stars begin to resolve at about B = 19. The distance modulus of the group is m — M = 2 7.6 (Tammann and Sandage 1968). The value has been confirmed (Freedman and Madore 1988).

The largest of the HII regions at one end of the major axis has a diameter of about 12" for its high-surface-brightness main body. The extent of its outer associated filaments is 18". These angular diameters correspond to linear diameters of 190 psc and 2 90 psc, respectively, at a distance of 3.3 Mpc (Tammann and Sandage 1968).

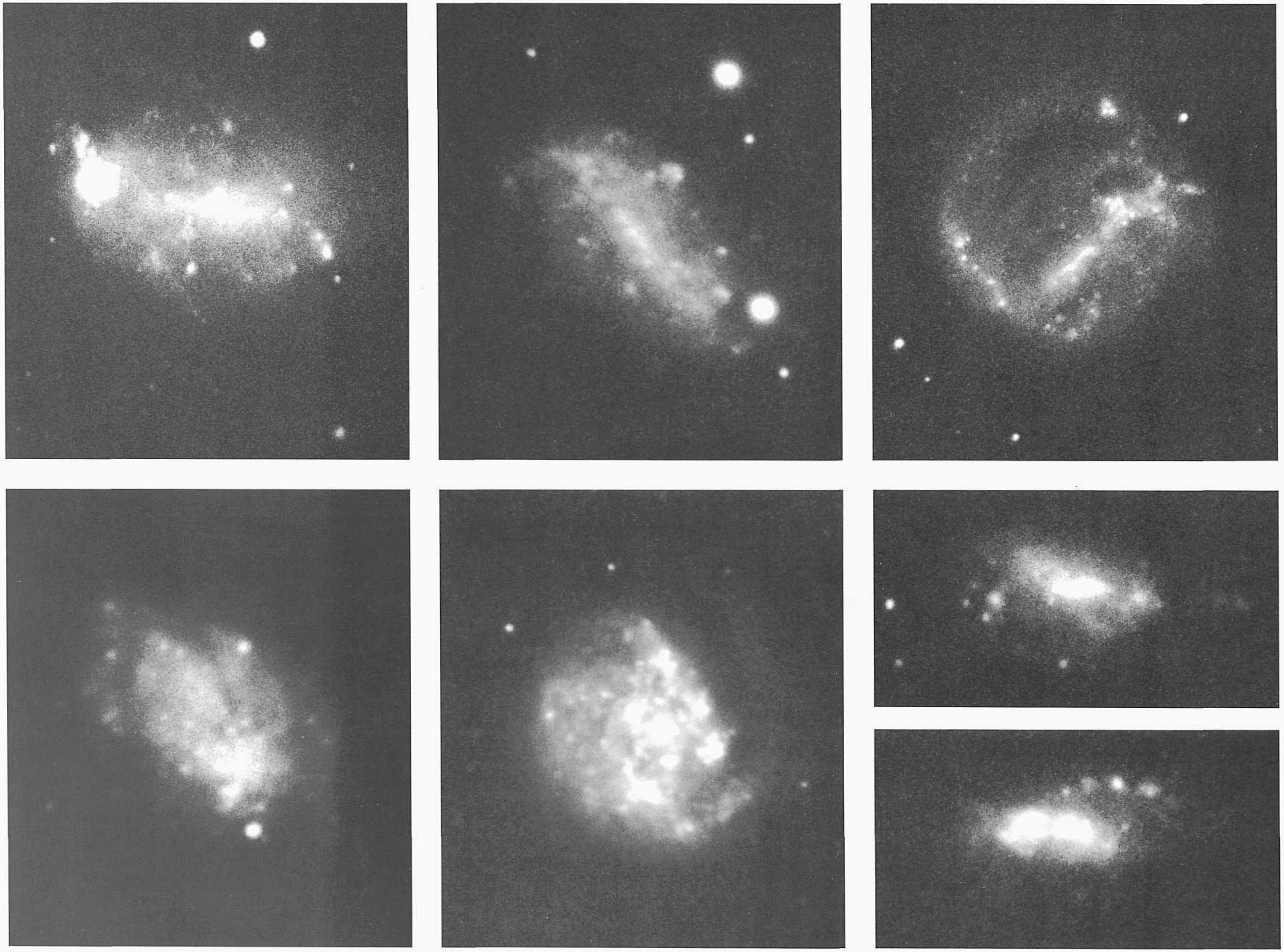
The redshift is v_{n_o} = 281 km s^{-1}.

PANEL
327

PANEL
328



NGC 1602 SBm pair
CD-676-Br not ill RSA
Jan 25/26, 1979 panel 51
IlaO + GG385
180 niin

NGC 1602 is the highly resolved companion to the SO] (7) galaxy NGC 1596 (panel 51). The redshifts are $V_O(1S69)$ = 1324 km s~' and u_o(1602) = 1382 km a"[1]. The near-equality of the redshifts and the proximity of the components at an angular separation of 3.1', suggest a binary pair. At the mean redshift distance of 27 Mpc, the projected linear separation of the pair would be small at 24 kpc.

NGC 1602 is resolved into many HII regions. There is a complex of six such regions (unresolved in the print here) near the end of the major axis. The envelope of this complex has an angular diameter of 10", which, at the distance of 27 Mpc. is a linear diameter of 1300 psc, similar to the diameter of the complex in NGC 4861 on the preceding panel. At higher spatial resolution, this complex would presumably appear as an association of early-type stars and HII regions.

The NGC 1596/1602 pair is of particular interest because of the large difference in morphological type. The SO and Im types span the total range of the classification sequence (see the diagram of the dwarf classification sequence in Chapter II here). Pairs with such diverse types are of obvious importance in studies of the meaning of the Hubble sequence for galaxy formation and possible evolution within the sequence. Does one morphological type change into the other with time or with the type of environment, or are the morphological types of individual galaxies stable over most of a Hubble time, as suggested by the calculations of Roberts (1963) and of Sandage (1986d)? These central points are discussed in Chapter IV here, "The Meaning of the Classification."

NGC 3738 SdHI BI Cr
PH-7106-S Racine wedge
Jim 7/8, 1976
103aO + GG13
25 inin

NGC 3738 is a member of the very nearby group containing NGC 4214, NCC 4395, IC 4182, and other highly resolved late-type galaxies just beyond the Local Group. The aggregate is called the CVn I Cloud by de Vaucouleurs (1975) and by Sandage and Tammann (1975a). It is Group B4 in Kraan-Korteweg and Tammann (1979).

NGC 3738 is small (D_{25} = 2.6') for its bright apparent magnitude. The surface brightness of the disk is high, making reconnaissance of its stellar content difficult. Images that are probably brightest stars appear in the outer part of the disk beginning at about B = 20, but their discrimination from HII regions by standard methods has not yet (1991) been done.

The redshift is v_n = 312 km s"'.

NGC 3782 SBcd(s)III CVn [I Cloud?
PH-8026-S Racine wedge
Feb3/4, 1981
103aO
2 niin

NGC 3782 is probably a member of the CVn II Cloud (Sandage and Tammann 1975a). which has a mean redshift of about $<v_o>$ = 750 km s^{-1}. The redshift of NCC 3782 is v_o = 785 km s"'.

The Mil-region candidates are unresolved at the 1.5" level. Brightest stars may exist starting at about B = 21 but they have not yet been distinguished From the Illl-region confusion by the standard methods.

NGC 4299 Sd(s)III VCC 491
CD-1318-S/Br Karachentsev 330
March 12/13, 1980
103aO
75 inin

The spiral pattern in NGC 4299 is better formed than in other galaxies on this and several of the preceding panels: hence, the classification of NGC 4299 is Sd rather than Sm.

The galaxy is listed as a cluster member in the Virgo Cluster Catalog. It is illustrated in the Atlas of Virgo Cluster Spirals (Sandage, Binggeli, and Tammann 1985a, panel 15) on a common scale with other Virgo Cluster spirals.

NGC 4299 forms an apparent pair with NGC 4294 (SBcII-III) at the separation of 5.5'. Small angular separations in the Virgo Cluster region do not always mean a physical pair because of the depth effect of the cluster. However, the near-equality of the redshifts and their abnormally low value make the case for a binary pair strong here. The redshifts listed in the RSA are v_o(4294) =232 km s~' and v_0(4299) = 107 km s~J . At a common distance of 21.9 Mpc (m - M = 31.7 for the Virgo Cluster) the projected linear separation of the pair would be small at 35 kpc.

NGC 3661 SBmlll pair
CD-1858-HB
April 6/7. 1981
103aO + GG385
15 ...in

Many Illl-region candidates exisl in the bar of the disturbed morphology of NGC 3664. A smaller compuninn (NGC 3664A; type Slim) with the same disturbed morphology and the same high degree of resolution into Illl-region candidates exists at a separation of 6.3'. The redshil't of NGC 3661 is v_o = L231 km »"'. If. ns seems likely, the two galaxies form a pair at the same redshift distance of 25 Mpc. their projected lineal* separation is small at 16 kpc. This, and their disturbed morphology, suggest that *j* close encounter may have occurred.

None of the many Illl-region candidates are resolved at the 1 " level.

NGC 5464 **SBmlll**
CD-1355-S/Br
March 15/16, 1980
103aO + GG385
5 nün

NGC 5464 and NGC 178. below, are similar. Both have small angular diameters, high surface brightness, HH-region candidates, spiral patterns that are difficult to tract', and bright absolute magnitudes for the SBm morphology.

The redshift of NGC 5464 is v_o = 2455 km s"[1] . The largest Illl-region candidate appeal's to resolve at the 2" level, corresponding to a linear diameter of about 475 pse. The absolute magnitude, corresponding to the apparent magnitude of B_T = 13.2. is bright, at M_B = -20.6.

NGC 178 SBmlll
CD-1567-S/Br
Aug9/10, 1980
103aO + GG385
8 niin

The redshift of NGC 178 is r,, = 1599 km s^{-1} . The largest of the Illl-region candidates in the narrow plume away from the main body may resolve at about the 1 .5" level. The high surface brightness of the main body and the bright knots it contains show that a robust star-formation rale is occurring.

The absolute magnitude of NGC 178. based on B_T = 13.1 . is bright for SBm types, at Mj = -19.9.

The remaining late-type RSA galaxies in the regular sequence of the classification, shown in the next four panels, are mostly of type Im. (A few are still of the slightly earlier SBm type.) Im types have no discernible spiral pattern. They are dwarfs (mostly fainter than absolute magnitude M;j = -17 where H = 50).

The Im dwarfs listed in the RSA, where the apparent magnitude limit is m_{pg} = 13 , must be very nearby. Because of their closeness, the galaxies on the next four panels are highly resolved into individual stars. They are prime candidates for studies of stellar content.

IC 4662 **Imlll**
CD-2198-S
March 30/31, **1982**
103aO + GG385
35 **niin**

IC 4662 is highly resolved into individual stars beginning at about *B* = 19. Because the galaxy is at low galactic latitude *(b* = —18°), contamination of the faint stellar content of IC 4662 **with** foreground stars is appreciable.

The **redshift of** IC 4662 is v_0 = 240 km a"[1]. The angular diameter is small at D-25 = 2.2'. Assuming a distance of 5 Mpc, the absolute magnitude is Mg = —17.2 and the linear diameter is 3.2 **kpc.**

IC5152 **SdmlV-V**
CD-57-D
Aug **19/20,** 1977
103aO + GG385
75 min

From kinematic arguments alone, IC 5 1 52 is a member of the Local Group (Sandage 1 986a). Its measured heliocentric redshift is v_{sun} = 119 km **s**$^{-1}$. It is well known that the direction of the solar motion relative to the Local Group is toward Galactic coordinates **of approximately** / = 9 7°, 6 = —5 °, with an amplitude of **approximately** 295 **km s**$^{-1}$ **(Yahil,** Tammann, and Sandage 1977: Sandage 1986a). Subtracting this vector **of** the solar motion from the heliocentric redshift of IC 5152 gives a negligible cosmological redshift vector for IC 5 1 52 of i'$_o$ = 47 km s^{-1}: hence, IC 5152 is at rest relative to the Local Group to within the errors of **the** determination (compare Fig. 9 of Sandage 1 986a).

Local Group membership is consistent with the proximity **required** by the profound resolution of IC 5152 into stars beginning at about *B* = 17. **Cepheid** variables have been found (Sandage and Carlson, unpublished 1 988), but a **precise** distance based on them is not yet available (c. 1991). The estimated distance modulus is *m -M* = 26 **(D** = 1.6 Mpc).

NGC 3377A = UGC 5889 **Im** Leo Gr
PH-711-B
Jail 19/20, 1953
103aO + GGl
30 **niin**

This dwarf companion to NGC 3377 (E6: panel 19) is separated from the **principal** galaxy **by** 6.8'. The 19 50 coordinates of this dwarf are RA = 10^{h} 44.73^{m}, Dec = 14° 20.2'. Its angular diameter is **Large** at D25 = 2 .0'. Its surface brightness is low, at about 24 *B* mag sec^{-2}.

A pointlike knot exists close to the center. This may be a nucleus similar to the bright nuclei in dE.N galaxies. Other starlike images exist over the face, similar to the prototype large Im galaxy IC 347 5 in the Virgo Cluster, illustrated in the Atlas of Virgo Cluster Dwarfs (Sandage and Binggeli 1984).

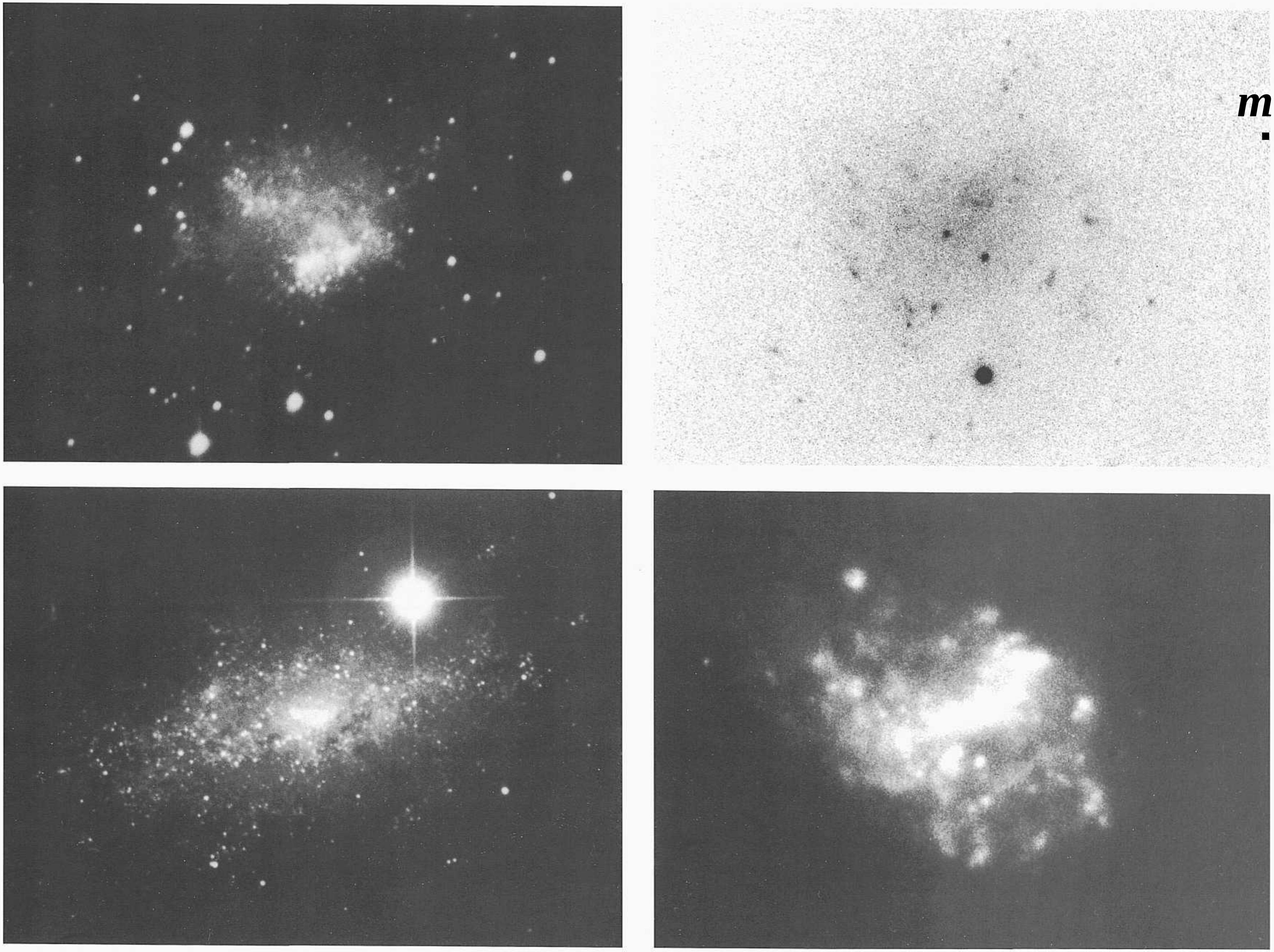
HI 21-cm radiation has been detected in NGC 3 37 7 A at a redshift (corrected to **the** centroid of the Local Group) of v_0 = 446 km s^{-1} (Lewis 198 7). The redshift of NGC 33 7 7 is v_o = 591 km s"[1], suggesting that NGC 33 7 7 and NGC 3377A form a binary pair. At the redshift distance of 10 Mpe, the linear diameter of NGC 3377A would be very large at 5.8 kpc, and the projected linear separation from NGC 3377 would be small at 20 kpc. If the distance were larger at 1 8 Mpc as assumed by Ferguson and Sandage (1 9 90) for members of the Leo Group, **the** diameter would be 10.4 kpc and the separation from NGC 3 3 77 would be 36 kpc.

In either case, the linear diameter of NGC 3377A is huge, as in the class of huge dE and/or Im dwarfs that exist in the Virgo Cluster (Binggeli, Sandage, and Tammann 1985, Table XIV; Sandage and Binggeli 1984, panels 6. 18. and 19).

A case has been made (Sandage and Hoffman 1991) that NGC 3377A is in a state of transition between a gas-rich Im dwarf and a gas-poor dE.N by self-transformation caused by gas sweeping from stellar winds. The winds are generated by super star clusters similar" to those observed in NGC 625 (panel 336), NGC 1569 (panel 336), and NGC 1705 (panel 335). **described** in the next section on **Amorphous galaxies.**

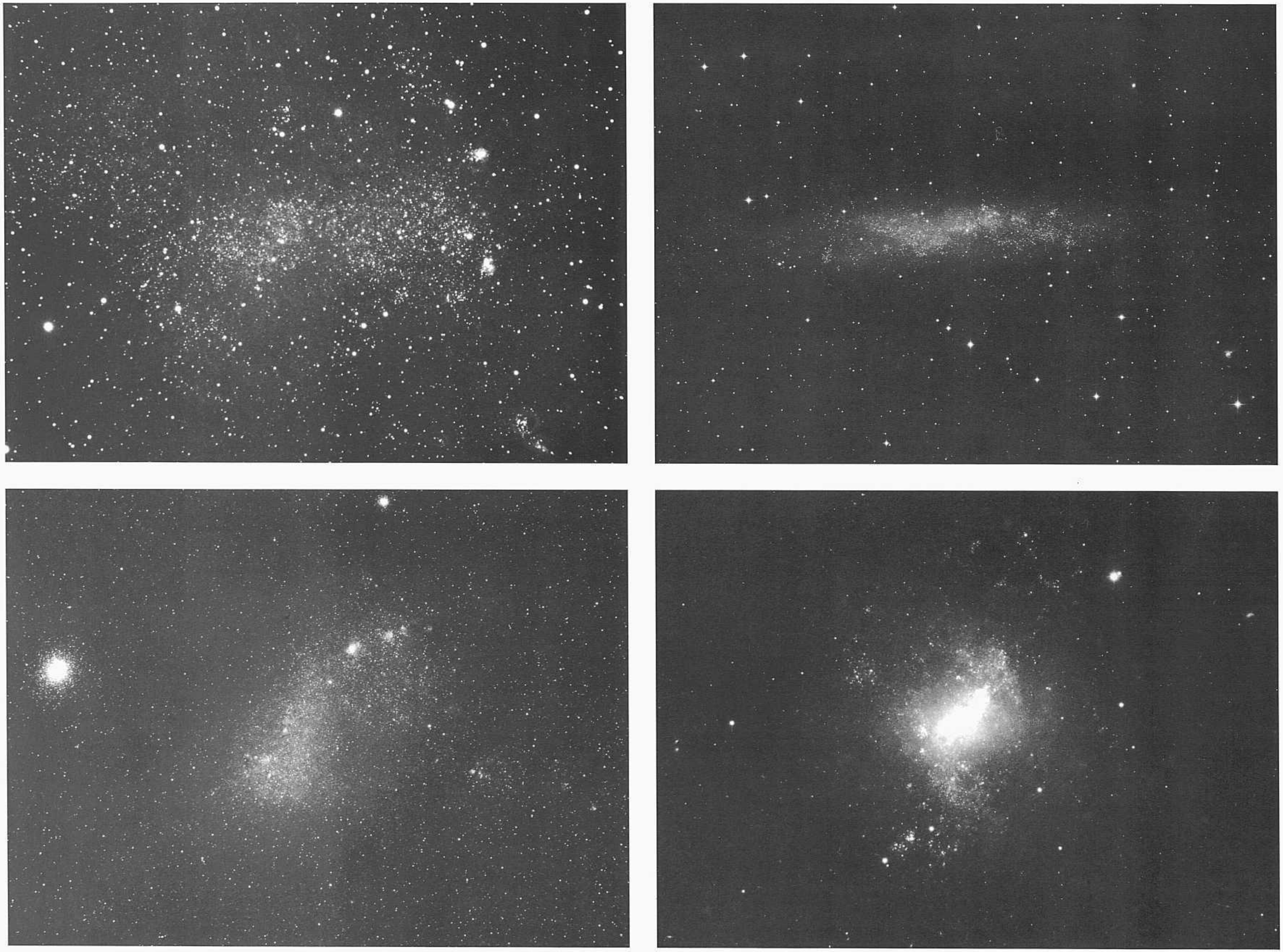
NGC 7764 SBmlll
CD-1064-Br
Aug 16/17, 1979
103aO + GG385
45 niin

NGC 7764 has high surface brightness, many Hll-region candidates, and a **poorly** defined **spiral** pattern. The redshift is v_o = 16 74 km s^{-1}. The absolute magnitude of this SBm galaxy is bright at iW$_n$ = -20.1. The absolute magnitude of the LMC, which is the prototype galaxy of the SBm class, is five times fainter at M_B = -18.4.



PANEL
329

PANEL
330



NGC 6822 **ImlV-V** **Local Gr**
PH-103-S
Aug 19/20, 1952
103aO + **GG1**
30 min

NGC 6822 is the first external galaxy **for** which **Hubble** (1925) published details **of the** discovery and photometry **of** Cepheid **variables.** This **low-surface-brightness** Im dwarf shows **no** evidence of a spiral pattern. **It** is in the **Local Group** at a distance modulus **of** $(m — M)_{lt}$ = 23.95, **corresponding to** a **distance** of 6 **I** 6 kpc (Kayser 1967).

The brightest stars resolve at *B* = 17 (Kayser 1967, Fig. 3). Large resolved **llll** regions exist; the largest has an angular diameter of 50". corresponding to a lineal- **diameter** of 150 psc.

SMC **ImlV-V** **Local Gr**
W10-Bex-115-Henizc

The Small **Magellanic** Cloud is a satellite of our Galaxy in the Local Group at a mean distance modulus of *m* - *M* = 18.85 determined from Cepheids. However, the galaxy is **extended in** the line of sight due to its tidal disruption in a recent close encounter with the LMC **(Murai and Fujimoto** 1980). The extension in the sight line, determined by Mathewson, Ford, and Visvanathan (1986. 1988) is from a near distance of 43 kpc to a far distance of 75 kpc. The main concentration of the SMC is at a distance of 59 kpc from the Sun.

The brightest blue stars begin to resolve at *B* = 10.2. The brightest red supergiants resolve individually at V = 1 1 .8 at a color of *li* — *V* =1.7.

NGC 3109 **SmlV** **HA, p.** ***39***
CD-1S5-S
Feh 3/1, 1978
103aO + **GG385**
60 min

NGC 3 109 is a highly resolve,! **nearby** galaxy **immediately** outside **the** Local **Group, ll** has **a redshift, corrected to the centroid** of **the Local Group,** of v_0 **= 122 km** s^{-1}**. Evidently il is at ;i distance** where **the** local **expansion** field has **become evident,** just **beyond the** zero **velocity** surface of the Local **Group (Sandage 1 986a, Fig.**

The distance modulus **determined from Cepheids** is m - *M* = 26.4. or /) - 1.9 **Mpc** (Sandage and Carlson 1988). **The brightest blue** stars begin to resolve at *B* = 18.0. Tin- **brightest** red stars begin to **resolve at** V = 18.8 **al a color of/;-** *v*= **1.7.**

NGC 4214 **SBmlll** **CVn I Cloud**
PH-3563-S **B4 Gr**
April 15/16, 1960 **HA, p.** ***40***
103aO + GG13
20 **min**

NGC 42 14 is a highly resolved Magellanic Cloud-type galaxy in the nearby CVn I Cloud (the B4 Group), which also contains NGC 119 0. NGC 4395, NGC 4449. and [C 4 182. among other well-resolved very-late-type galaxies. A description of the group is in the paragraphs **for** NGC 4395 (panel 324). **The** redshift of NGC 4214 is *v*,, = 290 km s'.

Preliminary photometry **of the brightest** resolved stars in NGC 42 14 gives a distance modulus **of** *m* - *M* = 28.4 **based** on *V* = 20.4 **for** the brightest red supergiants. The apparent magnitude for the brightest blue supergiants is *B* = 18.8, also from this **preliminary** photometry.

HoII ImlV-V HA, p. *39*
PH-1600-B M81/NGC 2403 Gr
Nov 30/Dee 1, 1956
103aO + GG1
25 niiii

Hull was first identified by Holmberg (1950) in his catalog and study of the M81/NGC 2403 Group. The resolution into individual stars is at the same bright level as in other members of the Group, such as NGC 2403 (Sc; panel 273), NGC 2366 (SBmlV-V: panel 327), and NGC 4236 (SBdIV: panels 324, S10).

Photometry of the brightest red and blue stars has been done by Sandage and Tammann (1974b) and by Hoessell and Danielson (1984). The blue stars begin to resolve at about B = 19.7 in the photometry of Santiago and Tammann. The brightest red supergiants begin to resolve at about V' = 20.2.

In the photometry of Hoessell and Danielson, the brightest blue stars resolve at B = 17.8. The identification of the brightest stars differs between the two studies. Finding charts of the individual stars are given in both. New photometry is required (c. 1991) to remove this important discrepancy.

HoII has a maximum "rotational velocity" of 58 km s^{-1}, determined from the 21-cm line profile (Huchtmeir, Seiradakis, and Materne 1981). Its heliocentric systemic velocity is $r_{sl(/J}$ = 159 km s^{-1}. Correction to the centroid of the Local Group gives v_0 = 329 km s^{-1}, clearly beyond the zero velocity surface of the Local Group. HoII is, beyond doubt, in the near expansion field (see Fig. 9 of Sandage 1986a) of the very local Hubble flow.

Leo A ImV
PH-95-S
Jaii 3/4, 1952
103aO + WG2
15 min

The dwarf galaxy Leo A (RA_{50} = 9^{1}' 57.55'", Dec5Q = +30° 59.2') was discovered by Zwicky (1942) in one of the first surveys done with the Palomar 18-inch Schmidt beginning in 1936. Photometry of the stellar content (Sandage 1986b) shows that the brightest blue stars begin to resolve at B - 19 and the brightest red supergiants at V - 19. Leo A is one of the faintest dwarfs of type Im in or near the Local Group. If the distance modulus is m — M = 26 (Sandage 1986 b), its absolute magnitude is Mg = -1 3 .

Leo A has a redshift relative to the centroid of the Local Group of v_0 = —32 km s^{-1} (Sandage 1986a). It is, therefore, a Local Group member near the zero velocity surface that separates the Local Group from the cosmologieal expansion field. It is evident from the velocity and distance data that the kinematic radius of the Local Group in the direction of Leo A extends to a distance of about 1.6 Mpc from the Sun.

Sextans A ImlV HA, p. *39*
CD-156-S
Feb 3/4, 1978
103aO + GG385
60 min

Sextans A and B are just beyond the zero velocity surface of the Local Group at a distance modulus common to both at m — M = 26.2 *(D* = 1.7 Mpc), determined from Cepheids (Sandage and Carlson 1982, 1985). The redshift of Sextans A, corrected to the centroid of the Local Group, is v_o = 102 km s^{-1}. Hence, Sextans A is in the very nearby expansion field, immediately beyond the zero velocity surface (Sandage 1986a, Fig. 9); it is not a kinematic member of the Local Group.

Photometry of the brightest resolved stars (Sandage and Carlson 1985: Hoessell, Schommer, and Danielson 1983) shows that the brightest blue supergiants in Sextans A begin to resolve at B = 18 .5 : the brightest red supergiants begin to resolve at V = 18.2.

Pegasus Dwarf ImV
PH-7288-S
Nov 20/21, 1976
103aO + GG13
30 min

The Pegasus Dwarf (RA_{50} = 23^{1}' 26.05"', Dee5o =+14° 29') was discovered by A.G. Wilson during the early stages of the original National Geographic-Palomar Sky Survey. Photometry of the brightest stars has been done by Hoessell and Mould (1982) and by Sandage (1986b). The photometry of Cepheid variables (Hoessell *et at.* 1990) has led to a distance modulus of m— M = 26.2.

The brightest blue stars begin to resolve at about B = 20. The brightest red supergiants begin to resolve at about V = 20.4.

The redshift, corrected to the centroid of the Local Group, is v_0 = 43 km s^{-1} (Sandage 1986a): hence, as with Leo A, the Pegasus dwarf at a distance of 1.7 Mpc is close to the zero-velocity surface of the Local Group.

Sextans B ImlV-V
PH-7105-S
Jan 7/8, 1976
103aO + GG13
30 min

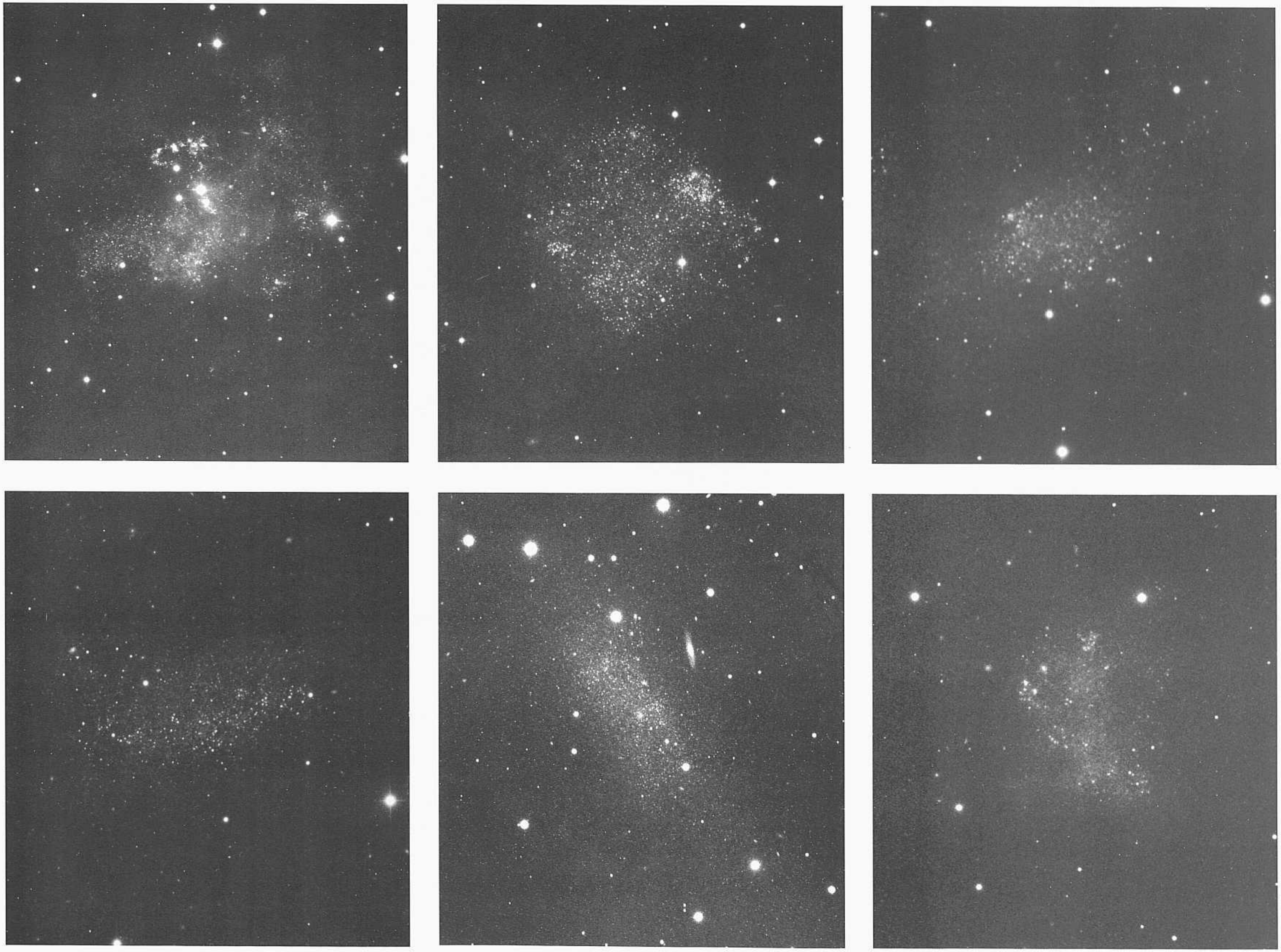
Sextans B, at the same distance as Sextans A based on a study of Cepheids in both galaxies (Sandage and Carlson 1 985), has a redshift corrected to the centroid of the Local Group of v_0 = +114 km s~1 . The Cepheid distance modulus is m - M = 26.2. Hence, in the direction of Sextans A and B the zero-velocity surface of the Local Group is closer to the Sun than 1.7 Mpc.

The brightest blue stars begin to resolve at B = 19: the brightest red supergiants begin to resolve at about V = 19.

Hoi ImV M81/NGC 2403 Gr
PH-5740-S
Jan 18/19, 1971
103aO + GG13
20 min

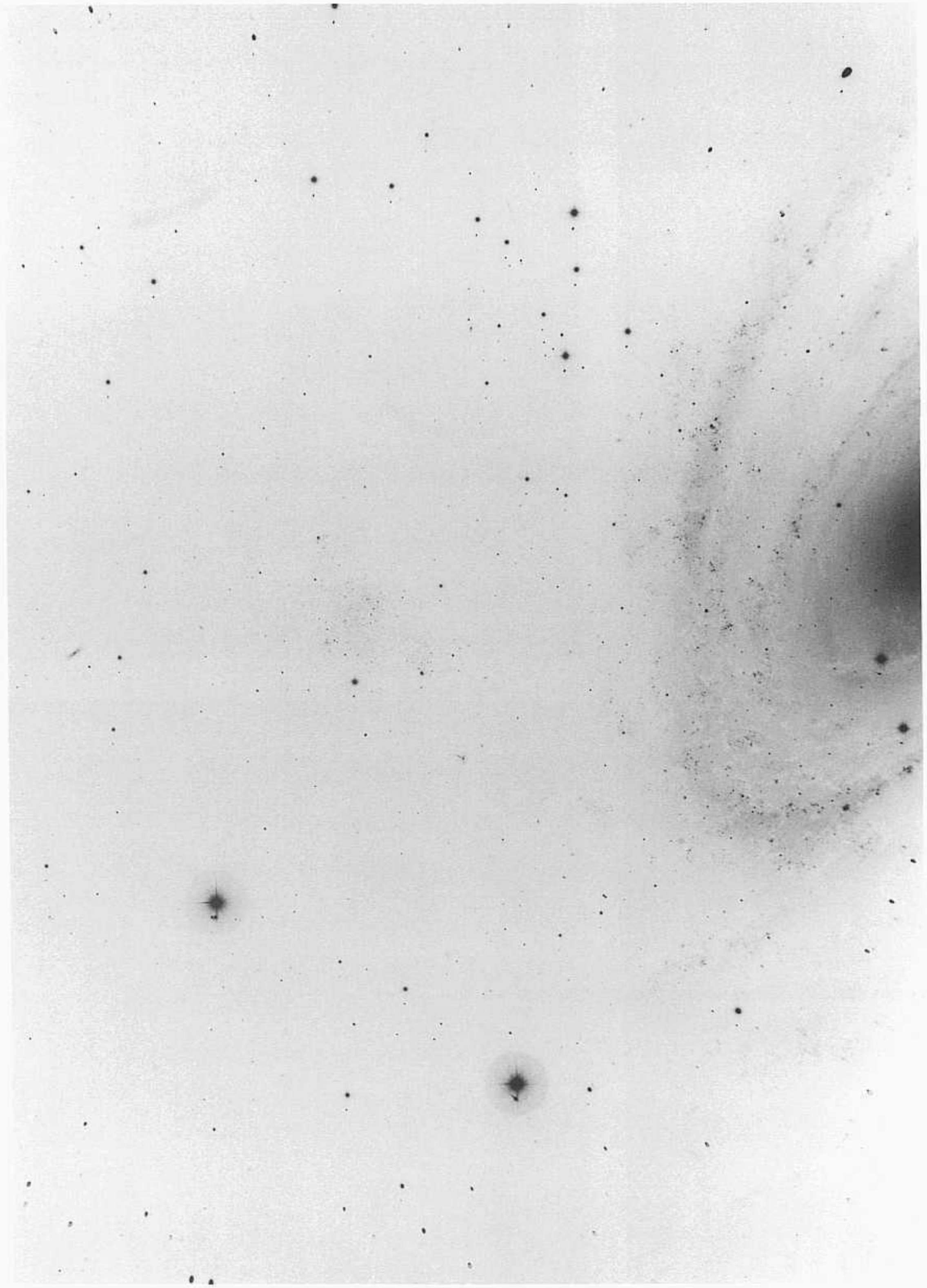
Hoi was first catalogued by Holmberg (1950) in his study of the M81/NGC 2403 Group. The 21-cm systemic velocity of Hoi is v_{sun} = 140 km s^{-1}. Reduction to the centroid of the Local Group gives v_o = 300 km s^{-1}, placing the object well beyond the zero-velocity surface of the Local Group. The distance of the M81/NGC 2403 Group, based on Cepheids in NGC 2403, is m - M = 27.6 (Tammann and Sandage 1968). This distance was confirmed by Freedman and Madore (1988).

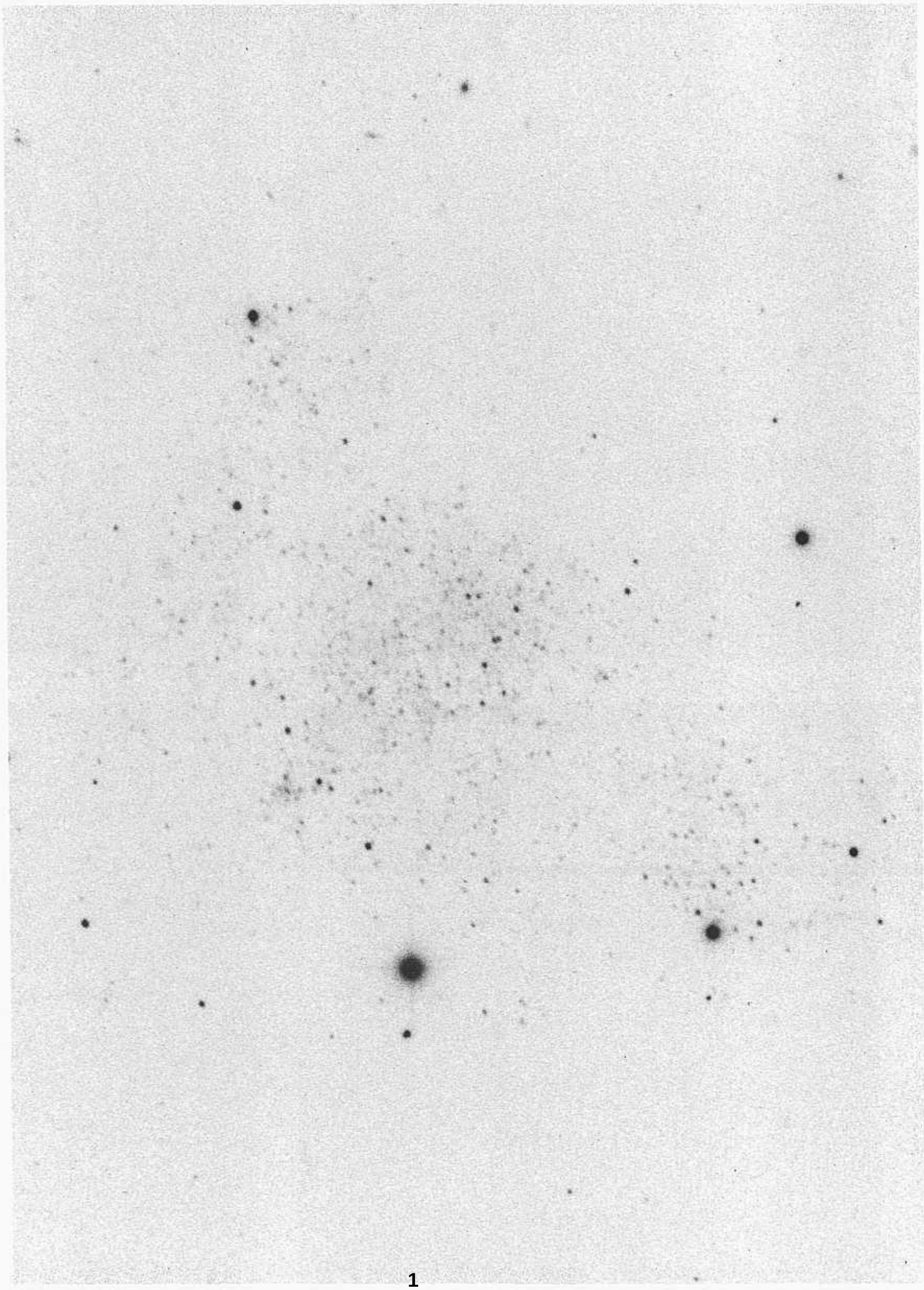
Hoi is less active in its star formation than HoII, shown at the upper left panel. From the photometry and color-magnitude diagram of Hoessell and Danielson (1984), stars of 15 solar masses are currently forming in Hoi, compared with 25-solar-mass stars in HoII.



PANEL
331

PANEL
332





HoIX + NGC 303 I ImV + Sb(r)I-H HA, p. *19*
PH-7140-S panel 129
Feb 1/2, 1976
103aO + GG13
30 niin

HoIX, a dwarf **companion In M8 I**, has **I**....n **catalogued by** van **den Bcrgh (1 9">9, listed** as **DUO 66) and by Holmberg (1969). The low-surface-brightness Im** dwarf **is 10'** nearly **due east of MB I. Bertola** and **Maffei (1974) measured** a **magnitude within an isophote of 26** ***It*** **ina^ per** see" **of** ***li*** **= 1-1.7. Kraan-Korteweg** and **Tamniaim (1 *J 79) adopt** a **total magnitude of** ***IS*** **= 14.6. The distance modulus of** ***m*** **—** ***M*** **= 27.6 for MH 1 (Tammann** and **Sandage 196B). as confirmed by Freedman** and **Madore (I** 9HH). **gives** a **total absolute magnitude of /17/{ = —13.0 for HoIX.**

HoIX ImV M81/NGC 2403 Gr
PH-7110-S
Feb 1/2, 1976
103aO + GG13
30 niin

Photometry of the stellar content (Sandage 1984a) shows thai the **brightest blue** stars **begin** to resolve at about *B* = 19.5. The **brightest** red supergiants begin at about ***V*** **= 20.5 although** there are red star **candidates** whose **membership** is unknown as bright as V' = 19.4.

A 2 1-em study of MSI and the region of HoIX has been made by Gotten m an and Weliaehew (1975) where **III radiation** was deteeted at the position of **HoIX.**

The Amorphous Classification Section

Following definitions and a discussion given elsewhere (Sandage and Brucato 1979), we have classified galaxies as Amorphous based on an amorphous appearance to the unresolved light, the generally high surface brightness of the image, and the Ha filaments that often cover the disk. Examples are M82, NGC 1569, NGC 625, NGC 1705, and others shown in this section. Many of the galaxies of this new morphological type have variously been called "starburst" galaxies; the connection may be important in understanding the physical processes giving rise to the morphological form.

NGC 3034 **Amorphous** **HA, p.** *41*
PH-3921-S **Karachentsev 218**
March 29/30, 1962 **M81/NGC 2403 Gr**
(103aE + Intfer) - (103aD + GG11) **M82**
60 niin **panel** 334

M82 is the prototype of the Amorphous class. It is a companion of M8 1 at **a** separation of 3 7'. At a distance of 3.3 Mpc determined from Cepheids, the projected linear separation of M81 and M82 is small, at 36 kpc.

The image on the left is a **combination** of an Ha interference filter photograph and a 103aD + GG11 yellow continuum image that has been **photographically** subtracted from it. The extensive series of Ha emission filaments perpendicular **to** the plane is emphasized in this subtraction image.

The Hex emission is polarized to the same **high** degree (identical intensity and position angle) as the continuum radiation at **the** same locations, showing that the high filaments are due to scattered Hoc emission light from the more central regions (Visvanathan and Sandage 1972).

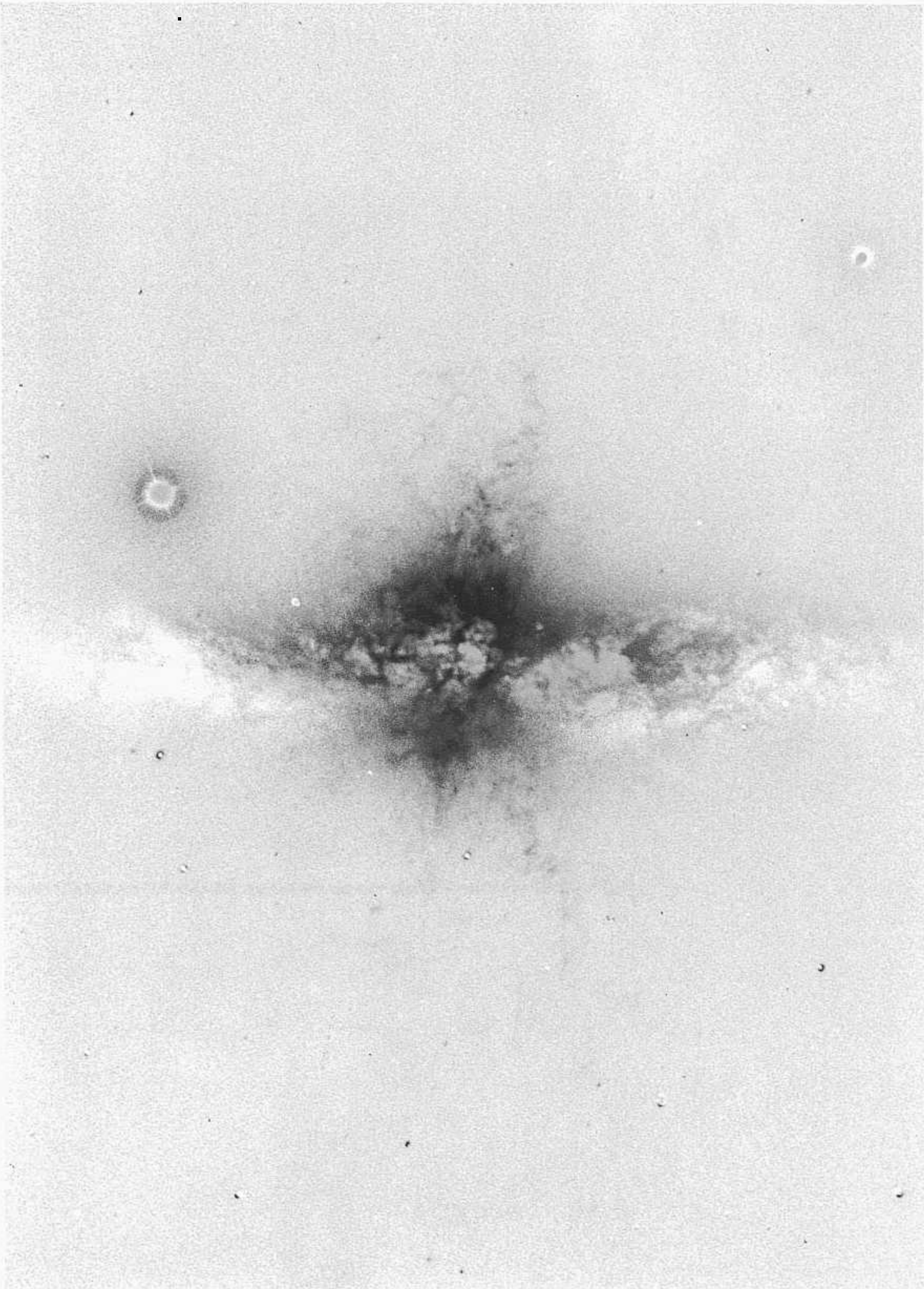
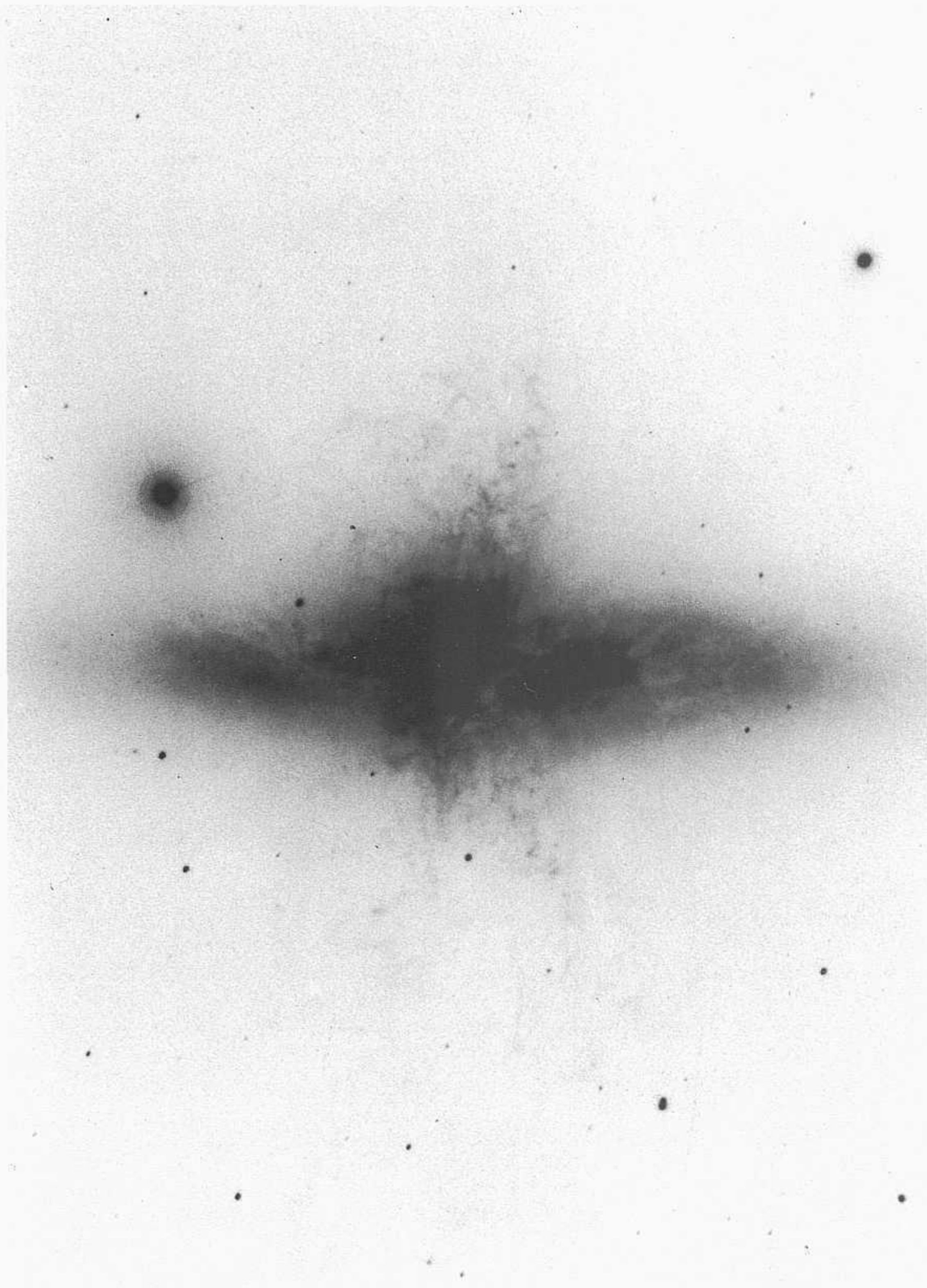
Nevertheless, there is an expansion of material from the center that is real, as shown from long-slit **spectroscopy (Lynds** and Sandage **1963).** O'Conncll and Mangano (1978) have suggested that the expulsion of material from the central regions may be due to massive star formation in the center. Extensive early discussions of the **process** have been made by many authors. A listing of the initial references is **given by** Kronberg *el id.* (1979).

The hoi OB stars, and probably supernovae as well, excite and extrude the gas along the minor axis. This **process** is a favorite hypothesis to explain the amorphous form. Many galaxies in this class (e.g., NGC 625 and NGC 1 569 later in this section) show the same features of emission filaments and explosive motions. Such galaxies, and therefore those members of the Amorphous class similar to M82, have been called starburst galaxies.

NGC 3034 **Amorphous** **HA, p.** *41*
Masked **Ha interference** **Karachentsev 218**
PH-3921-S **M81/NGC 2403 Gr**
March 29/30, 1962 **M82**
103aE + interference **filter** **panel** 334
180min

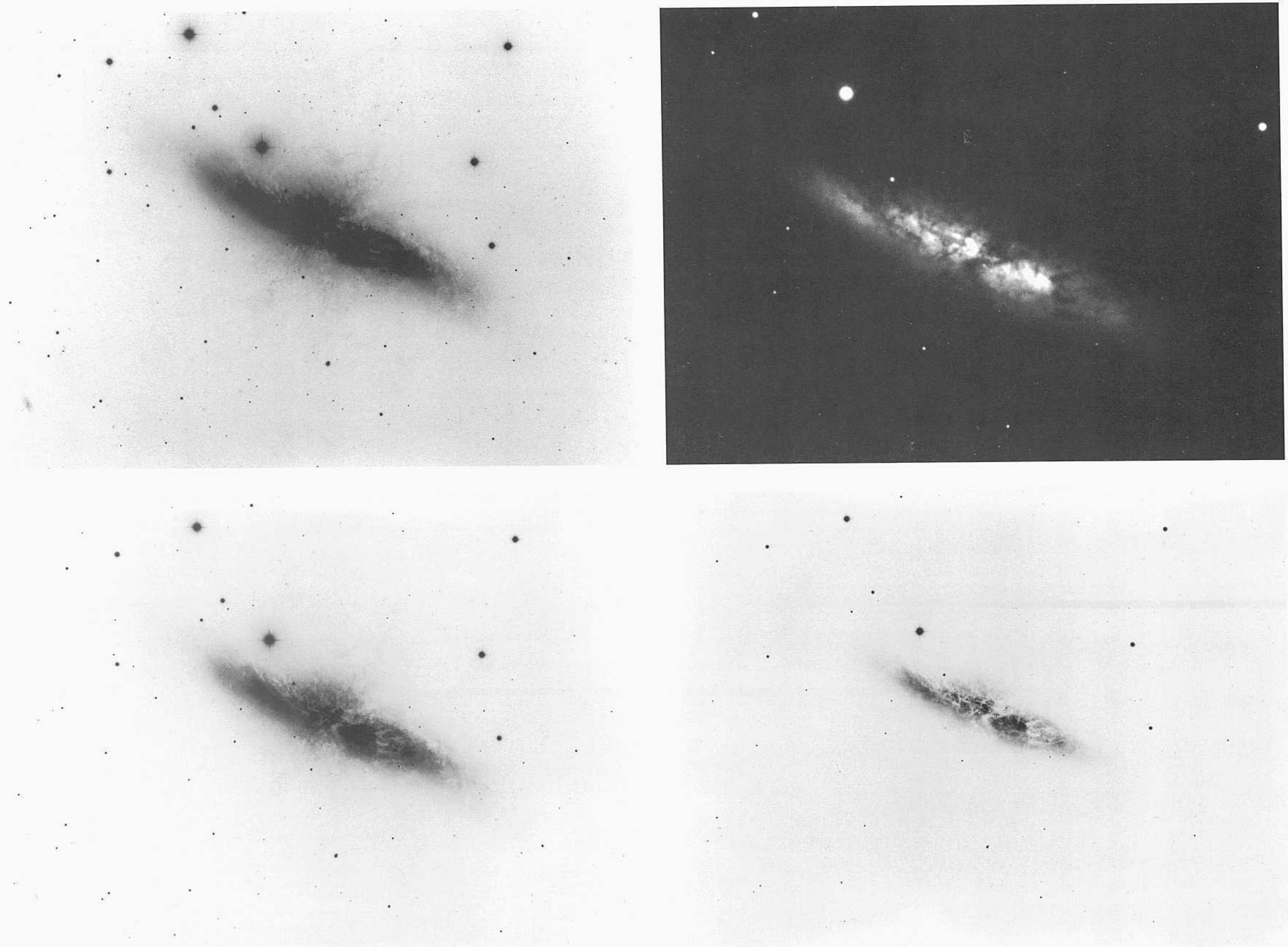
The image on the right is from an Hex photograph taken with an interference filter of 80 Å total half-width, dodged to increase the latitude of the print. Spectra with the slit along the minor axis show that the Ha gas mass is expanding from the center on both sides of the major axis (Lynds and Sandage 1963). Confirmation, and a more detailed mapping of the expansion velocity field along the minor axis, were made by Burbidge, Burbidge, and Rubin (1964).

As mentioned in the paragraphs at the left, light from the base of the minor-axis filaments is highly polarized, as was discovered by Elvius (1962, 1967. 1969). The outer filaments are also highly polarized (Sandage and Miller 1964; Sandage and Visvanathan 19 69: Visvanathan and Sandage 1972).

PANEL
333

PANEL
334



NGC 3034 Amorphous HA, p. *41*
PH-51-S M82
Nov 29/30, 1951 panel 333
103aO + WG2
30 min

The four views of M82 on this panel show the features progressively deeper into the center.

The heavily printed image at the upper left is from a broad-band blue plate showing primarily continuum radiation. The delicate filaments high along the major axis are polarized (Sandagc and Miller 1 964). As described on the preceding panel, the identical polarization in the Ha emission line in the same regions shows that these filaments are made visible by light from the center that is scattered by dust, illuminating the filamentary structure from below.

NGC 3034 Amorphous HA, p. *41*
PH-51-S 1VI82
Nov 29/30, 1951 panel 333
103aO + WG2
30 min

This image is from the same original plate used in the print above, but printed to a different contrast by control in the darkroom. The purpose of this print is to begin to show the intricate and extensive dust pattern in the central regions of M82. Very few individual objects are visible over the face of the image. The light is still amorphous.

[NGC 3031 Amorphous HA, p. *41*
PH-214-S M82
Nov 10/11, 1952 panel 333
103al) + GG1 1
2 min

The positive print at the lop right is made from a short-exposure yellow plate. A few individual knots that may hi[1] stars or star clusters appear close to the center. 1ml most of the lumpy Structure is due to dust lanes and patches cutting up the amorphous light. The few individual discrete objects may be giant clusters such as in NGC 625 (panel 336), NGC L569 (panel 336), and NGC 1705 (panel 335).

Radio observation at high spatial resolution over a lime span suggest that many supernovae are present in the central region (Kronberg, Biermaiin. and Schwab 1981). consistent with Lhe starburst hypothesis. If true, the inferred supernova frequency in M82 would be exceedingly high.

NGC 3034 Amorphous HA, p. *41*
PH-52-S M82
Nov 29/30, 1951 panel 333
103aO + WG2
5 min

The dust pattern in the center of MH2 is well seen in this short-exposure blue plate at the lower right.

NGC 3077 Amorphous HA, **p.** *41*
PH-896-S M81/NGC 2403 Gr
Jaii 23/24, 1955
103aD + GG11
30 niin

NGC 3077 was catalogued as a member of the M81/NGC 2403 Group by Holmberg (1950) in his identification and study of the group. The original Hubble type was Irr. Holmberg's (1958) type for NGC 3077, in dividing the Irr types into two groups (by analogy with Baade's two population types), was Irr II, based on color.

The unusual feature in both M82 and NGC 3077 is that neither are well resolved into stars despite the small distance of 3.3 Mpc, based on Cepheids in NGC 2403 and in M81. The small redshifts of M82 and NGC 3077 confirm membership in the group. The redshifts are $f_o(82)$ = 409 km s⁻' and $u_o(3077)$ = 165 km s̄ '.

Both galaxies have high surface brightness and a smooth texture to their surface luminosity, as if there is a veiling of the stellar content. In addition, both have emission-line spectra.

The heavy print of NGC 3077 at the upper left shows the lack of resolution into individual stars. Compare this feature with the very high stellar resolution level in NGC 2403 (panel 273). M81 (panel 129). NGC 2366 (panel 327), HoII (panel 331), and NGC 4236 (panel 324), which are other members of the group. If NGC 3077 is a starburst galaxy like M82, the activity is hidden (as in M82) presumably by dust and/or by a dominating continuum luminosity that floods the image. These characteristics define the Amorphous class.

NGC 3077 Amorphous HA, p. *41*
PH-867-S M81/NGC 2403 Gr
Nov 3/4, 1954
103aO
20 niin

The positive print of NGC 3077 at the bottom left is from a blue plate rather than a yellow plate as in the image above it. Heavy dust absorption lanes exist throughout the image. A few knots are present near the center. These are either individual stars or are star clusters such as are known in other galaxies of this class including NGC 1705 on this panel and NGC I 569 and NGC 625 on the next.

These few individual starlike objects in NGC 3077 begin to appear at about B = 18. Three are very *vt'il.* appearing at about V = 17. Two of the others are moderately blue, found by comparing red and blue plates. At a distance modulus of $m - M$ = 27.6, these apparent magnitudes translate into absolute magnitudes of about -10 and -1], similar to the luminosities of super star clusters in other galaxies of this type, discussed in the remaining panels of this section.

NGC 5253 Amorphous Centaurus Gr
CD-245-S
Feb 14/15, 1978
103aO + GG385
35 niin

NGC 5253 is a member of the nearby Centaurus Group, whose central member is NGC 5128. The mean redshift of the group is near $<v_o>$ = 280 km s̄¹. The group has a diameter of approximately 20° on the plane of the sky. The distance to the group is presently (1991) controversial, ranging betw'ecn 3 Mpc (Tonry and Schechter 1991) and 8 Mpc (Sandage and Tammann 1975a). At a distance of 5 Mpc (m - (V7 = 28.5) the projected linear diameter of the group, corresponding to 20° angular diameter, is 1.7 Mpc, similar to the Local Group.

The heavy print at the top of the middle column shows the characteristic high-surface-brightness, smooth-structured envelope luminosity of the main body that defines part of the features of the Amorphous class. On small-scale photographs with low spatial resolution, such forms would incorrectly be classed as E or SO types because of this enveloping light. Yet we know that such galaxies are copious current producers of high-luminosity stars. The case is particularly clear in NGC 5253 because of evidence that two very bright supernovae have occurred within the past hundred years (SN 1895B = Z Cen: SN 1972E). The 1972 supernova, discovered by Kowai, probably reached B = 8.5 magnitude at maximum.

NGC 5253 Amorphous Centaurus Gr
CD-2123-S
March 20/21, 1982
103aO + GG385
5 min

The thin positive print at the bottom of the middle column is made from a different original plate than was used above. The high surface brightness of the amorphous light still dominates the central part of the image, but the individual stars in this starburst galaxy are now visible, starting at about B = 18.5. At a distance modulus of $m — M$ = 28.5, the corresponding absolute magnitudes of these objects are M/j = —10, in agreement with the calibration made of such .stars at the Eddington limit using galaxies with known Cepheid distances (Sandage and Carlson 1988).

Note that the dust lanes in NGC 5253 are similar to those in NGC 3077 but are less opaque.

The redshift of NGC 5253 is v_n = 147 km s^{-1}.

NGC 1705 Amorphous
CD-140-S
Feb 1/2, 1978
103aO + GG385
50 min

NGC 1705 was classed as an SO pec in both the RC1 and the RC2 based on small-scale plates taken at Mount Stromlo with the 30-inch Reynolds Telescope. This classification is inappropriate; the problem is caused by the high surface brightness of the amorphous light, as described in the paragraphs on NGC 5253 in the middle column here.

The spectrum is rich in emission lines across the entire disk (Sandage 1978). The strongest lines are Ha, 11(3, and Nl and N2. Objects presumed to be stars are embedded in the intense disk light. They are numerous at B = 20, and the brightest are undoubtedly brighter than this. The color of the disk light is very blue. Robust current star formation is occurring.

NGC 1705 Amorphous
CD-145-S
Feb 2/3, 1978
103aO + GG385
20 min

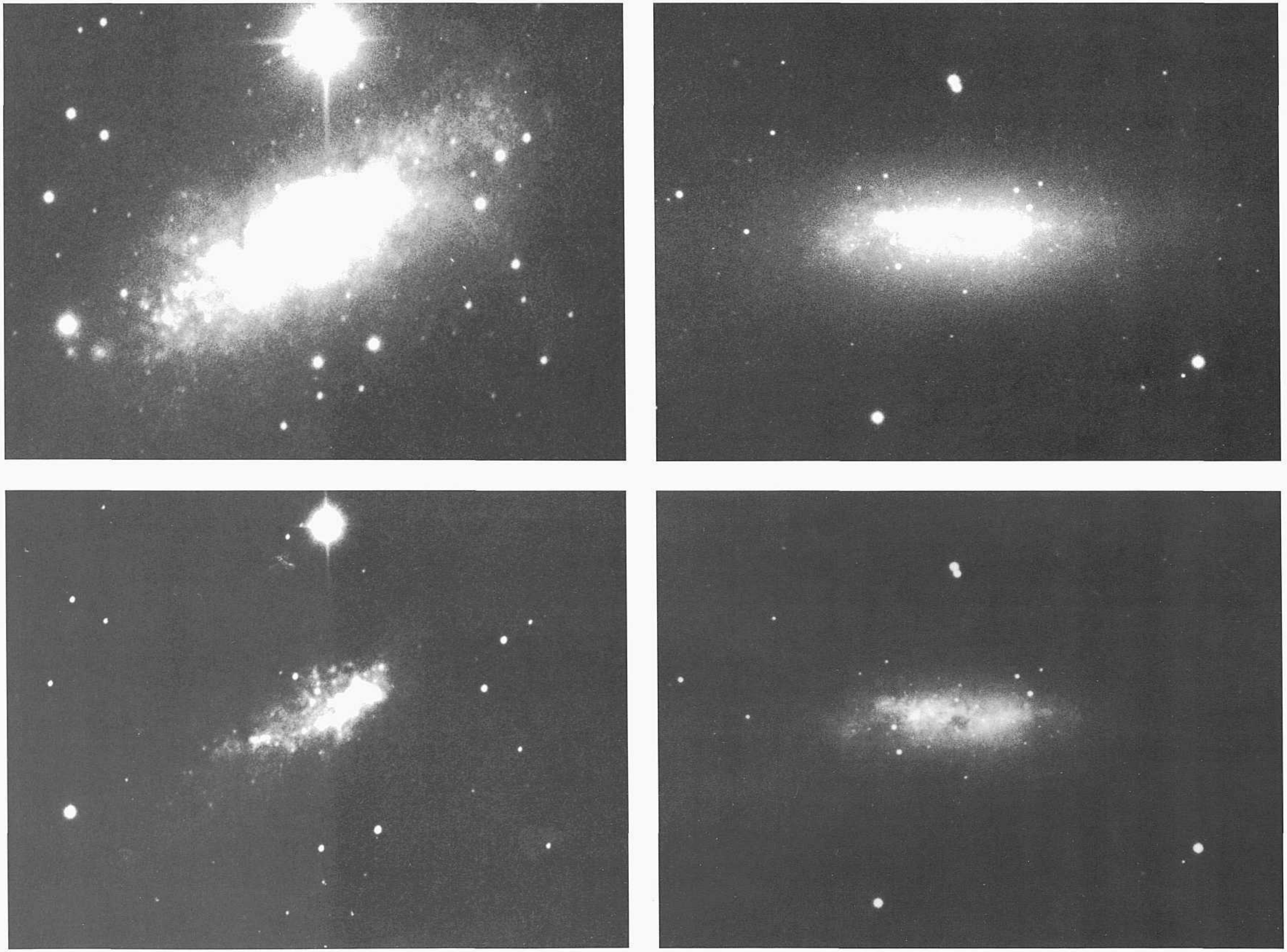
The most curious feature in the image is the presence of an intense blue object displaced from the center by about a third the disk length. The object has a hydrogen absorption spectrum showing the same velocity as the disk emission. The spectrum resembles those of the super star clusters in NGC 1569 **(Arp** and Sandage 1985) that have absolute magnitudes of Mg = -13.

The redshift of NGC 1705 is v_o = 445 km s~'. At the redshift distance of 9 Mpc (m - M = 29.8) the compact blue object with an apparent magnitude of B = 16 must have an absolute magnitude of M_B = -14. Such super clusters are known in NGC 625 (panel 336), NGC 1705 here, NGC 1569 (panel 336), and perhaps NGC 1140.

Spectra (Meurer *et al.* 1988, 1992) show-that gas is being expelled from NGC 1705 by super-galactic winds created by the momentum transfer of the photon energy from the super star cluster to the gas. This is the characteristic process in starburst galaxies and may be a common feature throughout the Amorphous type.

PANEL
335

PANEL
336



NGC 1569 SmlV/Ainorplious
PH-147-H
Oct 13/14, 1952
103aO
25 mill

The distance modulus of NGC 1569 is about $m - M$ » 29 (D = 6 Mpc) from arguments based on its stellar content (Arp and Sandage 1985). Holmberg (1958) classified the galaxy as Irr I. similar to, for example, NGC 2366. However, the image is dominated by a high-surface-brightness amorphous light over much of the central region, shown in the heavy print at the lop left. The spectrum of the disk light is dominated by emission lines (Mayall 1935; de Vaucouleurs, de Vaucouleurs, and Pence 1974).

Stars begin to resolve over the image at about B = 20 (Abies 1971). Tin- redsbifl of NGC 1569 is u_B = 144 km s~[J] . The extragalactic nature of the galaxy was first recognized by Baade (1931), who made the suggestion that its type is similar to the Magellanic Clouds, one of the first of the type to be identified in the general field.

NGC 1569 SmIV
PH-150-H
Oct 13/14, 1952
103aO
5 min

The print here, from a short-exposure plate by Hubble, shows the resolution of the inner region into stars, beginning at about B = 20. However, two very bright objects of B = 15 .7 and B = 16.5 exist in the image. These are members of the galaxy, as shown from the equality of their velocities with the emission velocities of the gas in the disk (Arp and Sandage 1985). The spectra also show that these bright objects are super star clusters, as also described in the discussion of NGC 1705 on the preceding panel. The absolute magnitude of these bright young clusters is unusually high (but matched in NGC 1705 and NGC 62 5) at B = -13.

A discussion and a series of stepped exposure prints of NGC 15 69 showing these clusters is given by Arp and Sandage (1985, Fig. ı)-

A discussion of the role of supergalactic winds in the self-transformation of Im and BCD galaxies into dE,N dwarf elliptical and dS0,N dwarf SO galaxies is given by Sandage and Hoffman (1991).

NGC 625 Amorphous or Imlll
CD-526-S
Sep 29/30, 1978
103aO + GG385
45 min

NGC 62 5 shares the Amorphous features that have been described on this and the preceding panel for NGC 5253, NGC 1705. and NGC 1569. The very-high-surface-brighlncss disk has an emission-line spectrum thai contains [In standard high excitation lines ol 3727. Hell, [Nelll], Hel, H, NI, N2, [Nil], [SII], [AMI], and [A1V]. These lines are evidently excited by the high current star-formation rale of massive stars, evidenced by the resolution ol these stars beginning at about B = If!.

The redshift of NGC 62 5 is v_o = 352. The distance modulus is about m — $ft'I$ = 2Ji. judged from the stellar content.

NGC 625 Amorphous or Imlll
CD-526-S
Sep 29/30, 1978
103aO + GG385
45 min

The light print made from the same plate, above, shows some of the resolution into stars. In addition, visual inspection of the image at the Mount Slromlo 74-inch reflector showed the presence of a bright blue object displaced from the center (as in NGC 1705) at about ii = 15 (Sandage 1978). This object is a super star cluster similar to those in NGC 1705 and NGC 1569. previously described on this a nil the preceding panel. The absolute magnitude of the super star cluster in NGC 625 is near $/Wj$ = -1 3 . similar to the values in the other cases just cited.

NGC 1691 H Amorphous pec pair:
CD-1873-HB HA, p. *44*
April 10/11, 1981
103aO
75 niin

NGC 4691 forms a wide apparent pair **with** NGC 4684 (SO2/3: panel 42) at a separation of **19'.** The **redshifts** are i>„(4684) = 141 1 km s"' and u₀(469 1) = 942 km s~ . At the mean redshift distance of 24 Mpc *(H* = 50) the projected linear separation is 135 kpc if they form a kinematic pair. However, the **redshift** difference of 470 km s~ is high and fails to establish a definite case.

The heavy print at the to]) left shows the external ring; of low surface brightness, **interpreted** by Hubble as smooth arms: hence his classification was SBa.

The classification here is based on the intricate dusl pattern in the central regions, similar to the dust in NGC 307 7. However, the Amorphous classification is less certain than in the **prototype** galaxies on the preceding Iour panels.

NGC **4691** **R Amorphous** pec **pair?**
CD-1873-HB **HA, p.** ***44***
April 10/11, 1981
103aO
75 min

The light **print** here, from the same plate used for the heavy print above, shows the dust pattern in the central regions. The dust lanes are generally perpendicular to the major axis, similar to part of the pattern in NGC 1808 (Sbc pec: panel 193), attributed in the description there to a galactic fountain activity. By analogy, **this** has been taken to suggest the possibility that the gas and dust of NGC 4691 might have a **starburst property.** Supporting evidence is the emission-line spectrum throughout the disk (Sandage 19 78). composed of strong 3727, strong Balmer series emission, strong N2, and weaker Nl .

NGC 2968 **Amorphous or** SO3 pec **panel 49**
PH-7603-S **Karachentsev 210**
April 3/4, 1979
IHaJ + GG385
30 niin

NGC 29 68 is also illustrated and described in the SO section on panel **49.** H forms a triplet with NGC 2964 (Sc; panels 240, 251) at a separation of 6.3' and with NGC 2970 ($S0_3$: not in the RSA) at a separation of 5.0'. The redshifts are i>₀(2968) = 1551 km s~', u₀(2970) = 1629 km s~', and u₀(2964) = 1292 kms"'. At the mean redshift distance of 3 0 Mpc (// = 5 0) the projected linear separation of NGC 2 964 from NGC 2968 is 55 kpc and the separation of NGC 2970 from NGC 2968 is 44 kpc. A physical association between NGC 2968 and NGC 2970 is assured by the circumstance that a supernova occurred (SN 1970L, discovered by Wild) on the luminous bridge connecting NGC 2 968 and NGC 2970. A photograph of the configuration is in Tammann (1973).

The **Amorphous** classification of NGC 2968 is based on the character of the dust (similar to that in M82 and NGC 3077).

NGC 4383 Amorphous? (not SO) VCC **801**
CD-1854-HB
April 4/5, 1981
103aO
75 min

NGC4383 is listed as a member of the Virgo Cluster in the Virgo Cluster Catalog. Its redshift is small at v_0 = 284 km s^{-1}, but its distance is much **larger** than would be implied by this small value, consistent with cluster membership and the high virial velocities of cluster members. Resolution into stars and **Hll-region** candidates does not occur, indicating a distance that must be similar to that of the Virgo Cluster core.

The classification of NGC 438 3 as Amorphous is indicated by the high surface **brightness** of the image and the character of the dust lanes.

NGC 1531 **Amorphous** **group**
CD-1669-S **panel 197**
Dec 31/Jan 1, 1980/1981
103aO + GG385
4-5 **min**

NGC 1531, here, is a close companion of NGC 1532 (Sbc; panel 1 97); the pair is presently in a close encounter.

The enlargement of this print is great enough to exclude any **part** of NGC 1532 (panel 197) which is at an angular separation greater than 1.8'. A description of the pair and the peculiar morphology of NGC 1532 is on panel 197.

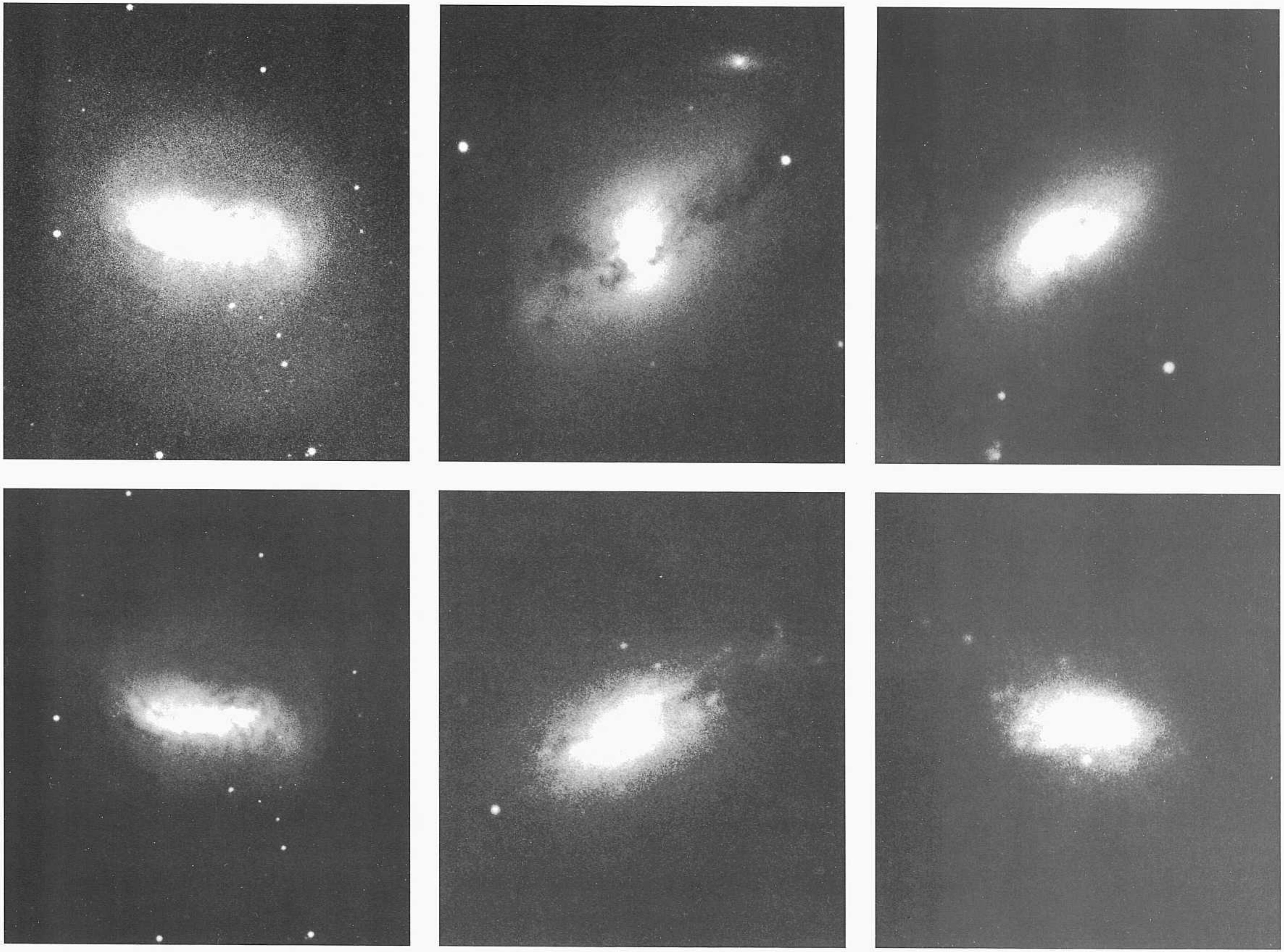
NGC 1531 has an amorphous texture to its luminosity distribution: there is evidence of dust in the image.

NGC **4765** **Amorphous?**
CD-2165-S
March 27/28, 1982
103aO + GG385
45 **min**

NGC 4765 is just outside the boundary of the Virgo Cluster survey region (Binggeli, Sandage, and Tammann 1985). The region is complex; it is near the supergalactic ridge-line in a confused kinematic area where redshifts do not indicate distance.

The redshift is v_o = 626 km s~[1]. Resolution into knots is visible at the **periphery** of the disk. It is probable that such resolution is present throughout the disk but is hidden by the high surface brightness.

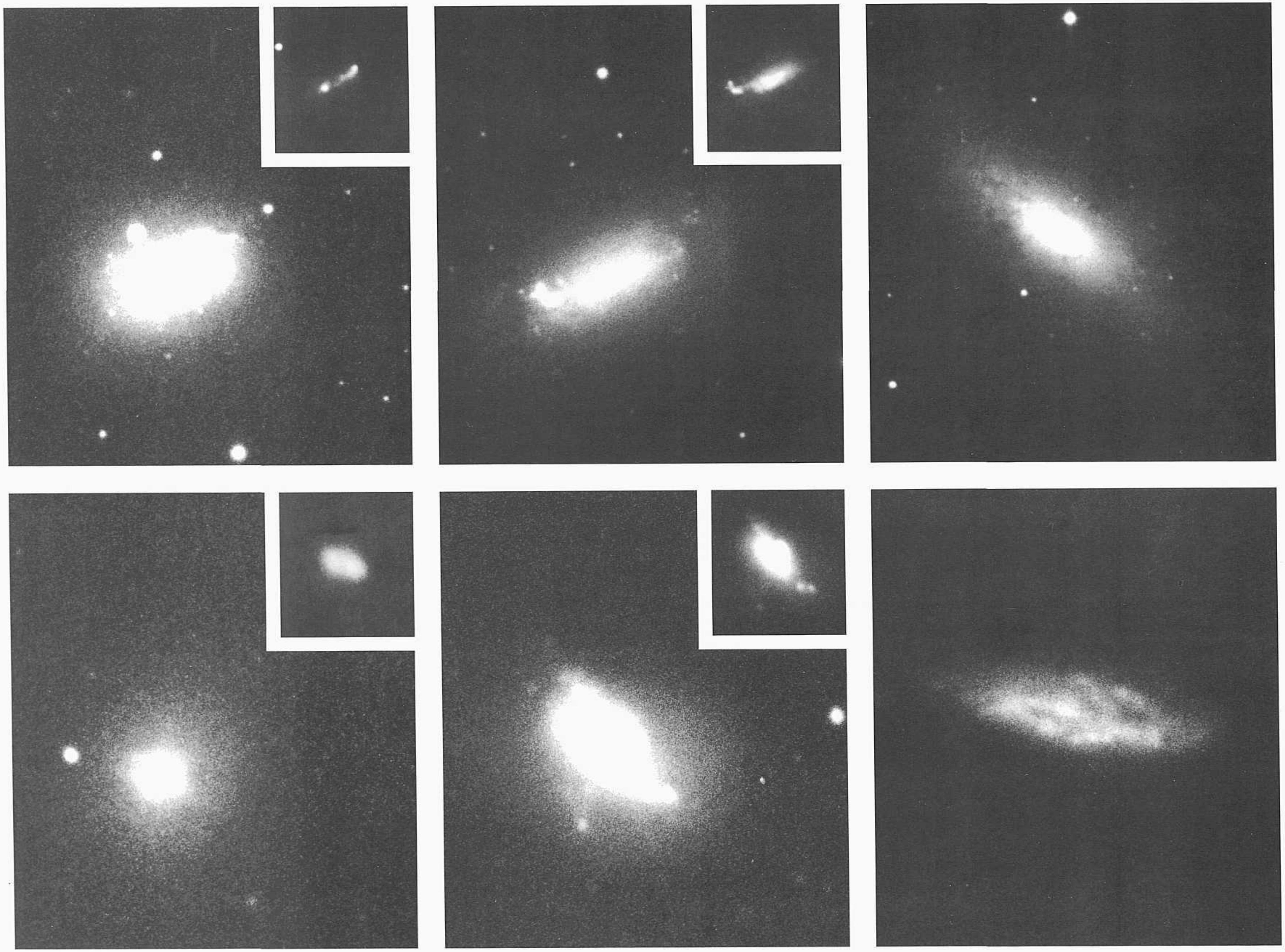
The morphological classification is uncertain.



I^3ANHL

337

PANEL
338



The six galaxies on lliis page do not fit into the morphological boxes of the standard classification system. Each, at the resolution available on the existing plate material, has certain features common to the Amorphous galaxies shown on the preceding five panels. Therefore these galaxies have been put at the end of this section.

Most have intense emission spectra. Several (NGC 3125, NGC 3773, etc.) have possible superluminous star clusters at absolute magnitudes of about /V//j = —15.

NGC 3125 Amorphous
CD-721-S
Feb 1/2, 1979
103aO + GG385
15 mill

NGC 3125 has an outer envelope morphology similar to those in NGC 625, NGC 1705, and NGC 5253. The disk is of high surface brightness. There is a hint of resolution into individual objects (stars?) in the outer envelope. The most telling feature suggesting the Amorphous classification is the two very bright objects near the center (seen in the insert), of magnitude B = 17.

The redshift is v_o = 827 km s"[1]. At the redshift distance of 16 Mpc (m - M = 31) the absolute magnitudes of the knots are A'/g = —14, similar to the luminosities of the four super star clusters in NGC 625. NGC 1705, and NGC 1569, described on the preceding panels.

The spectrum of the disk of NGC 3125 shows extremely hard, high-excitation emission lines including Hell at 4686 (Penston, Fosbury, Ward, and Wilson 1977). The three amorphous galaxies just mentioned also have high excitation emission spectra.

The presence of the super star clusters, the hard emission radiation, and the amorphous light of the envelope are the reasons for assigning the Amorphous classification.

NGC 3773 Amorphous; pec jet
CD-2184-S
March 29/30, 1982
103aO + GG385
30 mill

NGC 3773 insert
CD-2183-S
March 29/30, 1982
103aO + GG385
5 min

The morphology of NGC 3773 is similar to that of NGC 3125, above. The surface brightness of the smooth disk light is very high. The spectrum of the disk shows a strong ultraviolet continuum and intense emission lines of 3727, hydrogen Balmer f3, Nl, and N2 (Sandage 1978).

The two very bright objects at the center each have an apparent magnitude of about B = 16. These show in the insert print as a merged pair. The redshift of NGC 3773 is v_o = 851 km s~[1]. At the redshift distance of 17 Mpc (m - M = 31), the absolute magnitude of each of the objects is Mg = -15, similar to the bright objects in NGC 3125 and other galaxies of this class.

The insert print is made from a different original plate than is used in the heavy main print, but is not of short-enough exposure to separate the images of the pair of central objects that still overlap here.

NGC 1800 Amorphous
CD-527-S
Sep 29/30, 1978
103aO + GG385
45 min

NGC 1800 insert
CD-1345-S/Br
March 15/16, 1980
103aO + GG385
10 min

The optical morphology of NGC 1800 is similar to that of NGC 625. The surface brightness is high. The light is amorphous. Individual stars resolve in the outer regions of the disk, outside the high-surface-brightness area (and very likely inside as well). Bright knots exist that may be superluminous star clusters. The spectrum of the disk light shows high excitation conditions; moderately strong 3727, HfJ, Nl, N2, and [Nil] emissions are present. The radiation is hard, judged by the greater intensity of the N2 line than that of 11(3 (Sandage 1978).

The redshift is v_Q = 586 km s^{-1}.

The bright knots in the outer regions show in the insert print. The surface brightness in the center is still too high to see the center where other possible superluminous star clusters may exist.

NGC 3353 Amorphous? Ursa Major Cluster
PH-7978-S
Feb 1/2, 1981
103aO
12 nun

NGC 3353 insert
PH-7979-S
Feb 1/2, 1981
103aO
2 min

The optical morphology of NGC 3353 is similar to that of other galaxies on this and the preceding panels. The surface brightness of the amorphous light is high. The optical spectrum of the disk shows intense high-excitation emission lines and many lines of the Balmer series, also in emission (Sandage 1978).

The redshift is v_o = 1089 km s^'.

A bright knot exists close to the center, embedded in the high-surfacc-brightness image and not seen in this insert print. On the available plate material the object is not circular. (It may be double, similar to the double "cluster" in NGC 3773, at the left). The apparent brightness is B = 15 (or if double, B = 16 for a single image).

At a distance modulus of m — M - 31.7 (H = 50) the absolute magnitude of the object(s) would be .V/g = —16. Hence, the objects are candidates for super star clusters, similar to such objects in other galaxies of this class.

NGC 4694 Amorphous VCC. 2066
CD-802-S
Feb 24/25, 1979
103aO + Wr2c
45 min

NGC 4694 is at the eastern edge of the Virgo Cluster survey field (Binggeli, Sandage. and Tammann 1985). It is listed as a cluster member in the cluster catalog. Its redshift is v_0 = 1059 km s^{-1}.

The spectrum shows a strong UV continuum and a pronounced hydrogen absorption spectrum in the center. Several features, all similar to the various characteristics of other Amorphous galaxies in this section such as M82 and NGC 3077. arc (1) the early-type absorption spectrum, indicating recent star formation, (2) the character of the amorphous light in the image, and (3) the nature of the evident dust patches.

NGC 3043 S pec
PH-7956-S
Nov 8/9, 1980
103aO
12 mill

The classification of NGC 3043 is uncertain because of the high inclination and poor spatial resolution. The surface brightness is low. limission lines of 3727 and Ha extend across the image (Sandage 1978). The galaxy is shown here for completeness.

NGC 3418 **Amorphous** **pair**
PII-8049-S **Arp 205**
Feb 4/5, 1981 **Racine** wedge
103aO
12 min

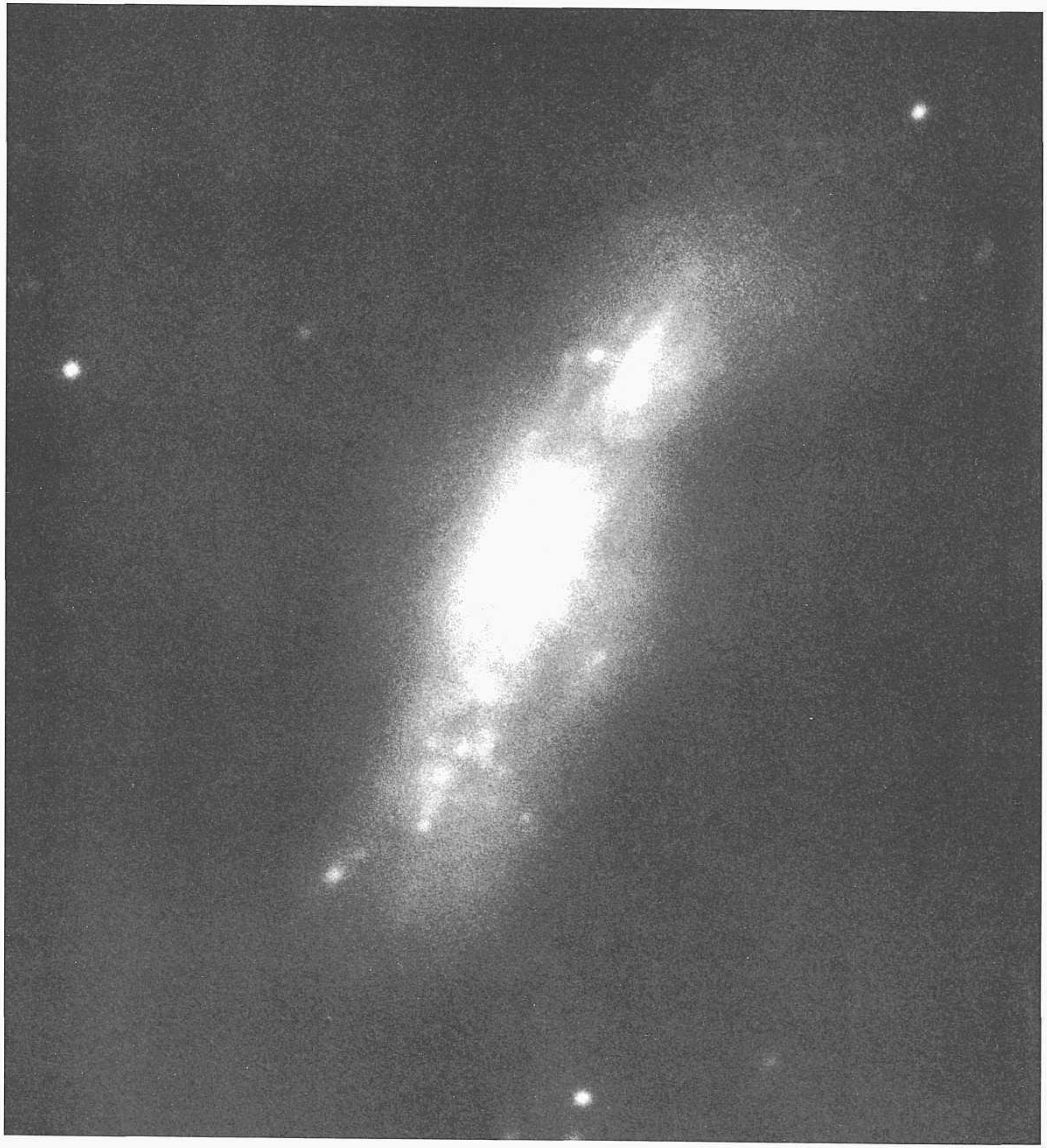
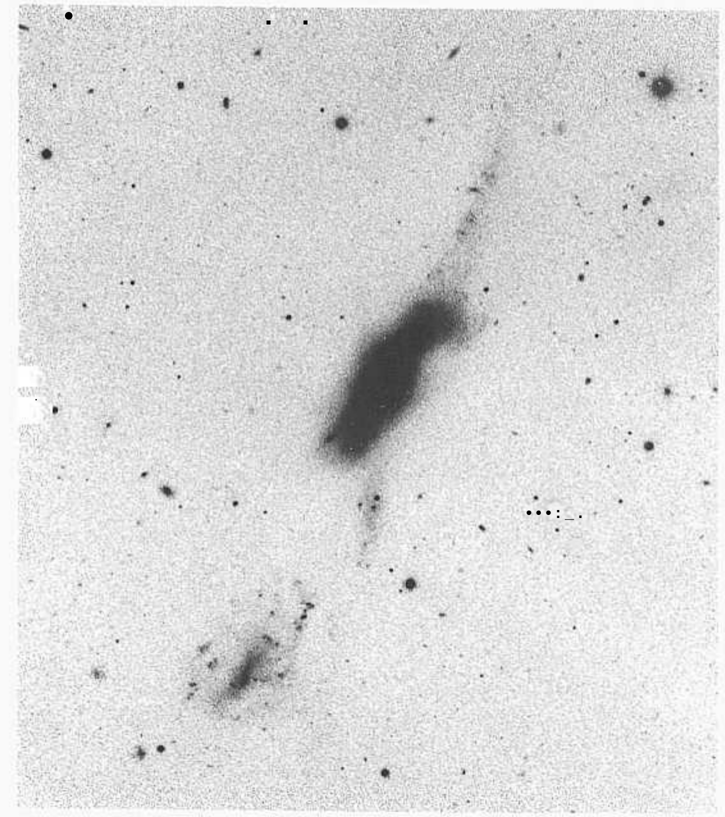
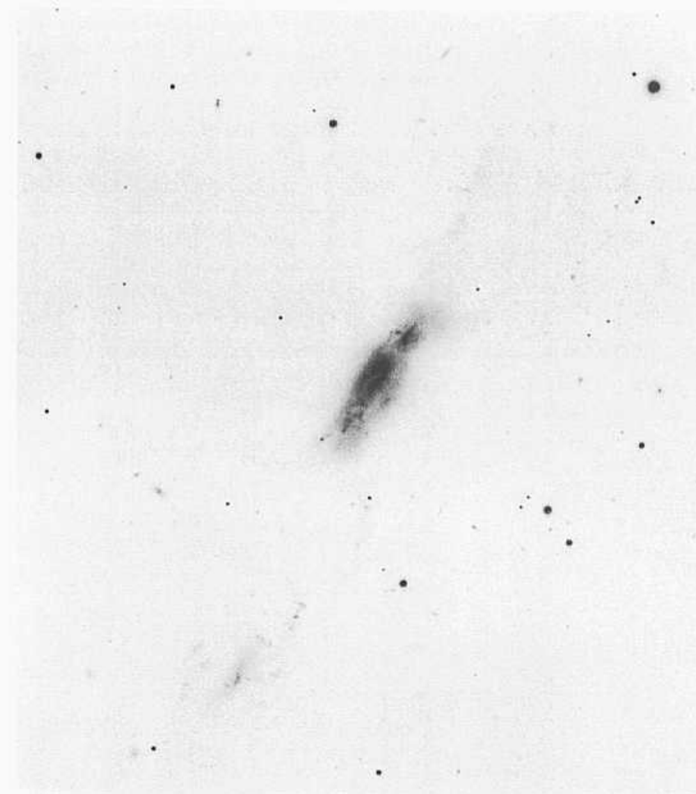
NGC 3448 **is the brightest member of a pair** that **is evidently** in a close encounter. What appears to he a tidal **plume** exisLs on one side of the main body (toward the upper-right corner of the prints on **the right).**

A close companion exists on the other side, at a separation of 3.9' (near the lower-left corner of the two). This anonymous galaxy of very low surface brightness is of morphological type Scd with some suggestion of a tidal **perturbation** in one of its arms. There is also a shred **(tidal debris?)** between the main body of NGC 3448 and the companion.

The v_0 redshifts for each segment of the configuration listed by Palumbo, Tanzella-Nitti, and **Vettolani** (1983) arc about 1440 km s'" for the main body of NGC 3448 itself. 1325 km s' for the Scd companion, and 1494 km s^{-1} for the tidal plume of NGC 3448 on the opposite side of the image from the companion. At the mean redshift distance of 28 Mpc *(H* = 50) the projected linear separation of the Scd companion from NGC 3448 is small at 32 kpc.

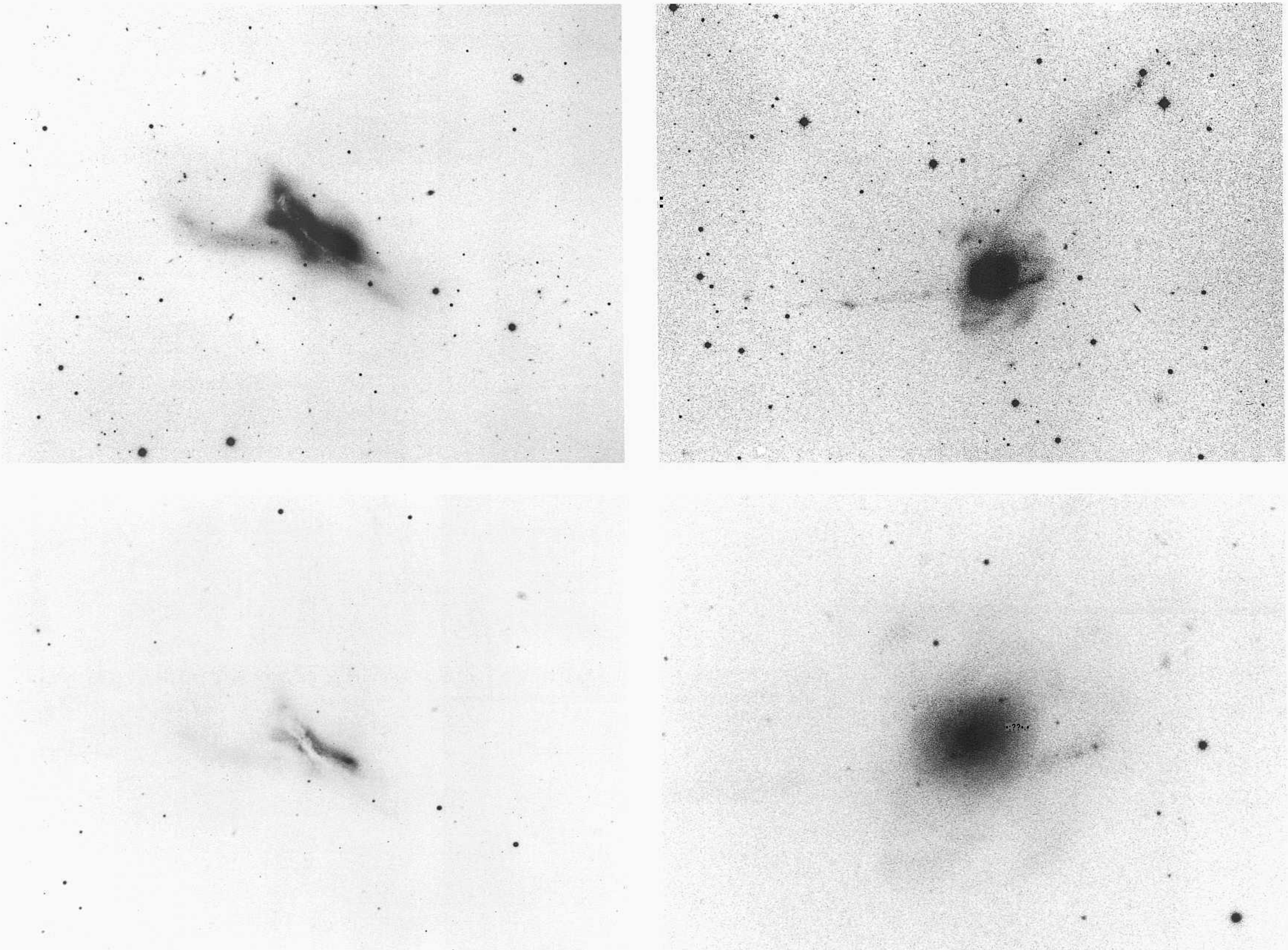
The three prints here have been made from the same original Palomar plate, printed to different contrast and scale.

The plate was taken with a Racine wedge in the optical path. The bright stars have secondary images 5 mag fainter than the primary and are separated by 18" in a direction south and slightly east of the primary.

PANEL
339

PANEL
340



NGC 520 Amorphous HA, p. *41*
PH-176-H
Sep 3/4, 1953
103aD + GGll
40 min

The morphology of NGC 520 has always been described as unusual, not fitting into any of the morphological boxes of the standard classification sequence. Hubble (as reported by Pettil 1954) classified NGC 520 as Irr. Holmberg (1958) placed NGC 520 into his new Irr II class, based on the amorphous appearance of its luminous image, the absence of resolved stars, and its red color. These are the same features, along with the dust pattern similar to that in M82 (panels 333, 334) and NGC 3077 (panel 335), used in classifying the galaxy Amorphous here.

However, the faint plumes on opposite sides of the center suggest either tidal interaction or, following Toomre and Toomre (1972), the result of a merger, as in NGC 4038/4039 (panel 280).

Images of what may be individual stars appear in the main plume beginning at about B = 22.5. The redshift is v_o = 2350 km s'. At the redshift distance of 47 Mpc (H = 50, m - M = 33.4), the absolute magnitude of such objects is bright, at M_B = -11.

NGC 520 Amorphous HA, p. *41*
H-1674-H
Nov 28/29, 1935
Imp. Eel.
60 min

The light print of NGC 520 made from a plate taken with the Mount Wilson Hooker 100-inch telescope shows no evidence for the double nucleus that might he expected from a recent merger, although some theories suggest that none need be expected. Based simply on the morphology of the image, the idea that a merger has occurred remains an unproved hypothesis.

NGC 7252 Merger or SO, pec
CD-1564-S/Br
Aug9/10, 1980
103aO + GG385
45 min

NGC 7252. with its two principal long, thin plumes and its many shorter plumes near the main body, was originally suggested by Toomre and Toomre (1972) to he the product of a merger. Schweizcr (1 982 , 1983) argued the rase for a merger of two disk galaxies using data on surface brightness, spectroscopy, and internal kinematic structure. Dynamical interaction simulations by Borne and Richstone (1982, 199 1) support this interpretation.

The heavy exposure in the lop print with a wide view shows the principal plumes. These features are shown particularly well in the series of images by Schweizer (1982). Star formation (HH-region candidates) in each of the outer plumes is also suggested there.

NGC 7252 Merger or SOi pec
CD-1564-S/Br
Aug 9/10, 1980
103aO + GG385
45 min

This light print is made from the same original plate used for the heavy print above. The inner image shows an SO-like luminosity distribution, and the central core is clearly SO; there is an apparent break in the gradient of the profile two-thirds the way out the disk, giving the two-zone look characteristic of the SO class often discussed in the SO section.

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INDEX

Index to all galaxies shown in the Carnegie Alias

NAME	PANEL	TYPE
NGC 1087	279	Sc(s)III.3
NGC 1090	296	SBc(s)I.8
NGC 1097	201	RSBbc(s)I-n
NGC 1156	326	SmIV
NGC 1169	96.106.S9	**SBa(r)]**
NGC 1172	31	SO *i* (0.3)
NGC 1175	40	$S0_2(8)$
NGC 1179	295	SBc(r)II.2
NGC 1187	182	Sbc(s)II
NGC 1199	22	E2
NGC 1201	33	SO!(6)
NGC 1209	13	E6
NGC 1232	216. S13	Sc(rs)I
NCG 1232A	216	SBmlll
NGC 1241	206	SBbc(rs)I.2
NGC 1249	311	SBc
NGC 1255	250	Sc(s)II
NGC 1275	24	E pec
NGC 1288	134	Sb(r)I-II
NGC 1291	100.102.S8	SBa
NGC 1292	249	**Sc(s)II**
NGC 1297	42	$S0_2/_3(0)$
NGC 1300	154.S8	SBb(s)I.2
NGC 1302	70	Sa
NGC 1309	255	Sc(s)II
NGC 1313	309	SBc
NGC 1316	73	Sa pec (ripples)
NGC 1317	62.S12	Sals)
NGC 1325	141	Sb(s)II
NGC 1326	100	RSBa
NGC 1332	34	S0i(6)
NGC 1337	231	Sc(s)I-II
NGC 1339	10	E4
NGC 1341	304	SBc(s)II-III
NGC 1344	28	E5/S0](5)
NGC 1350	71. 88. S3	Sa(r)
NGC 1351	28	E6/S0](6)
NGC 1353	190	Sbc(r)II
NGC 1357	68	Sa
NGC 1358	100.107.S8	SBa(s)I
NGC 1359	271	**Sc(s)II-III**
NGC 1365	199.S8	SBbc(s)I
NGC 1366	28	S0!(7)/E7
NGC 1371	**64, 80.88.S3**	Sa(s)
NGC 1376	221	Sc(s)I
NGC 1379	2	E0
NGC 1380	61	S03(7)/Sa
NGC 1381	37.50	$S0_X(8)$
NGC 1385	308	SBc
NGC 1386	76. S14	Sa
NGC 1387	56	$SB0_2$ pec
NGC 1389	35	S0i(5)/SB0!
NGC 1395	5	E2
NGC 1398	120.121	SBab (r)I
NGC 1399	19	El
NGC 1400	43	$S0_3(l)$
NGC 1404	5	E2
NGC 1406	291	Sc
NGC 1411	40	SO2(4)
NGC 1415	77	Sa/SBa(late)
NGC 1417	128	Sb(s)1.3
NGC 1421	291	Sc
NGC 1425	139	Sb(r)II
NGC 1433	158.169.**1**70	SBb(s)I-II
NGC 1437	254	Sc(s)II
NGC 1440	57	SBOj/2/a
NGC 1448	287	Sc(s)II
NGC 1452	97.107	SBa(r)
NGC 1453	2	E0
NGC 1461	40	$S0i/_2(7)$
NGC 1493	308	SBc
NGC 1494	315	Scd/SBcd
NGC 1507	318	Scd/SBcd
NGC 1511	292	Sc pec or Amorph?
NGC 1512	161	SBb(rs)I pec
NGC 1515	139	**Sb(s)II**
NGC 1518	272	ScIII
NGC 1521	8	E3
NGC 1527	40	$S0_2(6)$
NGC 1531	197,337	Amorph
NGC 1532	197	Sbc(s)(tides?)
NGC 1533	90	$SB0_2(2)$/SBa
NGC 1536	313	SBc
NGC 1537	13	E6
NGC 1543	100.102	$RSB0_2/_3(0)/a)$
NGC 1546	273	Sc(s)III
NGC 1549	5. SI	E2
NGC 1553	39	SO i/2(5) pec
NGC 1559	299	SBc(s)II.2
NGC 1566	171,S5	Sbc(s)1.2
NGC 1569	336	SmIV/Amorph
NGC 1574	56. S7	$SB0_2(3)$
NGC 1596	51	S0i(7)
NGC 1602	51.328	SBm
NGC 1617	79. 87	Sa(s)
NGC 1625	186	Sbc(s)I-II
NGC 1637	306	SBc(s)II.3
NGC 1638	73	Sa
NGC 1640	206	SBbc(r)I-II
NGC 1659	263	Sc(s)II-III
NGC 1667	234	Sc(r)I-II
NGC 1672	136	Sb(rs)II
NGC 1688	299	SBc(s)II
NGC 1700	8	E3
NGC 1705	335	Amorph
NGC 1726	27	$E4/S0_2(4)$
NGC 1744	316	Scd/SBcd
NGC 1784	210	SBbc(r)II
NGC 1792	255	Sc(s)II
NGC 1796	313	SBc
NGC 1800	338	Amorph
NGC 1808	193	She pec
NGC 1832	160	SBb(r)I
NGC 1947	45	SO 3(0) pec
NGC 1961	137	Sb(rs)II pec
NGC 1964	131	Sb(s)I-II
NGC2082	270	Sc(s)II-III
NGC 2090	250. 257	Sc(s)II
NGC 2139	312	SBc
NGC 2146	146	Sbll pec
NGC2179	64	Sa
NGC 2188	319	Scd/SBcd
NGC 2196	111	Sab(s)I
NGC 2207	214	Sc(s)1.2
NGC 2217	101, 1**04, 10**7	SBa(s)
NGC 2223	205	**SBbc(r)I.3**
NGC 2268	188	Sbc(s)II
NGC 2276	263	Sc(r)II-III
NGC 2280	221	Sc(s)1.2
NGC 2300	6	E3
NGC 2310	42	$S0_{2/3}(8)$
NGC 2314	8	E3
NGC 2325	9	E
NGC 2325	10	E4
NGC 2336	204, S13	**SBbc(r)I**
NGC 2339	299	SBc(s)II
NGC 2347	186	Sbc(r)I-II
NGC 2366	327	SBmlV-V
NGC 2369	178	Sbc(s)I pec
NGC 2397	279	Sc(s)III
NGC 2403	273	Sc(s)III
NGC 2427	269	Sc(s)II-III
NGC 2434	1	E0
NGC 2441	227	Sc(r)I-II
NGC 2442	207	SBbc(rs)II
NGC 2460	111. 145. S3	Sab(s)
NGC 2500	262	Sc(s)II.8
NGC2523	160	SBb(r)I
NGC 2525	298. S10	SBc(s)II
NGC 2537	275	ScIII pec
NGC 2541	264	Sc(s)III
NGC 2545	203	SBbc(r)I-II
NGC 2549	40	$S0_{1/2}(7)$
NGC 2551	134	Sb(r)I-II
NGC 2552	322	Sd/SBd
NGC 2608	183	Sbc(s)II
NGC 2613	139. S4	**Sb(s)(II)**
NGC 2633	155	SBb(s)I.3
NGC 2639	77	Sa
NGC 2642	163	**SBb(rs)I-II**
NGC 2646	56	$SB0_2$
NGC 2654	114	Sab:
NGC 2655	62	Sa pec
NGC 2672	22	E2 (tides)
NGC 2673	22	E0 (tides)
NGC 2681	62, 87	Sa
NGC 2683	**] 49**	**Sl,(nearly on edge)**
NGC 2685	45	SO3(7) pec
NGC 2693	22	E2
NGC 2701	271	Sc(s)II-III
NGC 2712	165	SBb(s)I-II
NGC 2713	174	Sbc(s)I
NGC 2715	246	Sc(s)II
NGC2732	36	S0i(8)
NGC 2742	250	Sc(rs)II
NGC 2748	288	Sc(s)II
NGC 2749	8	E3
NGC 2763	243	Sc(s)II
NGC2764	145.195	**Amorph or** Sli pec
NGC 2768	38, 53	$S0i/_2(6)$
NGC2775	78.87,S12	Sa(r)
NGC 2776	221	Sc(rs)I
NGC 2781	67	Sa(r)
NGC 2782	82	Sa(s) pec
NGC 2784	32	S0i(0,4)
NGC 2787	57. 95	SBO/a
NGC 2793	252	Sell pec
NGC 2798	105	SBa(s) tides
NGC 2811	65	Sa
NGC 2815	131	Sb(s)I-II
NGC 2832	22	E3 (tides)
NGC 2835	296	SBc(rs)I.2
NGC 2841	142.S4.S12	Sb
NGC 2844	77	Sa(r)
NGC 2848	244	Sc(s)II
NGC 2851	43	SO_3/Sa
NGC 2855	73, 74	Sa(r)
NGC 2859	58, S7	$RSB0_2(3)$
NGC 2865	10	E4 (SO?)
NGC 2880	54	SBOi
NGC 2888	6	E2 (SO?)
NGC 2889	135	Sb(r)II
NGC 2902	30	S0i(0)
NGC 2903	226	Sc(s)I-II
NGC 2907	48	S03(6) pec
NGC 2911	49	S03(2) or SO pec
NGC 2924	21	E0
NGC2935	155	SBb(s)I.2
NGC 2942	214	Sc(s)1.3
NGC 2950	57	RSBO2/3
NGC 2955	215	Sc(s)I
NGC 2962	93	$RSB0_2$/Sa
NGC 2964	240,251	Sc(s)lf.2
NGC 2967	230	Sc(rs)I-II
NGC 2968	49.337	Amorph or SO3
NCC 2974	9	E4
NGC 2976	317	Scd/SBcd
NGC 2983	95	SBa
NGC 2985	111	Sab(s)
NGC 2986	5	E2

NAME	PANEL	TYPE
NGC 4008	33	SO i(5)
NGC4013	19-1	SI,.-:
NGC. 4024	31	SOi(2.5.21
NGC 4026	50	S0i/2(9)
NGC4027	252	Sc(s)II.2
NGC. 4033	35	SO i(fi)
NGC 4036	60	S03(8)/Sa
NGC 4038	280	Sc(tid.-<)
NGC 4039	280	Sc(tides)
NGC 4041	268	Sc(s)II-lll
NGC 4047	232	Sc(s)I-I]
NGC 4050	131	Sl,<.-)l-l [
NGC4051	180	S].c(r)II
NGC 4062	265	S.-IsIII-III
NGC 4064	313	SBc
NGC 4073	12	E5
NGC 4085	291	ScIII:
NGC 4088	271	Sc(s)II-III/SBc
NGC 4094	I89	Sbc(s)I]
NGC 4096	287	Sc(s)H
NGC 4100	229	Sc(s)I-Il
NGC 4102	140	Sb(r)I
NGC 4105	56. 105	SOi/2(3)
NGC4106	56.105	SBO/a(tides)
NGC 4111	47.53	$S0_2$(91
NGC 4116	306	SBc(r)II-III
NGC 4123	201.S8	SBbc(rs)I.8
NGC 4124	44	802(1-116)
NGC4 125	28	E6/S0 1/2(6)
NGC 4128	35	SO i(6)
NGC 4129	291	Sc(s)ll
NGC 4136	230	Sc(r)I-Il
NGC 4138	74	Sa(r)
NGC 4143	59	S0|(5)/Sa
NGC 4144	319	Scd/SBcd
NGC 4145	235	Si-l i-111
NGC 4150	72	$S0_3$(4)/Sa
NGC 4151	119	Sab
NGC4152	233	Sc(r)1.4
NGC 4162	2.31	Sc(.-|I-ll
NGC 4178	311	SBc
NGC 4179	36. S2	SOi(91
NGC 4183	320	Scd/SBcd
NGC 4189	244	SBc(sr)I]
NGC 4190	326	SmIV
NGC 4192	135	SI,II:
NGC 4203	11	S()2(l 1
NGC 4212	278	Sc(s|II-III
NGC 4211	330	SBmlll
NGC 4215	17	S0|19I
NGC 4216	119	Sb(s)
NGC 4219	190	Sbc(s)II-IIl
NGC 4220	77	Sa(r)
NGC 4224	76	Sa
NGC 4233	35	SB0i(6)
NGC 4234	3 10	SBc
NGC4235	76	Sa
NGC 4236	324. S10	SBdIV
NGC 4237	246	Sc(r)II.2
NGC 4242	322	Sd/SBd
NCC 4244	3 19	Scd/SBcd
NGC 4245	95	SBa(s)
NGC 4251	36. S2	S0i(8)
NGC 4254	224	Se(s)1.3
NGC 4256	150	Sb(s)
NGC4258	135	Sb(s)II
NGC 4260	94	SBa(s)
NGC4261	6	E3
NGC4262	56	SBOi
NGC4267	54	$SB0_1$
NGC 4270	35	S0!(6)
NCC 4273	3 10	SBc
NGC 4274	66.88	Sa(sr)
NGC4278	20	El
NCC4281	44	$S0_3$(6)
NGC4283	2	EO
NGC 4283	20	EO
NGC4286	20	dE.N/Im
NGC 4293	59	Sa
NGC 4294	310	SBc
NGC 4298	279.289	Sc(s)III
NCC 4299	328	SdU)IIl
NGC 4302	289	Sc(on edge)
NGC 4303	213	Sc(s)1.2
NGC4304	208	SBbc(s)ll
NGC 4307	150	Sl)
NCC 4314	95. 106	SBa(rs) pec
NGC 4321	213	Sc(s)I
NGC4324	66	Sa(i-) ring
NCC 4339	38	S0i/2(0)
NGC 4340	57. S7	RSBO2
NGC 4342	23	E7(S0!)
NGC4346	55	SB0i(8)
NGC 4350	35	S0i(8)
NGC 4365	7. 18. SI	E3
NGC 4369	275	Sc(s)III-IV
NGC 4371	57	$SB0_2/_3$(r)(3)
NGC 4373	23	E4
NCC 4374	4	El
NGC 4377	52	SO] (3)
NCC 4378	70	Sa(s)
NGC4379	31	SO1(2)
NGC 4380	117	Sab(s)
NGC 4382	41	$S0_2$(3)pec
NGC 4383	337	Amorph?(not SO)
NCC4385	211	SBbc(s)II
NGC 4386	34	SO 1(5)
NCC 4388	I 11	Sal,
NGC 4389	3 13	SBc
NGC 4394	165	SBb(sr)I-II
NGC4395	324 . S6	ScIII-IV
NGC 4406	27	S0i(3)/E3
NGC 4412	201	SBbc(s)I-Il pec
NCC 4414	254	Sc(sr)II.2
NCC 4417	47	SOx(7)
NGC4419	86. 114	Sa(dust only)
NGC 4420	274	Sc(s)III
NGC 4424	60	S(a?) pec
NGC 4425	57.60	SBO pec or Sa
NGC 4428	265	Se(s)11.3
NGC 4429	60. S2	S03(6)/Sa
NCC 4433	194	SbcIII
NGC 4435	56. I53	SB0](7)
NGC 4438	56. 153	Sli!(tides)
NGC 4442	55	SBO 1(6)
NGC 4448	69	Sa(late)
NCC 4449	326. S6	SmIV
NGC 4450	110. SI 4	Sal, pec
NGC 4452	36	SOjIIO)
NGC 4454	67	Sa
NGC 4457	138	RSb(s)II
NGC 4459	43	SO3(3)
NGC 4460	36	SO/Sc:
NGC 4461	61	Sa
NGC 4462	123	SBab(s)I-II
NGC 4469	114	Sab(on edge)
NGC 4472	18. 26	El/SOjd)
NGC 4473	1I	E5
NGC 4474	37	$S0_1$(8)
NGC 4476	11.12	E5 pec(dust);S03(5)
NGC 4477	90	SBOi/2/SBa
NGC 4478	6	E2
NGC 4483	54	SBO, (5)
NGC 4485	317	Scd/SBcd
NGC 4486	17	EO
NGC 4487	250	Se(s)II.2
NGC 4490	317	Scd/SBcd
NGC 4494	4	El
NGC 4496	308	SBc
NGC4501	187	Sbc(*)II
NGC 4503	61	Sa
NCC 4504	247	Sc(s)II
NGC4507	123	SBab(rs)I
NGC4519	304	SBc(rs)II.2
NGC 4522	194. 291	Sc/SI>:
NGC 4526	44	$S0_3$(6)
NGC 4527	141	Sb(<)II
NGC4532	327	SmIII
NGC4535	297	SBc(s)I.3
NGC4536	174	Sbc(s)I-Il
NGC 4540	275	Sc(s)III
NCC 4546	89	SBOi/Su
NGC4 548	169.170	SBb(rs)I-II
NGC 4550	29	E7/S0|(7)
NGC4552	30	SO |(0)
NGC 4559	247	Sc(s)Il
NGC 4564	13. S1	E6
NGC 4567	281	Sc(s)ll-Ill
NGC 4568	281	Sc(s)II-III
NGC4569	109	Sab(s)I-H
NGC 4570	29	S0,(7)/E7
NGC 4571	260	Sc(s)II-III
NGC 4578	38	S0]/2(4)
NGC 4579	108	Sab(s)II
NGC 4580	86.276	Sc(s)/Sa
NGC 4580	276	Sc:
NGC 4586	76	Sa
NGC 4589	6	E2
NGC 4592	319	Scd/SBcd
NGC 4593	165	SBb(rs)I-II
NGC 4594	1 13.SI 1	Sa[+]/Sb"
NGC 4595	265	Se(s)II-III
NGC4596	101	SBa(very early)
NGC 4597	304	SBc(r)III:
NCC 4602	229	Sc(i-)I-Il
NGC 4603	176	Sbc(s)I-II
NGC 4605	292	Sc(s)III
NGC 4608	97	SBO3/*a*
NGC4612	57	RSBO1/2
NGC 4618	212	SBI)c(rs)II.2
NCC 4621	12. 32	E5
NCC 4623	13. SI	E7
NCC 4625	275	Sc(s)II-II] pec
NGC 4627	290	dE5.N
NGC 4630	275	Sc(s)III
NGC4631	290	Se(on edge)
NCC4632	288	Sc(s)IL3
NGC 4636	26	E0/S0](6)
NCC 4639	164	SBb(r)IJ
NGC 4643	97. 107	$SB0_3$/SBa
NGC 4645	12	E5
NGC4647	51 . 278. S14	Se(.-s)lll
NGC 4649	51	SO 1(2)
NGC4651	233	Sc(r)I-Il
NGC 4653	230	Sc(rs)1.3
NGC 4654	302	SBe(i-s)Il-III
NGC 4656	327, S6	Im
NGC 4657	327. S6	Im
NGC 4660	11.19	E5 (E/SO)
NGC 4666	194	SbcII.3
NCC 4668	313	SBc
NCC 4679	141	Sb(s)I-I]
NGC 4682	192	Sbc(rs)Il
NGC 4684	42	S0[(7)
NGC 4689	277	Sc(s)II.3
NGC469 1	337	R Amorph pec
NGC 4694	338	Amorph
NCC4696	43	$S0_3$(0)
NGC 4697	13. 19	E6
NGC 4698	78.79.87	SI1

NAME	PANEL	TYPE
NGC 5970	211	SBbc(r)I)
NGC 5982	22	E3
NGC 598!	320	Scd/SBcd
NGC 5985	160	SBb(r)]
NGC 60 15	2 65	Sc(s)II-II]
NCC 6070	2 29	Sc(s)I-H
NGC 6 106	2 64	Sc(rs)II.3
NGC 6118	2 29	Sc(s)1.3
NGC 6181	240	Sc(s)Il
NGC6207	274	Sell!
NGC 62 15	251	Sc(s)I]
NGC 62 17	2 09	RSBbc(s)I]
NGC 622 1	189	Sbc(s)II-III
NGC 6239	310	SBc
NGC 6300	168	SBb(s)II pec
NGC 63 10	62	Sa(r)I
NGC 6384	12 7.S4	Sb(r)1.2
NGC 6412	3 04	SBc(s)/Sc(s)I-I]
NGC 6482	6	E2
NGC 6503	2 88	Sc-(s)11.8
NGC 6574	219	Sc(s)II
NGC 6643	216.217	Sc(s)Il
NGC 6684	97	SBa(s)
NGC 6699	184	Sl)c(s)1.2
NGC 672 1	3	El
NGC 6744	188	Sbc(r)II/SBbc(r)Il
NGC 6753	125	Sb(r)I
NGC 6754	192	Sbc(s)II-m
NGC 6758	5	E2
NGC 6769	153	Sb(r)n
NGC 6770	153	SBb(tides)
NGC 6776	3	El pec (ripple)
NGC 6780	177	Sbc(rs)I-II
NGC 6782	122	SBab(s)
NGC 6808	258	Sc(s)II
NGC 68 10	I45	SI)
NGC 68 14	175	Sbc(rs)I-II
NGC 6822	330	imlV-V
NGC 6835	195	Amorph?
NGC 685 1	10	E4
NGC 6854	21	E0 + E1
NGC 686 1	13	S0;j(6)
NGC 6868	26	E3/SO 2/3 (3)
NGC 6870	26	E/SO
NGC 6875	59	S0/a(ripples)
NGC 6876	22	E3
NGC 6878	228	Sc(r)1.3
NGC 6887	133	Sli(s)l-ll
NGC 6890	144	Sb(s)II-II]
NGC 6893	13	SO 3(4)
NGC 6902	69	Sa(r)
NGC 6907	208	Sl?!x(s)II
NGC 6909	11	E5 (E/SO)
NGC 6923	208	SBbc(s)II
NGC 6925	185	Sl)(-(r)I-II
NGC 6935	67	Sa(r)
NGC 6942	92.106	SBa(s)
NGC 6943	140	Sb(rs)I]
NGC 6946	2 39	Sc(s)II
NGC 695 1	155	Sb/SBb(rs)I.3
NGC 6958	30	S0|(3)
NGC 6970	2 53	Sc(s)II
NGC 6981	183	Sbc(r)1.8
NGC 7007	59	SO 2/3/a
NGC 7014	23	E5
NGC 7020	70	RS02(5)/RSa
NGC 7029	32	SO, (5)
NGC 7038	175	Sbc(s)1.8
NCC 7041	29	SO
NGC 7049	59. 74	$S0_3(4)$/Sa
NGC 7059	2 49	Sc(r)I]
NGC 7064	3 20	Scd/SBcd
NGC 7070	3 06	SBc:
NGC 7079	97	SBa
NGC 7083	130	Sb(s)I-Il
NGC 7090	195	Amorph .ir SBc:(on edge]
NGC 7096	68. 88.S3	Sa(r)l
NGC 7097	9	E4
NGC 7107	3 16	Scd/SBcd
NGC 7119	282	Sc(s)II
NGC 7124	174	Sbc(rs)I-II
NGC 7125	225	Sc(rs)I-II/SBc(s)I-I]
NGC 7126	111	Sab(s)I
NGC 7135	51	SO i per (merger)
NGC 7137	2 66	Sc(rs)II.8
NGC 7144	1	E0
NGC 7145	1	EO
NGC 7155	56	SBO
NGC 7162	190	Sbc(rs)I]
NCC 7 162 A	324	Sil/SBrl
NGC 7 166	34	SO i(6)
NGC 7 168	7	E3
NGC 7 17 1	176	Sbc(r)I-II
NCC 7 177	1 18	Sab(r)II.2
NGC 7184	141	Sb(r)II
NGC 7192	40	$S0_2(0)$
NGC 7 196	27	E3/$S0_3(3)$
NGC 7205	144	Sb(r)II.8
NGC 72 13	75. S14	Sa(rs)
NGC 7217	143	Sb(r)II-III
NGC 72 18	271	Sc(s)II.8
NGC 7232	51	SO3(7) in- Sb
NGC 7233	51	Sa(late)
NGC 7252	3 40	Merger or SO i pee
NCC 7300	228	Sc(s)I-E
NGC 7302	32	SO] (4)
NGC 7307	311	SBc
NGC 7309	228	Sr(rs)I-[I
NGC 7314	278	S^sJIII
NGC 7329	163	SBb(r)I-II
NGC 7331	133	Sb(rs)I-U
NGC 7332	42	$S0_2$/3(8)
NGC 736 1	288	Sc(s)II-Ill
NGC 737 1	96, 106.SI 2	SBa(r)II
NGC 7377	75.SI 4	S09/3/Sa pee
NGC 7392	186	Slic(s)l-II
NGC 7410	96	SBa or Sa
NGC 7412	227	Sc(.s)I-II
NGC 7418	238	Sc(rs)1.8
NGC 7421	210	SBbc(rs)II-III
NGC 7424	2 95.S9	Sc(rs)II.3/SBc(s)II.3
NGC 7448	251	Se(r)11.2
NGC 7456	2 64	Se(s)Il-Ill
NGC 745 7	33	SOi (5)
NGC 7462	311	SBc
NGC 7479	200.S8	SBbc(s)I-II
NGC 7496	303.S10	SBc(s)IL8
NCC 750 7	1	EO
NGC 753 1	175	Slie(r)l-Il
NGC 753 7	282	Sc(s)
NGC 7541	255.282	Sc(s)II
NCC 7 552	156	SBb(s)I-II
NGC 7582	122	SBab(rs)
NCC 7585	84	S0i(3)/Sa
NGC 7600	33	SO i(5)
NGC 760 6	127.S13	Sb(r)l
NGC 7619	7	E3
NGC 762 3	23	E5
NGC 762 6	3	El
NGC 7640	311	SBc
NGC 7678	201	SBbc(s)I-Il
NGC 7679	86, 292	Se(s)/Sa(tides?)
NGC 7689	241	Sc(sr)II
NGC 7690	1 18	Sab(s)
NGC 7702	66	RSa(r)
NGC 7713	2 67	Sc(s)II-III
NGC 7716	111	Sab(r)I
NGC 7721	176	Sbc(s)I1.2
NCC 7 72 3	163	SBl)(rs)I-II
NGC 7727	83	Sa pee
NGC 7741	297.S10	SBc(s)H.2
NGC 7742	66	Sa(r!)
NGC 7 743	91.106	SBa
NGC 7 744	56	SBO!(3)
NGC 7755	203	SBbc(r)/Sbc(r)I-II
NGC 7764	329	SBmlll
NGC 7769	81.198	Sbc(s)(tides?)
NCC 7770	8 1.198	Sa pee
NGC 7771	81,198	SBab pec
NGC 7779	65. 133	Sa
NGC 7782	133.S13	Sb(s)I-II
NCC 7785	27	S0!(5)/E5
NGC 7793	321.S6	Sd(s)IV
NGC 7796	3	El
NGC 7814	1 12.Sl1	S(ab)