Ay 124 – Homework #1

Posted on Friday, Jan. 16 – Due by 5 pm on Friday, Jan. 23 (directly to the TA)

1. [16 points] What are the apparent bolometric magnitudes of:

(a) Sun-like star 50 pc away?

(b) 100 Watt lightbulb on the Moon?

(c) A galaxy containing $\sim 3 \times 10^{10}$ stars of an average luminosity $\sim 0.5\ L_\odot$ 20 Mpc away?

(d) A quasar with luminosity $L_Q = 10^{46}$ erg/s 1 Gpc away?

(Assume for simplicity that all of these objects have spectra identical to that of the Sun.)

2. [12 points] Compute the specific flux F_ν (in Jy, and erg/cm2/s/Hz) and F_λ (in erg/cm2/s/Å) from a $V = 22$ mag galaxy. What is the photon incidence rate over the primary mirror of the Hale 200-inch telescope from this object? (Assume that the *V* bandpass has a uniform response, and that it is 900 Å wide.)

3. [36 points] Sirius is a visual binary with a period of 49.94 yr. Its measured trigonometric parallax is 0.377 arcsec; assuming that the plane of the orbit is in the plane of the sky, the true angular extent of the semimajor axis of the reduced mass is 7.62 arcsec. The ratio of the distances of Sirius A and Sirius B from the center of mass is $a_A / a_B = 0.466$.

(a) Find the mass of each member of the system.

(b) The absolute bolometric magnitude of Sirius A is 1.33, and Sirius B has an absolute bolometric magnitude of 8.57. Determine their luminosities. Express your answers in $L_\odot$ units.

(c) The effective temperature of Sirius B is estimated to be approximately 27,000 K. Estimate its radius, and compare your answer to the radii of the Sun and the Earth.

4. [36 points] Consider a young star cluster in which stars have been made according to the standard Salpeter IMF: $dN/dm \sim m^{-(1+x)}$, where $x = 1.35$, and ranging from $m_{min} = 0.08\ M_\odot$ to $m_{max} = 80\ M_\odot$. Assume that the scaling relation between mass and luminosity $L \sim M^4$ applies for all masses.

(a) What is the average stellar mass? Derive a formula for it, for a general power-law IMF, and compute the value for the parameters given above.

(b) Ditto for the average stellar luminosity.

(c) If the cluster mass is $10^3\ M_\odot$, what is its absolute bolometric magnitude?

(d) What fractions of the total mass are contributed by the stars above and below the solar mass?

(e) Ditto for the luminosity.