Homework 1 - Handed out Sep. 6, due Tues. Sep. 18

Problem 1 is worth 10 points, problems 2 & 3 are each worth 5 points.

1. Assume the “naive” model of galactic structure discussed in class, which assumes uniform stellar density $D$ (= number of stars per unit volume), that all stars have the same intrinsic luminosity (hence the same absolute magnitude $M$), and that there is no interstellar extinction.

   (a) Show that the differential star count function $A(m)$ has the same functional form (that is, the same exponential dependence on $m$) as the integral star count function $N(m)$, and calculate the expressions for $A(m)$ and $N(m)$ explicitly in terms of numerical constants and $D$.

   (b). Now use the expression you derived in part (a) to predict star counts and compare them to reality, as follows: There are 15 stars brighter than or equal to apparent magnitude $m = +1$ over the entire sky ($4\pi$ steradians), 520 stars brighter than or equal to $m = +4$, and 4800 stars brighter than or equal to $m = +6$. Calculate the numerical values for the stellar density $D$ for each of these three cases. Assume that all stars have $M\approx+5$ (approximately the value for the Sun).

   (c) Compare your answers to the true local stellar density, $D = 0.13$ stars pc$^{-3}$, and discuss. Of the assumptions made in the model, which is the most incorrect? (Note: Another way of thinking of the naive model is that $D(m)$ represents a volume-averaged density for stars down to limiting magnitude $m$; discuss the comparison of prediction and observations in these terms.)

2. A star in the constellation Cygnus known as VI Cygni No. 12, has apparent magnitude $V=11.5$ and a measured “color index” $(B-V)=3.2$. Spectroscopy reveals that it is an A0 star, which (by definition!) has intrinsic color $(B-V)_0 = 0.0$. Assuming the standard interstellar extinction curve, such that the extinction at $V$ in magnitudes $A_V = 3.2 E(B-V)$, calculate $A_V$, and determine what its apparent visual magnitude would be in the absence of extinction. Comment on the result.

3. Interstellar extinction causes an apparent “stretching” of the volume enclosing a sample of stars counted down to a given limiting magnitude, and as a result, causes one to underestimate the stellar density. We will denote the true distance and stellar density by $r$ and $D(r)$ respectively, and the apparent distance and density by $\rho$ and $\Delta(\rho)$ respectively.

   (a) Calculate an algebraic expression for $\Delta(\rho)/D(r)$, if extinction increases linearly with distance, $A(r) = k \cdot r$. (You must show your intermediate steps to get credit for this part of the problem!)

   (b) For $k = 0.75$ mag per kpc, make a table showing the factors by which the distance is overestimated (e.g. list the ratio $\rho/r$), and the stellar density underestimated (e.g. the ratio $\Delta/D$), for distances of 500 pc, 1 kpc, 2 kpc, 3 kpc, and 5 kpc.