# THE POLAR-RING GALAXIES NGC 2685 AND NGC 3808B (VV 300)

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## INTRODUCTION

Polar-ring galaxies (PRG) are among the most interesting examples of interaction between galaxies. A PRG is a galaxy with an elongated main body surrounded by a ring (or a disk) of stars, gas, and dust rotating in a near-polar plane (Schweizer, Whitmore, and Rubin, 1983). Accretion of matter by a massive lenticular galaxy from either intergalactic medium or a companion galaxy is usually considered as an explanation of the observed structure of PRG. In the latter case there are two possibilities: (1) capture and merging of a neighbor galaxy, and (2) accretion of mass from a companion galaxy during a close encounter. Two PRG formation scenarios just mentioned are illustrated here by the results of our observations of the peculiar galaxies NGC 2685 and NGC 3808B.



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NGC 2685

NGC 2685 is one of the best known PRG's (Figure 1). The photographic observations of this galaxy were made in March 1978 using 2.6 m telescope of Byurakan Astrophysical Observatory (USSR). The prime focus plates (scale 21"/mm) were obtained in the UBV standard system (3 exposures in each band). For the details of the reduction procedure see Makarov, Reshetnikov, and Yakovleva (1989).

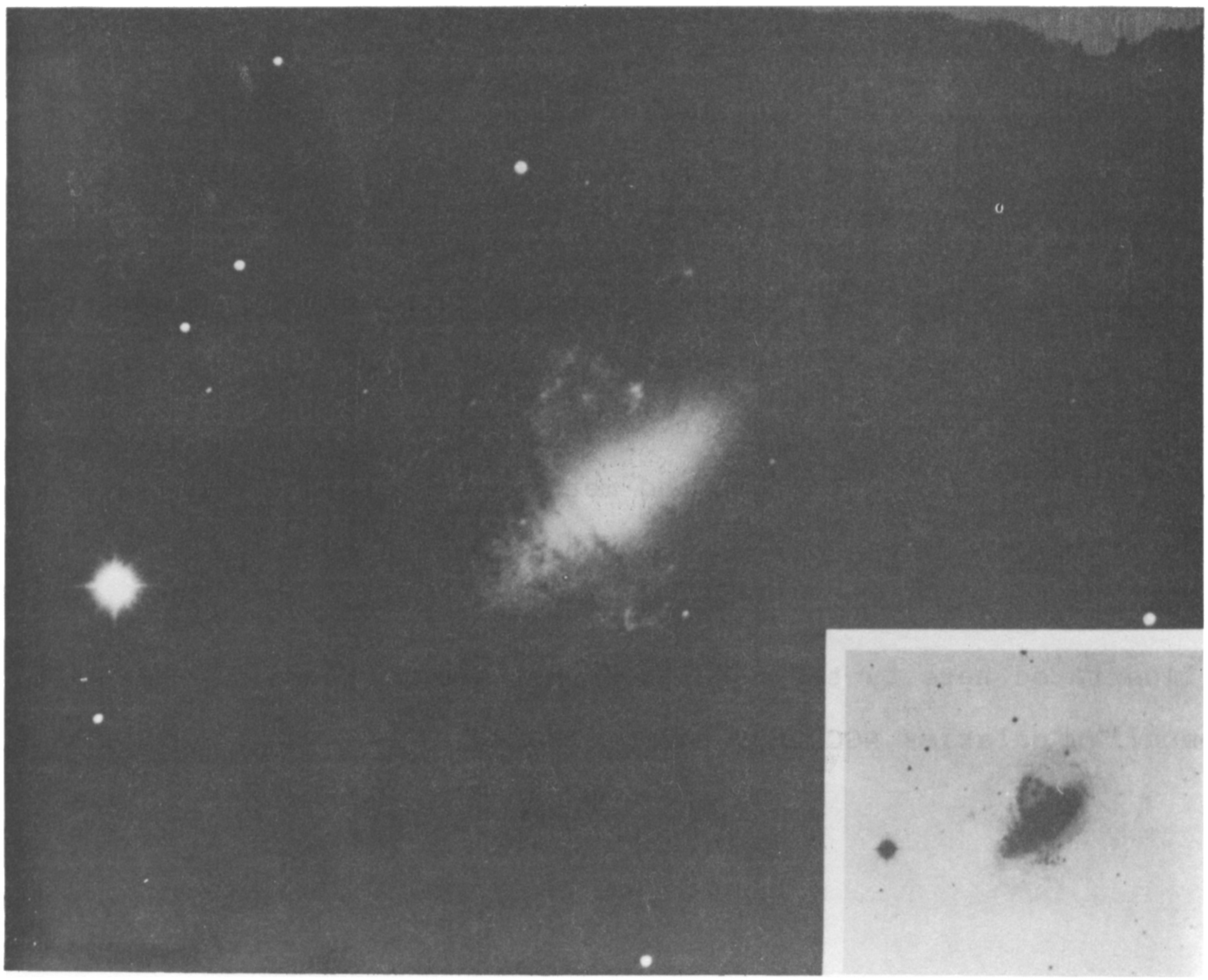

Figure 1. Reproduction of NGC 2685 from THE HUBBLE ATLAS OF GALAXIES (scale 1 mm = 2".2).



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Main Body

Figure 2 shows the B-band isophotes of NGC 2685. One can see that in the SW part of the galaxy undistorted by absorption the isophotes are nearly elliptical. Figure 3 is a plot of the orientation of these ellipses and their apparent axial ratios as a function of radial distance. The shapes of the curves are typical for two-component SO galaxies.

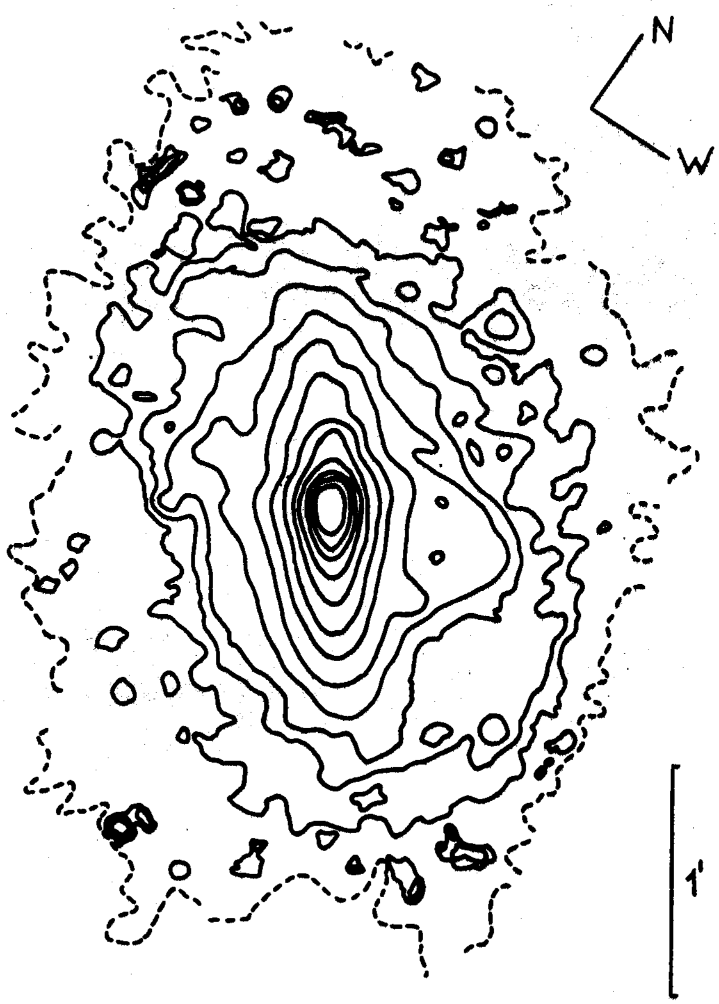


Figure 2. Low-resolution B-band isophotes of NGC 2685. Solid contour levels are drawn with the brightest level of 19.0 mag arcsec$^{-2}$ and a step of 0.5 mag arcsec$^{-2}$, external dashed contours - 25.5 mag arcsec$^{-2}$.



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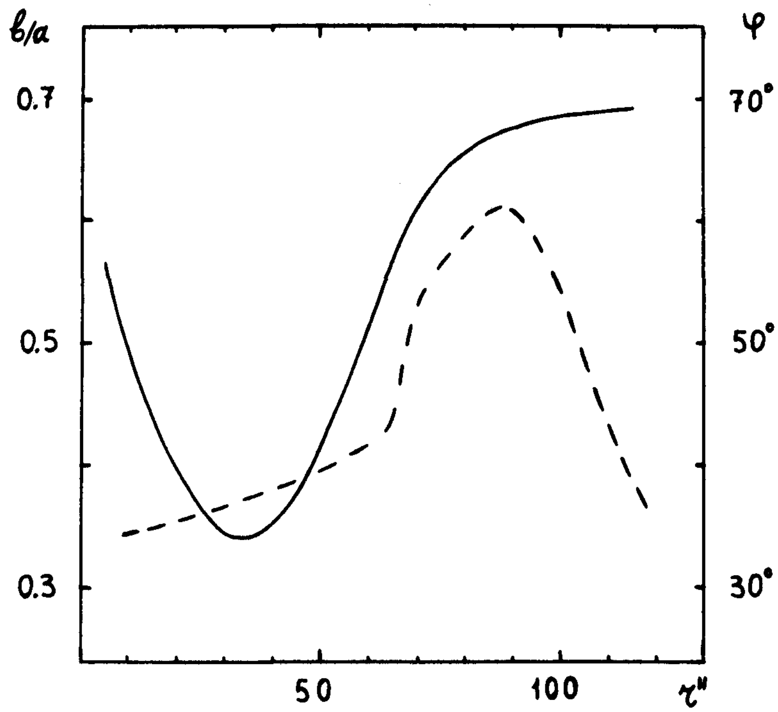


Figure 3. Orientation (dashed line) and apparent axial ratio (solid line) of the isophotes in the SW-part of NGC 2685.

Figure 4 shows the B-brightness profile measured along the major axis in the SW-side of the galaxy (circles). Solid lines show the best=fit profiles for the two-component model ($r^{1/4}$ spheroid + exponential disk). The parameters of the bulge and the disk corresponding to this fit are given in Table 1.



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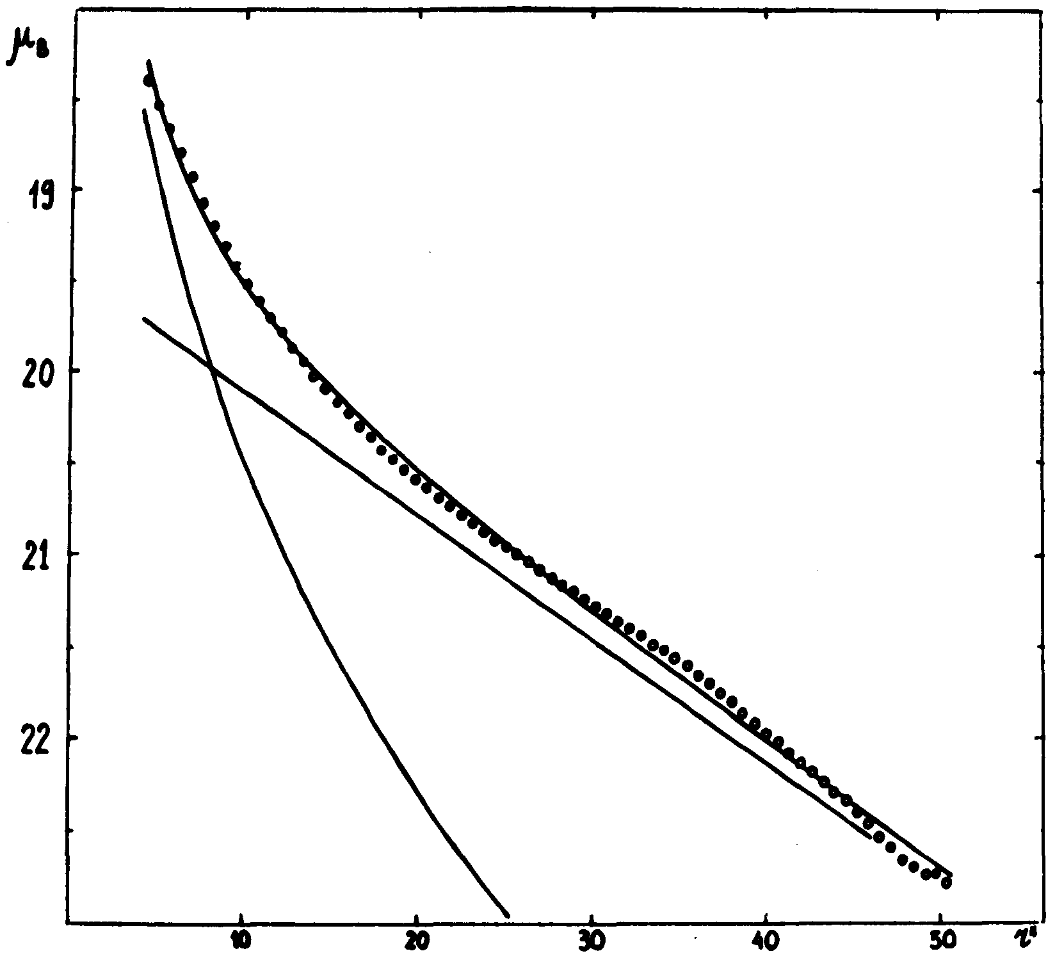


Figure 4. Two-component model of the light distribution as compared with major axis profile (SW-side of NGC 2685).

## System of Polar Rings

The main body of NGC 2685 is intersected by a system of dark arcs transforming into light rings off the main body (Figure 1). The major axis of the brightest ring is about 80" (6.6 kpc), P. A. = 100°.

All the features between the main body of the galaxy and the isophote $\mu_u$ = 23.0 mag arcsec$^{-2}$ were taken into account in estimating photometric parameters of the polar rings. These parameters are shown in Table 1. The integrated colors of the rings are typical for Sbc - Sc spirals.

The system of rings contains numerous condensations, with characteristics (B - V = +0.45, U - B = -0.3, $M_B$ = -12 to -14) typical for giant HII-regions in the arms of spiral galaxies.

The estimate of the mass of HI associated with the rings ($M(HI) = 5 \times 10^8\ M_o$) has been given by Shand (1980). Hence the ratio of HI mass to B-luminosity of rings is $M(HI)/L_B = 1.3$. The luminosity of the ring system given in Table 1 is a lower limit to the total luminosity. However, the absolute magnitude of the rings must be increased by ~$1^m$ because of projection effects. The resulting $M(HI)/L_{Bo}$ ratio is then ~0.5. This value is typical for late type spirals.

## Origin of Polar Rings

The body of available data, i.e., the size of the rings, their luminosity, mean colors, value of $M(HI)/L_{Bo}$, and presence of large-scale magntic fields (Hagen-Thorn, Popov, and Yakovleva, 1979) lead to the conclusion that the system of rings is a spiral galaxy. This conclusion is supported by the fact that luminous rings and dust lines crossing the NE-side of the main body have systematic shifts, which is usual for the arms of spiral galaxies. Therefore the apparent structure of NGC 2685 may be explained as a result of collision of normal SO and Sbc - Sc galaxies.

NGC 3808B

The Sc galaxy NGC 3808B is a component of an interacting pair with NGC 3808A (VV 300, Arp 87). It is located on the end of the spiral arm of NGC 3808A. On plates (Figure 5) one can see that the spiral arm appears to wrap around NGC 3808B.

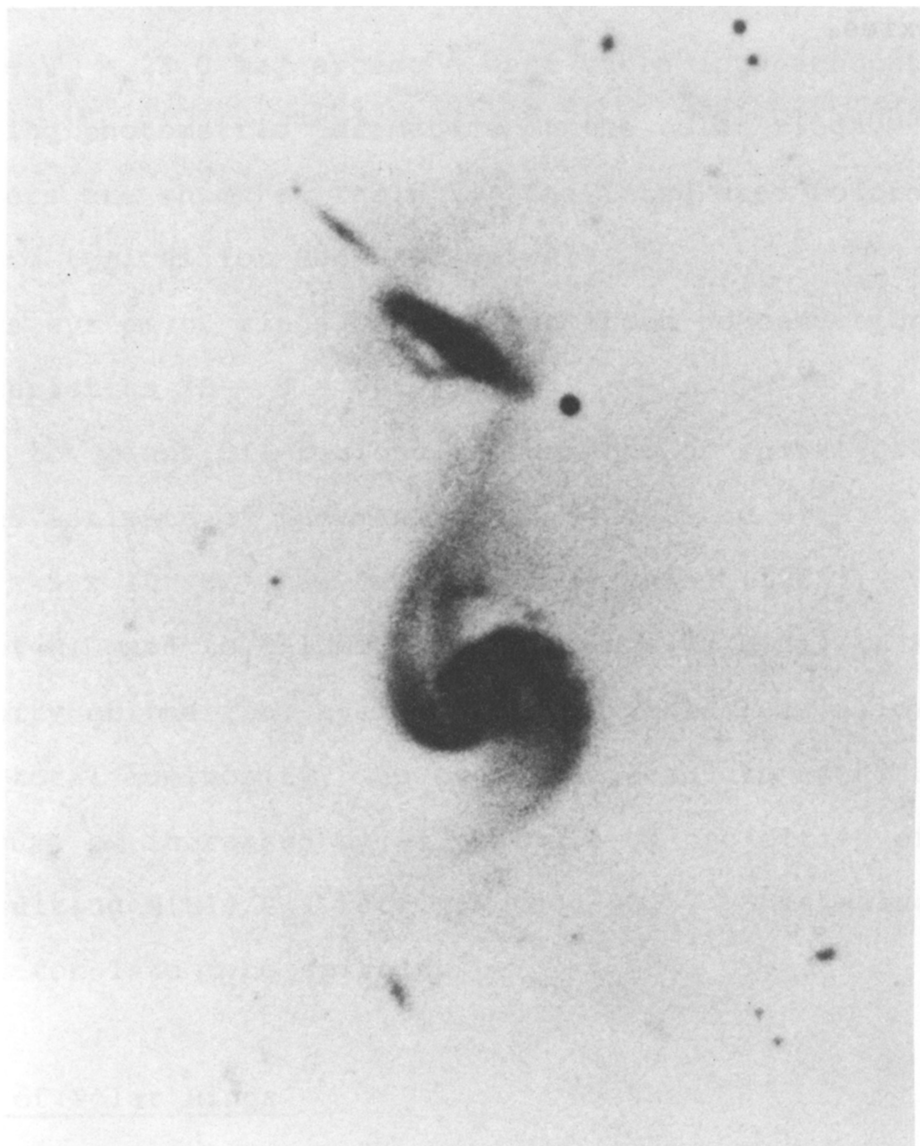

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Figure 5. Reproduction of VV 300 (Arp 87) from the ATLAS OF PECULIAR GALAXIES (scale 1 mm = 1".5).



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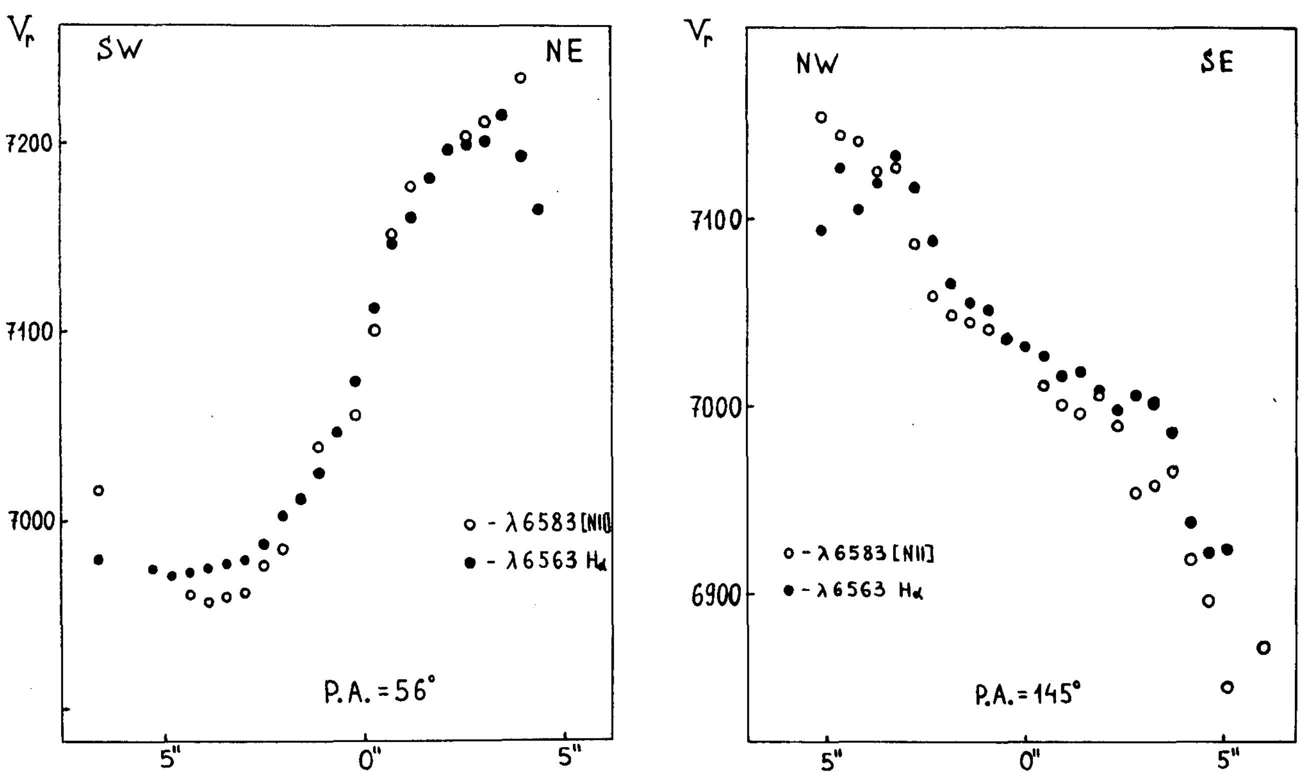
Spectral observations of NGC 3808B were made in February 1989 with the 6 m telescope of the Special Astrophysical Observatory (USSR) using the two-dimensional photon counting system "Kvant" in "long-slit" mode (Aliavdin et al., 1988).

Two spectrograms of this galaxy were obtained, with the slit positional angles P. A. = 56° (major axis) and P. A. = 145° (minor axis). On both spectra the Hα and [NII] emission lines are tilted (Figures 6 and 7). The natural interpretation of this fact is rotation of ionized gas both around minor and major axes of the galaxy.




Figures 6 and 7. The observed rotation curves of NGC 3808B at different position angles.



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The averaged rotation curves of NGC 3808B are shown in Figure 8 (heliocentric velocity of the nucleus is $V_r$ = 7086 ± 10 km/s). The observed rotation velocities in the plane of the galaxy and perpendicular to it are practically equal at r = 5". But since the main body of NGC 3808B is seen nearly edge-one the observed velocities measured along its major axis are luminosity-weighted averages over all the gas along the line of sight. A crude estimate shows that the value of the correction for this effect may be as large as (20 - 30)%. Hence the real velocity of rotation at r = 5" may be larger (30 - 40) km/s as compared to the observed value. Then, with a small extrapolation, the estimate of distance where the polar and equatorial velocities are equal increases to r = 7". The optical radius of NGC 3808B is 20" ($R_{25}$) (de Vaucouleurs, de Vaucouleurs, and Corwin, 1976). Therefore, Vpol ≃ Veqv at r ≃ (1/3)$R_{25}$. It means that probably nearly spherical dark halo may be an important mass component even within the inner part of this galaxy.

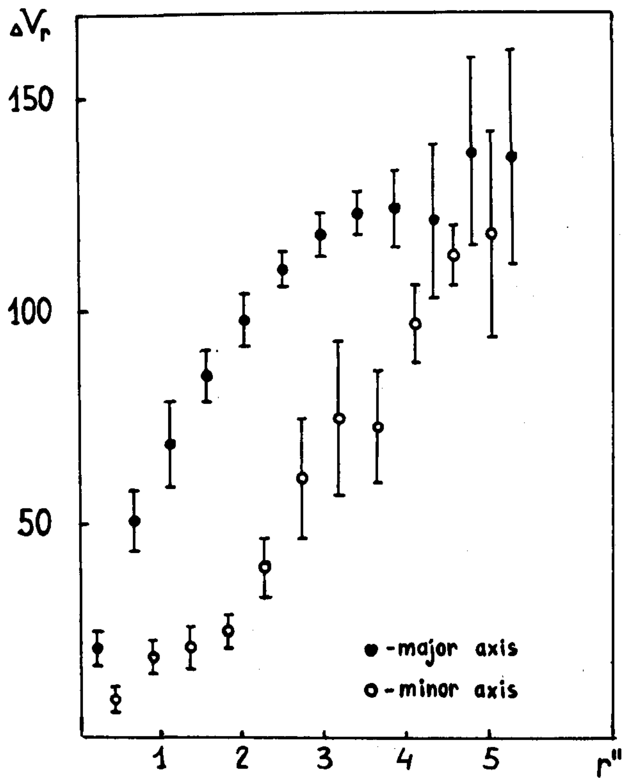


Figure 8. Rotation curves of NGC 3808B folded about the center.

Recent observations of three SO PRG's (Whitemore, McElroy, and Schweizer, 1987) have shown that dark spherical halo must be the dominant mass contributor even within the inner parts of these galaxies (at $r \approx 0.6R_{25}$). We have obtained similar result for Sc galaxy. This is in agreement with the conclusion made by Rubin (1987), according to which in spirals of all morphological types within the optical image of galaxy the dark matter contributes about 1/2 of its total mass.

NGC 3808B is probably an illustration of the scenario of polar ring formation as a result accretion of matter from a nearby galaxy.

However, since NGC 3808B is a late type galaxy with large extended disk, if the accretion is stopped, the lifetime of the ring will be relatively small (<< $10^9$ years).



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TABLE 1

Parameters of NGC 2685

| | | | | |
|---|---|---|---|---|
| I. | General Properties: | | | |
| | Distance (Mpc)[(1)] | 17 | | |
| | Galactic absorption[(2)] | 0.15 | | |
| | Absolute B mag, $M_{Bo}$ | -19.6 | | |
| | $(B - V)_T$[(3)] | + 0.85 | | |
| II. | SO Component: | | | |
| | $M_{Bo}$ | -19.45 | | |
| | $(B - V)_o$ | + 0.95 | | |
| | $(U - B)_o$ | + 0.3 | | |
| Bulge: | $\mu_e^B$ 19.32 | Disk: | $\mu_o^B$ | 19.43 |
| | $r_e$ $5\overset{''}{.}9$ (0.49 kpc) | | $\alpha^{-1}$ | $16\overset{''}{.}1$ (1.32 kpc) |
| | b/a 0.6: | | b/a | 0.35 |
| | Bulge-to-disk ratio, B/D | 0.94 | | |
| III. | Polar Ring Component: | | | |
| | $M_{Bo}$ | <-16.0 | | |
| | $(B - V)_o$ | + 0.50 | | |
| | $(U - B)_o$ | - 0.05 | | |
| | $M(HI)/L_{Bo}$ | 0.5: | | |

(1) Shane (1980)

(2) Burstein and Heiles (1984)

(3) de Vaucouleurs, de Vaucouleurs, and Corwin (1976)



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