5.3 Isophotal Twists in Elliptical Galaxies

The ellipticity of isophotes may vary with radius in the inner regions. Also, there may be a variation of major axis position angle (PA) of these isophotes with radius. The PA gives the orientation of the galaxy in the sky; it is the angle measured counterclockwise from north to the major axis, as shown in Figure 5.4.

A variation of PA with radius, or a twist, may be an indication of triaxiality, with no axis of rotational symmetry; see Figure 5.5. The bulge in M31 shows a twist in the major axis by about 10° near its center and has been fit by a triaxial model. M81 shows a similar small central twist, and near-infrared observations indicate that this may be common in spirals. Such twists may also be interpreted as an indication of the presence of small bars or nonaxisymmetric bulges in the central regions. This subject will be considered more fully in Section 5.10.

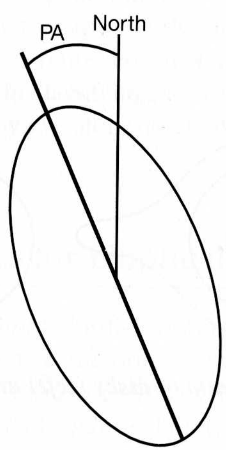

FIGURE 5.4 ***Position angle is measured from the north counterclockwise to the major axis of a galaxy.***

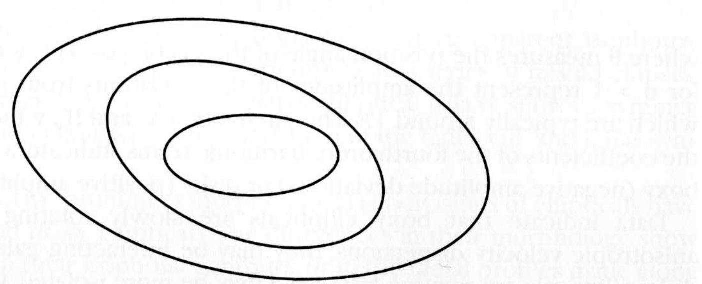

FIGURE 5.5 ***Some galaxies show isophotal twists and ellipticity variations with radius.***

5.4 Radial Profiles for Spiral Galaxies

Spiral galaxies have bulges that are very similar to elliptical galaxies. The bulge surface brightness generally has the form log $(\Sigma/\Sigma_o) \propto r^{-1/4}$, the same as for elliptical galaxies, although recent studies suggest that an exponential distribution may be at least as good a fit to the central light. Sometimes the bulge region has a boxy shape, just as some ellipticals do, as shown in Figure 5.6.

Almost every disk galaxy with a measured radial profile, including Magellanic irregulars, shows an exponential profile in the disk. In the region beyond the bulge, the brightness decreases approximately exponentially as:

$$\Sigma = \Sigma_o e^{(-r/r_s)}$$

where Σ_o is the intercept value, equal to the extrapolated central surface brightness, and r_s is the *scale length*. This is sometimes written in the form $\Sigma = \Sigma_o e^{-\alpha r}$, where $\alpha = 1/r_s$. Figure 5.7 shows a radial profile for a spiral galaxy.

A scale length is the distance over which light decreases by 1/e, or by about a factor of one-third. A galaxy with a larger scale length has a slower decrease in brightness than a galaxy with a smaller scale length. In Figure 5.7, the light decreases from 1000 (in arbitrary units) in the center to (1000/e) = 368 at a radius of about 0.2 R_{25}. (It is customary to measure the scale length in terms of R_{25}, so that you do not need to know the distance to the galaxy.) Typically $r_s/R_{25} \approx 0.2$–0.3, so there are 3–5 scale lengths out to R_{25}. That is, spiral arms can usually be traced out to a distance of ~4 scale lengths in a galaxy on typical prints. Recent studies indicate that blue scale lengths may sometimes be shorter than near-

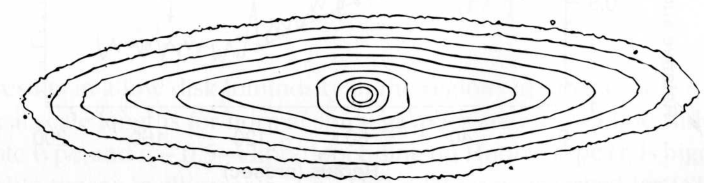

FIGURE 5.6 ***Magnitude contours are shown for the edge-on spiral galaxy NGC 2310, which has a boxy bulge. (From Shaw 1993.)***