

**Astro 730 Galaxies 2008**  
**Homework 1: Due in Class February 4**

1. The night sky at Kitt Peak has a typical dark time (no moon) zenith surface brightness of  $\mu_V \sim 21.8 \text{ mag arcsec}^{-2}$  (see e.g. [www.noao.edu/kpno/manuals/dim/](http://www.noao.edu/kpno/manuals/dim/)). A standard ground-based telescope equipped with a CCD camera can detect objects at the  $5\sigma$  level when the mean object brightness within a radius containing 1/2 of the light is equal to 1% of the sky background. (This applies for small objects with sizes of <few arcseconds and in the case where noise from photon statistics dominates over any detector noise.)
  - a. Estimate the brightness limit for Kitt Peak V-band observations of stars at the  $5\sigma$  level when the seeing gives images with  $r_{0.5} = 0.5 \text{ arcsec}$ .
  - b. If the WIYN 3.5-m telescope achieves this limit in 10 minutes with  $r_{0.5} = 0.4 \text{ arcsec}$  estimate how long it would take the 0.9-m to obtain the same result if the only noise source is photon statistics and it has  $r_{0.5} = 0.6 \text{ arcsec}$ ?
  - c. The *Hubble Space Telescope* has a 2.5-m aperture and is essentially diffraction-limited at V. If the same rules applied as for ground-based telescopes, estimate the ultimate limiting magnitude for stellar photometry at the  $5\sigma$  level. (*Extra Credit:* Go to [etc.stsci.edu/webetc/acs\\_img\\_etc.jsp](http://etc.stsci.edu/webetc/acs_img_etc.jsp) and compare your result with what HST can really do. Explain the differences.)
  - d. A typical luminous galaxy at redshift 0.7 has  $r_{0.5} \sim 0.7 \text{ arcsec}$  (see [www.astro.ucla.edu/~wright/CosmoCalc.html](http://www.astro.ucla.edu/~wright/CosmoCalc.html)). The apparent magnitude of a typical luminous spiral at this redshift is  $V \sim 24$ . Can we reasonably observe this galaxy to measure its V-band brightness with the WIYN 3.5-m? (*Extra credit:* Would we do better with *HST*? Explain.)

2. You join a project to study the stellar population in the arms of the spiral galaxy M81 which is at a distance of  $D=3.7$  Mpc.
  - a. Estimate the apparent V magnitude of a typical supergiant star. If these stars are spaced apart by  $\sim 100$  pc along the arms can we study the distributions and colors of these stars with the WIYN 3.5- m telescope. How about red giant stars with projected spacings of about 2 pc?
  - b. What age stellar populations would we be tracing with our WIYN data?
  - c. Consider a galaxy that has been forming stars at a constant rate for 10 Gyr. What stars will produce most of the light? Which mass range contains most of the stellar mass? Given these results comment on what approach you might take to decipher the star formation histories of nearby galaxies. (*Hint* For this problem just consider main sequence stars and use the scaling relationships in Appendix B. Then qualitatively consider the impact of having ignored the evolved stars.)
  - d. (*Extra:* Take a look at [hubblesite.org/newscenter/archive/releases/2007/19/image/a/format/zoom/](http://hubblesite.org/newscenter/archive/releases/2007/19/image/a/format/zoom/) and assess whether the strategy proposed above is likely to work in practice for studying young stellar populations across the arms of M81.)
  
3. One representation of the stellar initial mass function (IMF) suggested by Pavel Kroupa involves a break in the slope. For stars with mass  $M > M_b$  the number of stars scales as  $M^{-2.3}$ , i.e. a normal Salpeter IMF slope, but for stars with  $M \leq M_b$  the slope is flatter, typically something like  $M^{-1.3}$ .
  - a. Show how the total mass in stars scales with the choice of  $M_b$  in the case where  $M_b > M_1$ , the lower bound for an H-burning star at  $0.07 M_{\text{sun}}$ . In other words, if a total number of  $N$  stars form, how does their mass depend on the choice of  $M_b$ ?
  - b. Given that  $M_b \sim 0.7 M_{\text{sun}}$ , can we directly observe the

stars responsible for much of the stellar mass in the M31 galaxy (assume it is at a distance of 780 kpc)? Explain your answer.