PROBLEM SET #2

Galaxies; 32 pts total

due Monday March 17, 2014

1. [6 pts] Problem 24.27 in Carroll and Ostlie: Oscillations of the Sun in the vertical plane

2. [2 pts] Problem 25.10 in Carroll and Ostlie: Velocity Dispersions, Enclosed Mass Estimates of Galaxy Cores

3. [2 pts] Problem 26.2 in Carroll and Ostlie: Dynamical Friction Equation

4. [2 pts] Problem 27.3 in Carroll and Ostlie: Brightest-Star Distance Ladder

5. [10 pts] Parameters in the Superluminal AGN Jet Equations

(a) [1 pts] For superluminal jets, in class we derived a maximum opening angle ϕ_{MX} in terms of $\beta_{app} = v_{app}$/c, where $\beta_{app} > 1$. The opening angle cannot exceed ϕ_{MX} for the observed β_{app} and still keep v < c. We also derived an angle ϕ_{MN} in terms of β_{app}, where ϕ_{MN} is the angle that minimizes the inferred velocity v. Derive the simplest possible expression for ϕ_{MX}/ϕ_{MN}.

(b) [1 pt] Draw a plot like we did in class for β vs. ϕ, and sketch curves for β_a = 1, 2, 3, and 5. Indicate critical angles on your graph.

(c) [1 pt] What is the minimum β required to observe superluminal motion in a relativistic jet?

(d) [3 pts] Suppose γ=2 for a relativistic jet. Over what fraction of the sky would an observer see superluminal motions?

(e) [1 pt] What is the maximum superluminal motion observable for the jet in part (d)?

(f) [3 pts] Assume that the jet is relativistic in the sense that $\beta = 1 - \delta$, with $\delta << 1$ so that you may ignore terms of order δ^2. Construct an equation that relates γ and β_a, including only constants and first-order terms in δ.

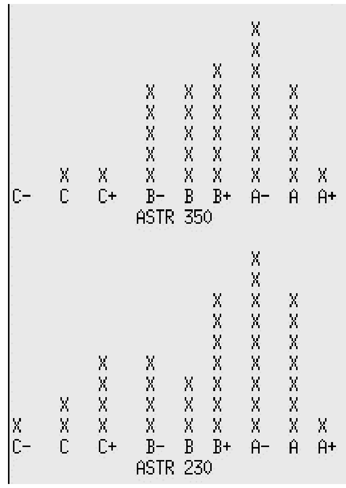
6. [10 pts] The two-sample K-S test is a common one used to determine if two samples are drawn from the same underlying distribution or not. In this problem you will explore this test. You may use any internet or book resources to understand the test, but you may not use any code to calculate numbers unless you write that code yourself from scratch with a simple coding language like fortran or C (no Mathematica or R). I would recommend you simply learn how the test works, and then use a calculator to compute the few values you need. Along the way you will likely need a table of critical values of the K-S distribution (see assignment page) for various values of confidence intervals α and sample sizes n_1 and n_2. If you determine that the distributions differ, recognize that the test does not tell you why they differ. It simply means that the two samples are unlikely, with some confidence level, to be drawn from the same distribution.

Note that this problem has quite a few points associated with it. The reason for that is that while there is enough information in the previous paragraph to do the problem, and actually doing it doesn't take long, understanding how it works is probably going to require some effort on your part. The Wikipedia page on two-sample K-S tests is a good place to begin. There are many ways to compute something incorrectly here, so take enough time reading to make sure you are doing it right. I'm not going to tell you how to do it.

(a) [3 pts] Describe how the test works, and why the interpretations you get depend on the sample size. Consider an example of two distributions that differ in the limit that both n_1 and n_2 get large.

(b) [3 pts] Consider the plot of grades for ASTR 230 and ASTR 350 on the next page. Can you be 95% certain that the grading distributions are inherently different for these two courses? Carefully lay out all equations that you use.

(c) [4 pts] Suppose each of the X's on the grade distributions actually represent 10 people. Now can you be 95% certain that the grading distributions are inherently different for these two courses? Can you be 99% certain of this?


C- C C+ B- B B+ A- A A+
ASTR 350
C- C C+ B- B B+ A- A A+
ASTR 230