# Selection of Homework Questions

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## Topic 7: Ellipticals

**(1) General :**

a. To first order, elliptical galaxies appear to be an extremely homogeneous group. Describe some of the 2 and 3 parameter correlations which support this claim, explaining what physical principals lie behind the correlations.

b. On closer scrutiny, ellipticals seem to divide into two distinct classes depending on the 2-D **shape** of their isophotes. How is this shape difference defined and in what other ways are these two types different from eachother?

c. It has been suggested that, while probably over-simplified, each type has experienced a different formation scenario. Outline these two possible scenarios and state which one goes with which type of elliptical galaxy.

**(2) The Sersic Brightness Profile** The radial surface brightness distribution (in flux units) for a wide range of systems can be described by the Sersic Law:

$$I(R) \;=\; I(R_e)\, exp\left\{-b\left[(R/R_e)^{1/n} - 1\right]\right\} \qquad \text{(Q7.1)}$$

where $R_e$ encloses half the total light.

a. Give the equivalent expression using surface brightness measured in magnitudes, $\mu$

b. Express the central surface brightness, I(0) and $\mu(0)$, in terms of the surface brightness at the effective radius, $I(R_e)$ and $\mu(R_e)$. Hence find equivalent expressions for I(R) and $\mu(R)$ using I(0) and $\mu(0)$.

c. The special case n=1 yields an exponential profile which is usually expressed in terms of the scale length $R_d$ : $I(R) = I(0) \exp(-R/R_d)$, so that $I(R_d) = 1/e \times I(0)$. Show that $L_{tot} = 2\pi R_d^2 I(0)$, and that $R_e = 1.67 R_d$. Hence show that b = 1.68 for this exponential disk. [Please don't be confused by the subscripts here: $R_e$ encloses half the light (e for effective), while $R_d$ marks the radius at which the surface brightness has fallen to 1/e of the central surface brightness (d for disk, since disks are close to exponentials)].

d. Show that the definition of $R_e$, namely $\int_0^{\infty} 2\pi R\, I(R)\, dR = 2 \times \int_0^{R_e} 2\pi R\, I(R)\, dR$, can be recast as $\int_0^{\infty} x^{2n-1} e^{-bx} dx = 2 \times \int_0^{1} x^{2n-1} e^{-bx} dx$. Hence, using numerical methods, show that $b = 1.999n - 0.327$ (for n = 1 - 8), giving b in terms of n. [Hint: you will need to evaluate the integrals numerically, as well as hunt for the appropriate b that satisfies the equation for each n. Having done that, plot b *vs* n and confirm that the line b = 1.999n - 0.327 goes through the points].

e. Using your previous results, how does $I(0) / I(R_e)$ [or equivalently, $\mu(0) - \mu(R_e)$ ] depend on n? Are ellipticals (n ~ 4) more or less concentrated than disks (n ~ 1)?

f. For M87 and M32, look up $B_T$ and $A_e$ in RC3 and, assuming they both fit the $R^{1/4}$ law at all radii, calculate the factor by which their centers outshine the moonless sky, which has $\mu_B = 22.7$. Also, estimate $D_{25}$ and compare it with the value given in RC3.

**(3) Galaxy Shapes**

Of course, we only ever see galaxies in projection on the sky. And yet, we feel we have significant knowledge of their 3-D shapes. Describe the observations and line of reasoning that has been taken to ascertain, statistically, the 3-D shapes of

(a) ellipticals
(b) spiral disks.

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