Astronomy 830, Autumn 2003, Problem Set 5

Due Friday, November 14 in class

Problem 1

On the class webpage you will find a file with the radial surface brightness profile data for the elliptical galaxy NGC 1700 from Goudfrooij et al. 1994 A&AS, 104, 179:

www.astronomy.ohio-state.edu/~pogge/Ast830/n1700b.dat

The data are given in three columns: (1) the semi-major axis radius, R, in arcseconds, (2) μ_B and (3) its uncertainty $\sigma_{\mu B}$, both in magnitudes/arcsec^2. This is the galaxy shown in Figure 4.25 of Binney & Merrifield as a poster-child for the deVaucouleurs Law.

a) The deVaucouleurs $R^{1/4}$ Law is given in Binney & Merrifield in Equation 4.18 written as the surface brightness I(R) in flux units. Using the relation $\mu_B=C_B-2.5\log I_B$ (and $\mu_{B,e}=C_B-2.5\log I_{B,e}$), rewrite the deVaucouleurs law in terms of magnitudes (μ_B versus $R^{1/4}$) parameterized by R_e and $\mu_{B,e}$.

b) Plot the radial surface brightness $\mu_B(R)$ twice: once as a function of log R and once as a function of $R^{1/4}$ (cf. figure 4.25 of B&M, same galaxy, different data). Based on visual appearances alone, would you agree with B&M's choice of this galaxy as an exemplar of E galaxies that are well fit by an $R^{1/4}$ radial surface brightness profile?

c) Using the μ_B data for NGC 1700, fit a deVaucouleurs profile of the form you found in part (a) using the method of least squares. (Note: by setting $y=\mu_B$ and $x=R^{1/4}$ for the fit, you are effectively "linearizing" the data so that the deVaucouleurs law describes a line in the μ-$R^{1/4}$ plane – this lets you use *lfit* for the job – be sure to include errors in y, $\sigma_{\mu B}$, when doing your fit – i.e., do a "weighted" fit). Use all of the data points. Plot your best-fit deVaucouleurs law over the data, and using the best-fit parameters found by *lfit* estimate the effective radius, R_e and mean surface brightness within the effective radius:

$$\langle \mu_B \rangle_e \approx \mu_{B,e} - 1.393$$

for NGC 1700. Include estimates of the uncertainties for all quantities.

d) Plot the residuals ($\mu_B - \mu_{B,\mathrm{fit}}$) for your fit to the data in part (c). You will notice that there are significant deviations from the deVaucouleurs law at the extreme inner and outer parts of the galaxy. Experiment with restricting the range of radii over which you fit a deVaucouleurs law to this galaxy (you decide where to make the cut) until you get a good fit to that part of the data that are reasonably well defined by a deVaucouleurs profile. Plot this fit over your data and give the new estimates of R_e and $\mu_{B,e}$. How much difference does this make? Comment on how the data deviate from a deVaucouleurs law, and why you might think this is so.

Note: if you choose to use a program other than *lfit* for the least-squares fitting, you must use one that does a *weighted* least squares fit using errors on the y-axis variable.

Problem 2:

On the same class webpage, you will find links to 12 FITS format images of galaxies from the Digitized Palomar Sky Survey (DPOSS). I have pre-scaled these images so that they will have a uniform appearance if you display them with data intensity values running from 0-255 using SAOImage ds9 (gimp will work as will xv, however ds9 is best, and *doesn't* require you to use *IRAF*: ask for a tutorial if you don't already know how to use ds9). In all cases, display them using simple black-and-white intensity scalings – do not use color, as any kind of pseudo-color intensity scaling will greatly confuse things. All images are derived from blue ($\lambda_C \approx 4400$Å) photographic plates.

a) Classify these galaxies from the images provided. Use no other resources to make your classification: in other words, no fair peeking in NED, the Hubble Atlas, or any other text or visual source – you make the call!

b) Does your classification depend on how you tweak the intensities, either by switching between white on black (photographic "positive") or the more traditional black on white (photographic "negative") views? Comment.

c) Once you have finished assigning morphological types, look up the RC3 type given by NED for each of these galaxies. Make a table listing your classification followed by the NED/RC3 classification.

d) Can you account for any discrepancies between your classifications and the ones listed by NED?

e) What is your opinion of the utility of the DPOSS for assigning galaxy classifications? Are some images over- or under-exposed? Are your discrepancies worse for early or late-type galaxies?

Note: I'm doing it this way instead of having you use the POSS plate prints proper because the plates are getting old and brittle, and I don't want to risk damaging them by having too many people handling them. Also, I didn't want you to have to spend time finding the relevant images on the plates; they often occupy very small regions of about 5-10 arcminutes across on plates that are 6x6-*degrees* on a side.