Astronomy 20

Homework # 2

Handed out on October 8, 2004

Due in class on Friday, October 15, 2004

1. What are the apparent bolometric magnitudes of: (a) a Sun-like star 50 pc away? (b) a 100 Watt lightbulb 10 km away? (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. (a) Compute the specific flux F_ν (in Jy, and erg/cm^2/s/Hz) and F_λ (in erg/cm^2/s/Å) from a $V = 22^m$ galaxy. What is the photon incidence rate over the 200-inch 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.)

(b) A spectrum of this galaxy is taken. The effective entrance aperture of the spectrograph is 2×2 arcsec^2. The surface brightness of the night sky at Palomar in the V band on a decent night is ~ 21 mag/arcsec^2 (i.e., 1 arcsec^2 emits a flux equivalent to that of a $V = 21$ mag object). What is the effective V magnitude of the foreground sky patch as seen by the spectrograph in its aperture? Now assume that the overall efficiency of the telescope + spectrograph + detector is 10%. A resolution element in the spectrum is 10 Å wide. How many counts per resolution element are detected from the galaxy alone in a 1-hour exposure? From the foreground sky? If a blank piece of sky is measured at the same time in order to subtract the sky spectrum from the total, what is the signal-to-noise ratio per resolution element in the final, sky-subtracted galaxy spectrum? (Neglect the detector noise, and assume a pure photon statistics.)

3. (a) Compute the apparent bolometric magnitude of the full Moon as seen from the Earth on a clear night. Assume that the mean albedo of the Moon (the side facing us) is about 10%, the Earth-Moon distance of 385,000 km, and neglect any absorption by the Earth's atmosphere. (Hint: the Moon is not a flat mirror...)

(b) Collective for the Cellestial (politically) Correct Power (CCCP), from Berkeley, Ca., has decided to harness the ecologically sound Lunar Power. They rented a solar power station, having a collector with the total effective area of 1,000 m^2, and the net conversion efficiency of 10%. Compute the power generated by the CCCP People's Lunar Power station.

4. 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 terms of the luminosity of the Sun.

(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.