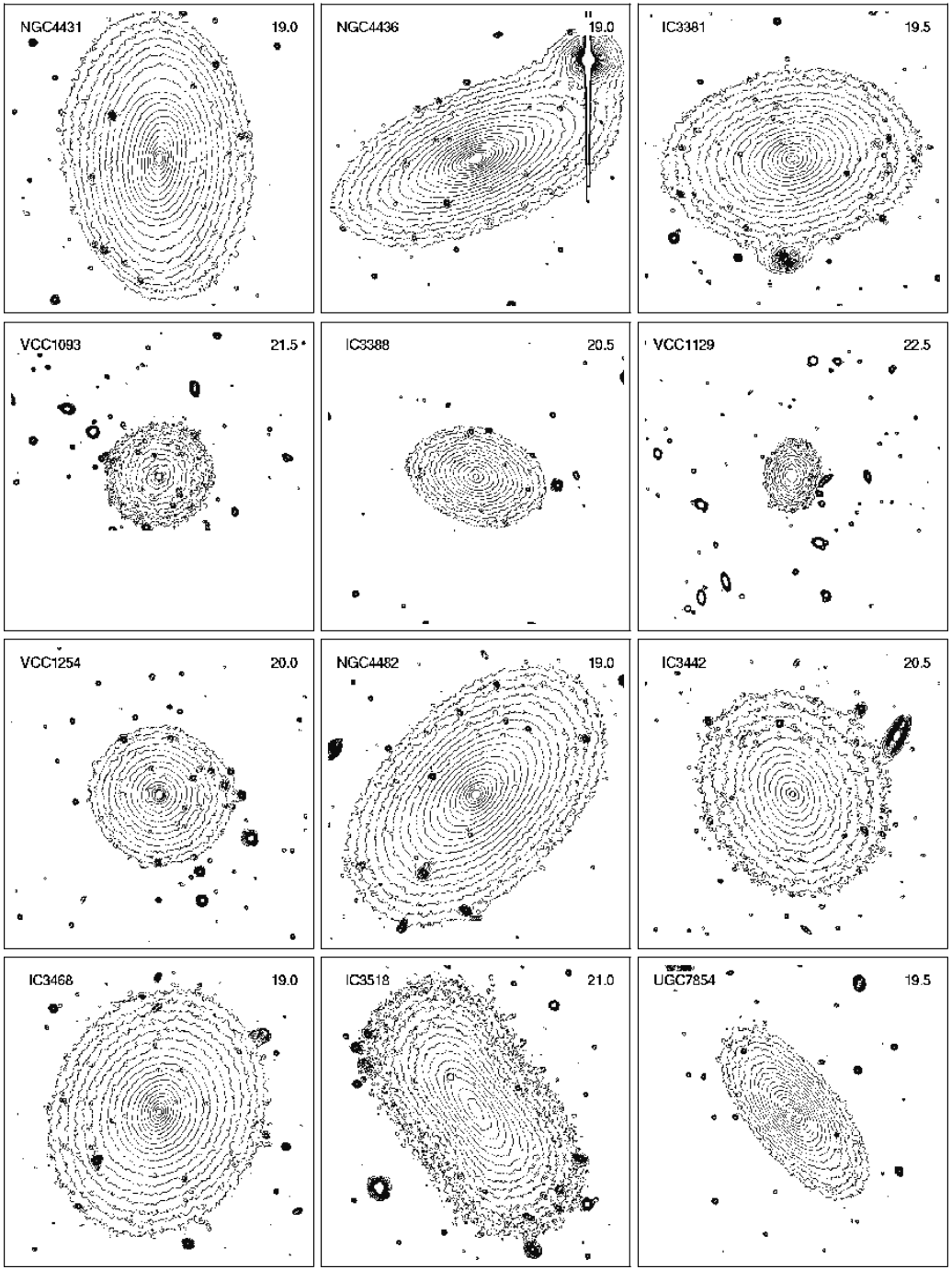
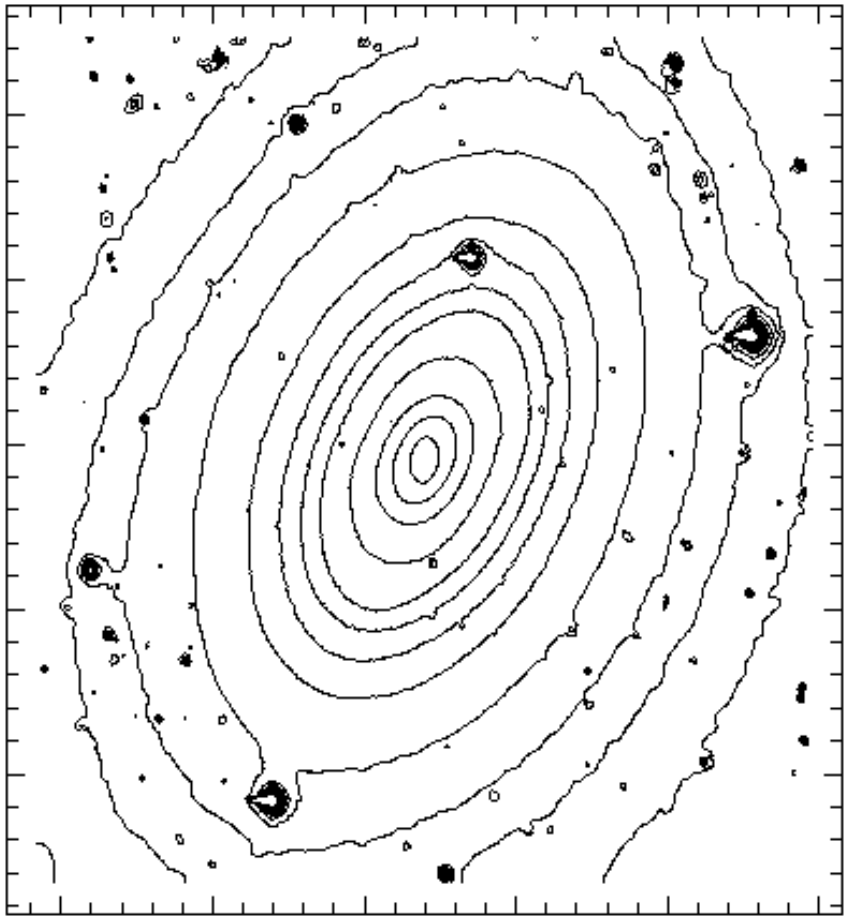
Elliptical Galaxies: Shapes

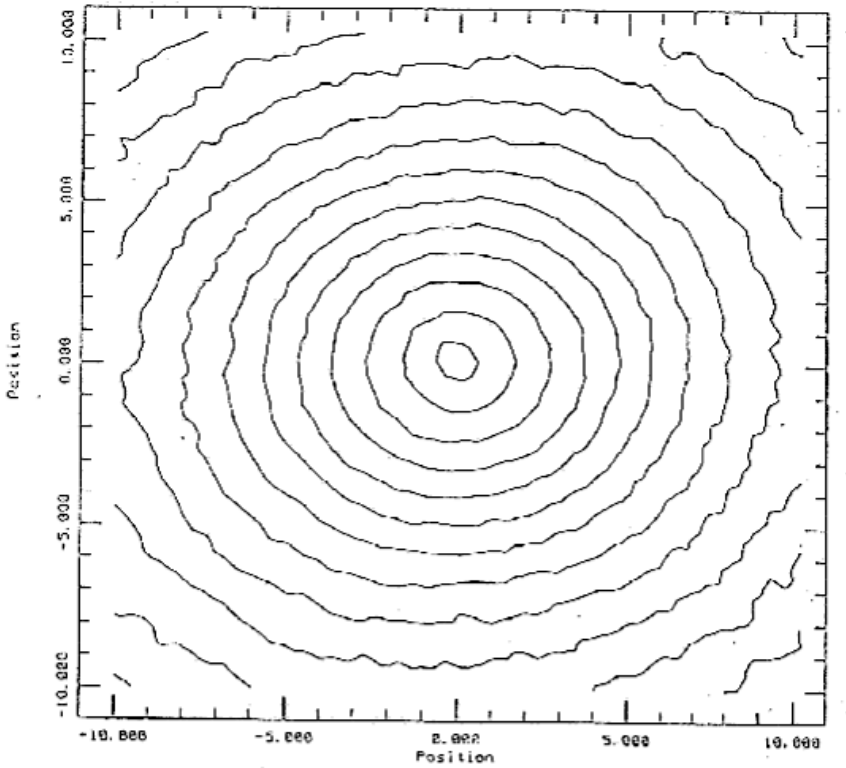


Typical Elliptical Isophotes



NGC 1533

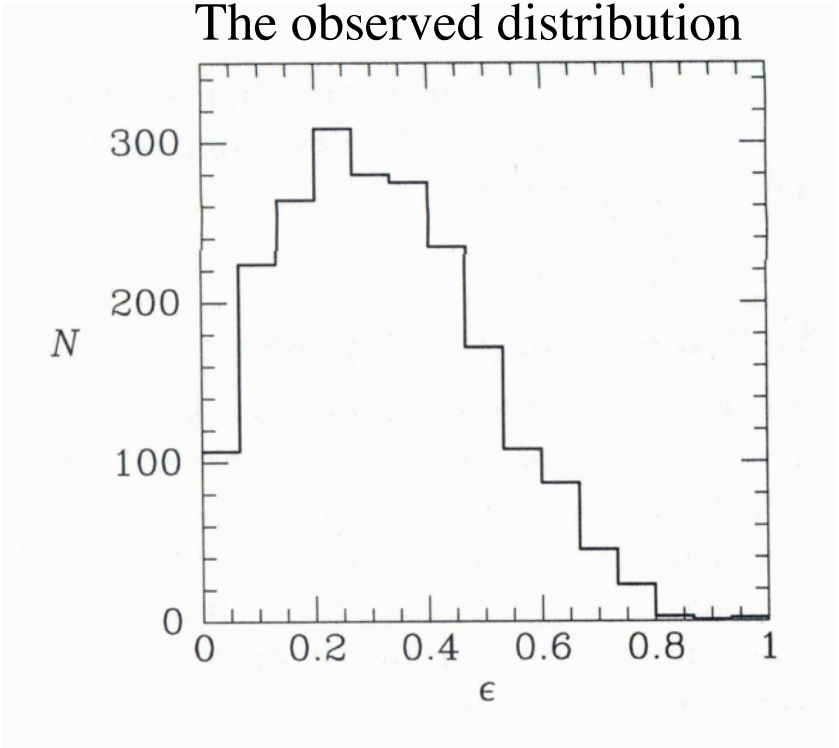
Note the apparent ellipticity gradient

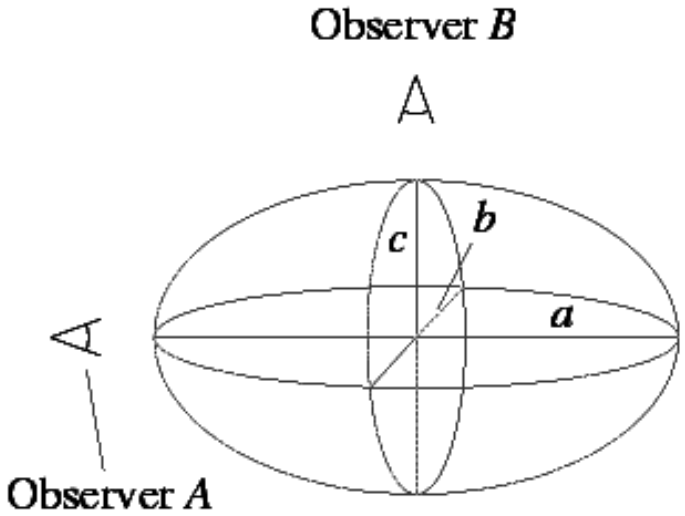


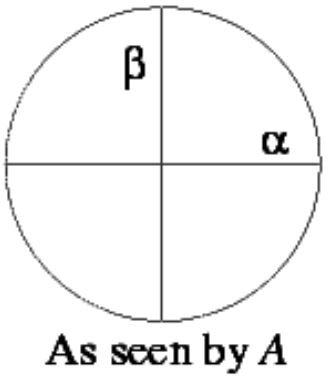
NGC 4689

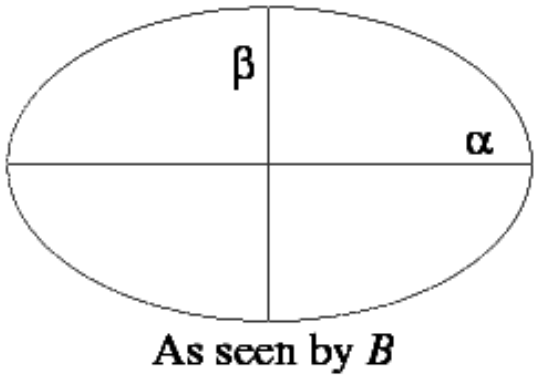
Shapes of Ellipticals

- Ellipticals are defined by En, where $n=10\varepsilon$, and $\varepsilon=1-b/a$ is the ellipticity
- Note this is not intrinsic, it is observer dependent!









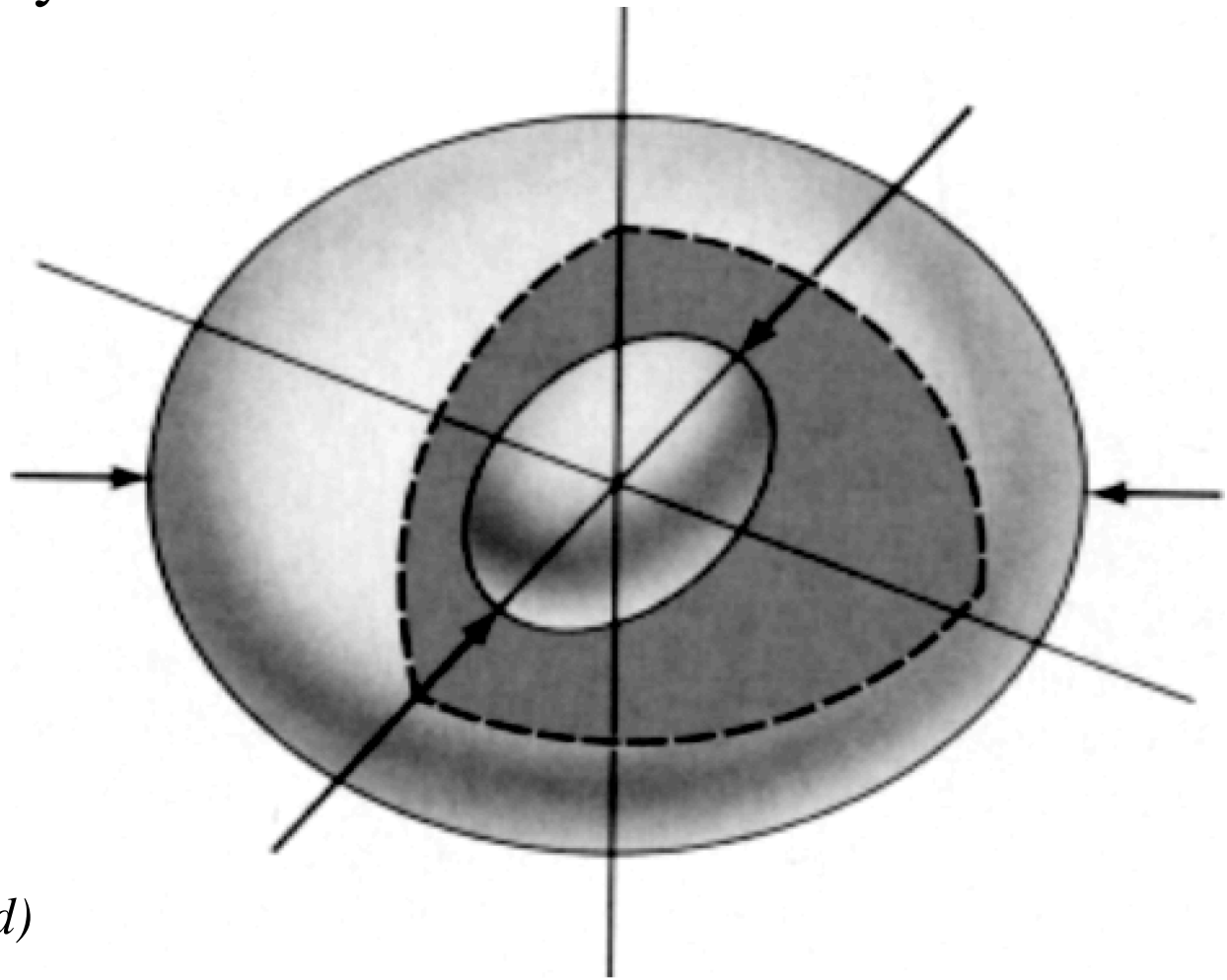
Triaxial Ellipsoids

- In general, the 3-D shapes of ellipticals can be triaxial (A,B,C are intrinsic axis radii):
  - Oblate: A = B > C (a flying saucer)
  - Prolate: A > B = C (a cigar)
  - Triaxial A > B > C (a football)
- Studies find that ellipticals are mildly triaxial, with typical axis ratios:

  A:B:C ~ 1 : 0.95 : 0.65 (with some dispersion, ~0.2)
- Triaxiality is supported by observations of isophotal twists in some galaxies (would not see these if galaxies were purely oblate or prolate)
- It is due to the anisotropic velocity dispersions, which stretch the galaxies in proportion along their 3 principal axes

Triaxial Ellipsoids in Projection

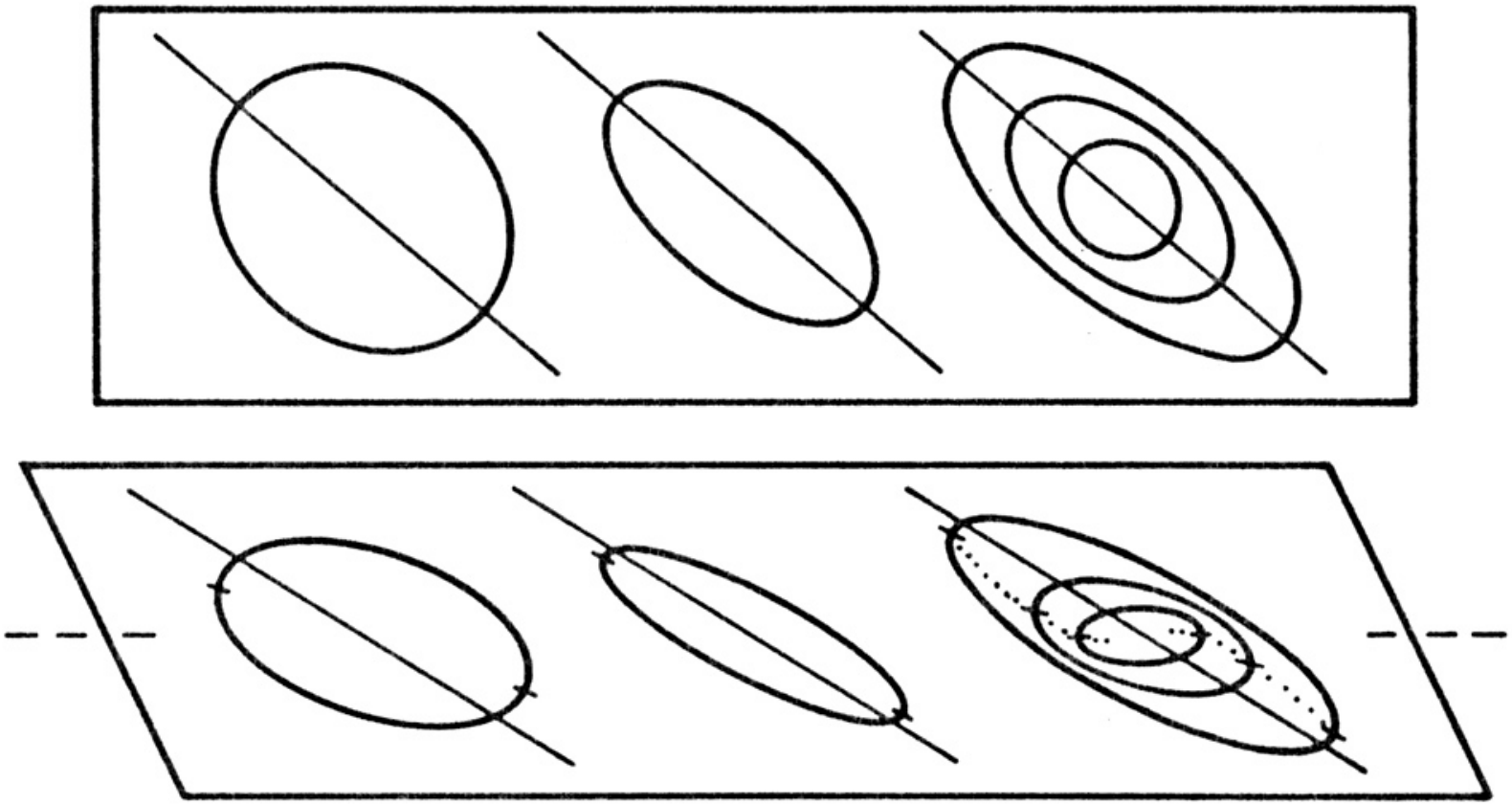
In a triaxial case, the orientation in the sky of the projected ellipses will not only depend upon the orientation of the body, but also upon the body's axis ratio



(from Binney & Merrifield)

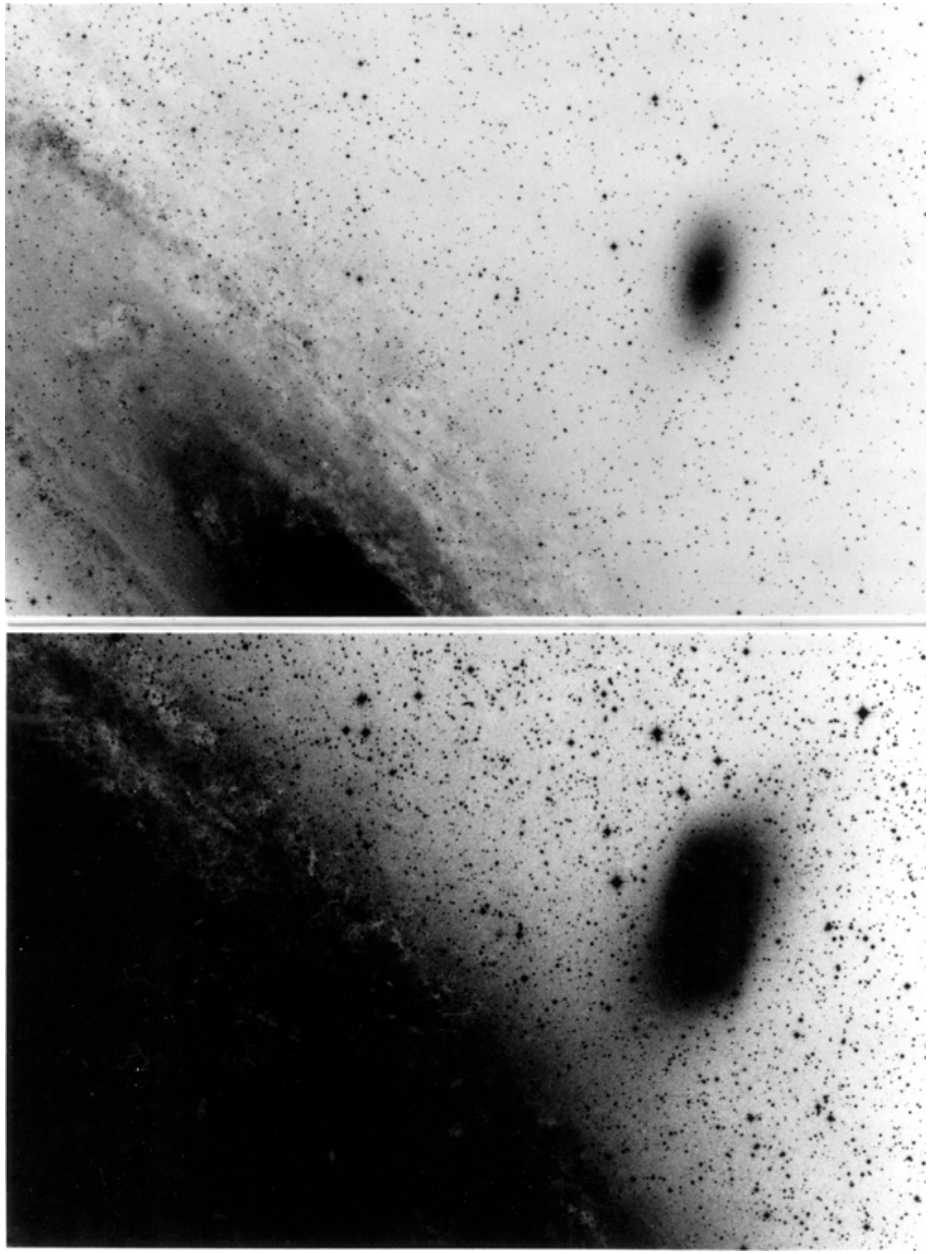
Isophote Twisting

Since the ellipticity changes with radius, even if the major axis of all the ellipses have the same orientation, they appear as if they were rotated in the projected image. This is called ***isophote twisting:***

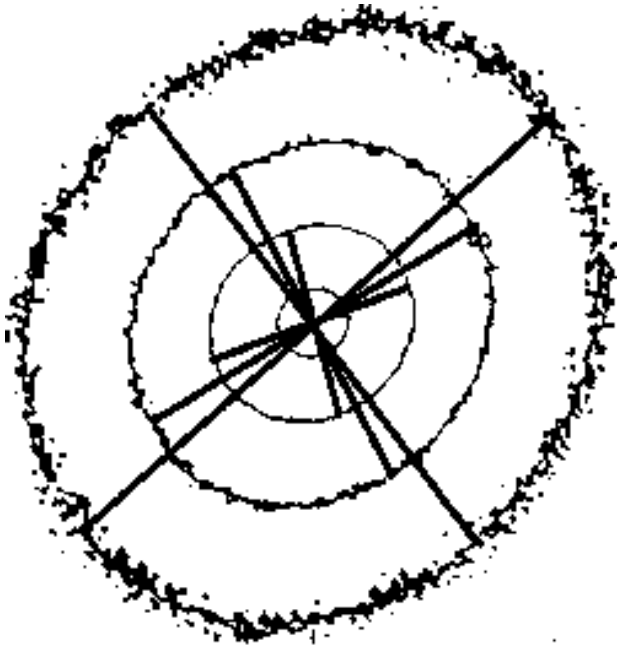


Isophote Twists

Here is an example of twisted isophotes in a satellite galaxy of Andromeda (M31):

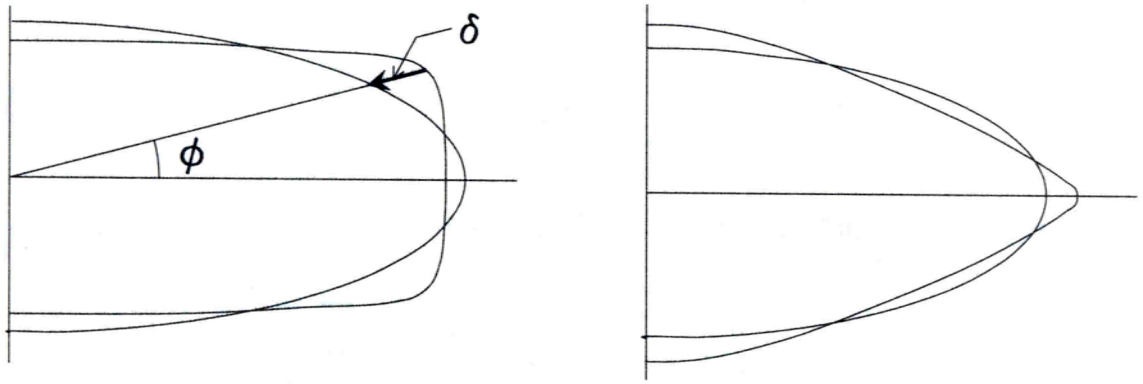


And another:



Isophotes: Deviations From Ellipses

Isophotes are not perfect ellipses. There may be an excess of light on the major axis (disky), or on the "corners" of the ellipse (boxy):



The ***diskiness/boxiness*** of an isophote is measured by the difference between the real isophote and the best-fit elliptical one:

$$\delta(\phi) = <\delta> + \Sigma\, a_n \cos n\phi + \Sigma\, b_n \sin n\phi$$

where the terms with $n < 4$ all vanish (by construction), and $a_4 > 0$ is a disky E, while $a_4 < 0$ corresponds to a boxy E.

Disky and Boxy Elliptical Isophotes

FIGURE 3. — Distribution of the ellipticity classes for all observed elliptical galaxies.

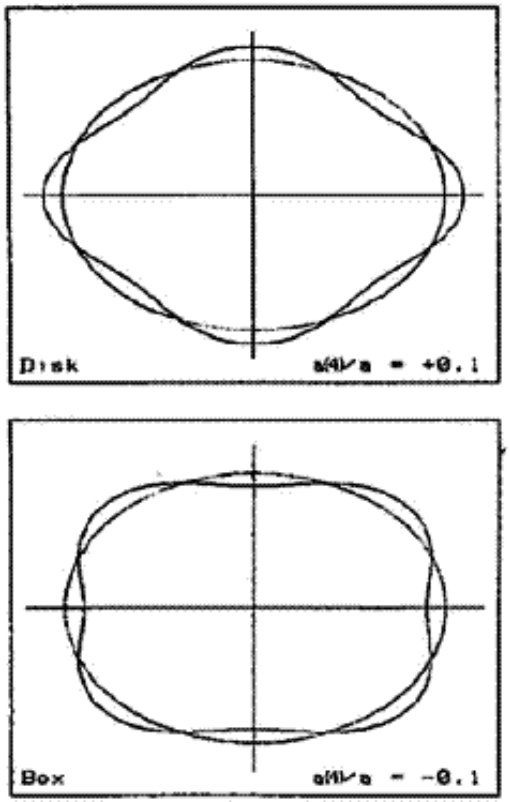


FIGURE 5. — Schematic drawing illustrating isophotes with $a(4)/a = +0.1$ and $a(4)/a = -0.1$.

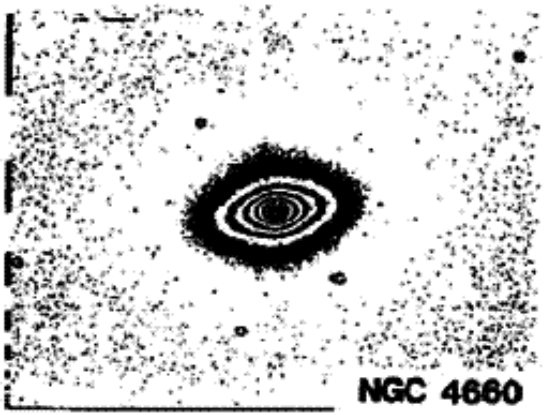


FIGURE 6. — R-image of NGC 4660, an elliptical galaxy with a disk-component in the isophotes ($a(4)/a \sim +0.03$).

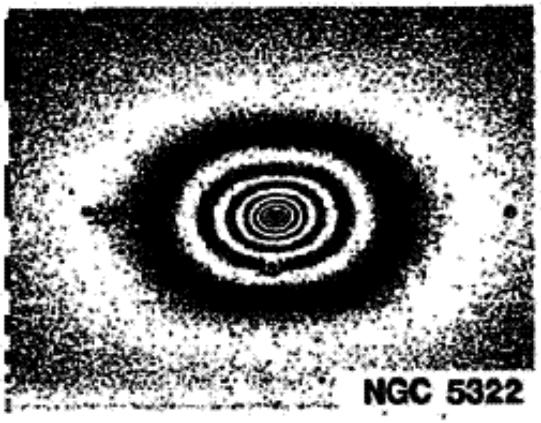
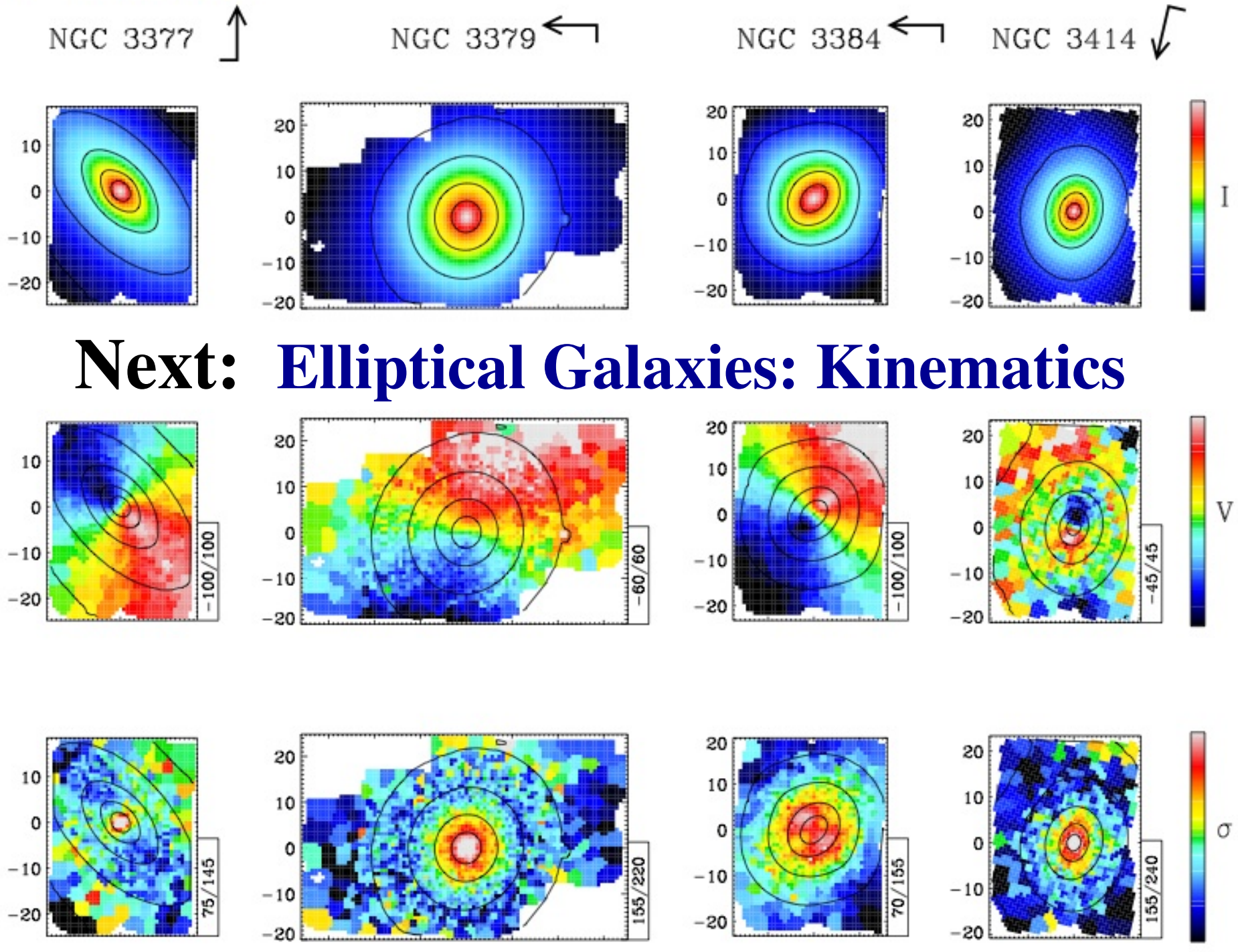


FIGURE 7. — R-image of NGC 5322, an elliptical galaxy with box-shaped isophotes ($a(4)/a \sim -0.01$).

Examples for boxy and disky isophotes from Bender et al. (1988)

Disky and Boxy Ellipticals

- Disky/boxy shapes correlate with various other galaxy parameters:
  - Boxy galaxies more likely to show isophotal twists (and hence be triaxial)
  - Boxy galaxies tend to be more luminous
  - Boxy galaxies have stronger radio and x-ray emission
  - Boxy galaxies are slow rotators, more anisotropic
  - In contrast, disky galaxies are midsized ellipticals, oblate, faster rotators, less luminous in radio and x-ray
- Some believe that more dissipationless mergers lead to more boxy galaxies, whereas any embedded disks imply some dissipative collapse, but the real picture is probably more complicated



Next: Elliptical Galaxies: Kinematics