Astronomy 210 Spring 2005
Homework #4

Due in class: Friday, Mar. 4.

Problems

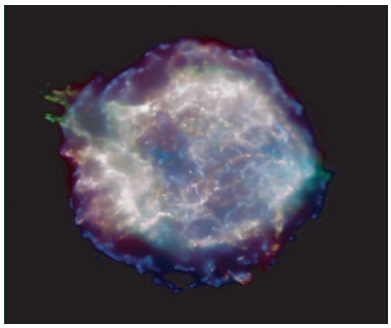
1. In class, we found T(r) for planets orbiting the Sun at distance r. But the same technique can be used for other stars with different temperatures and sizes. In general, however, if the Earth were orbiting at a = 1 AU around other stars, we would be uncomfortably cold or hot. Thus, the "temperate zone" would either be closer or farther from these stars. Starrting with the equation derived in class, modifiy it to realize Earth's average temperature of 300 K.

   (a) (7 points) If the Earth (albedo A = 0.37) orbited Rigel (surface temperature T = 12,000 K, radius $R = 35\,R_\odot$), what would be the average temperature at 1 AU? How far would the Earth have to be (in AU) to have its present average temperature?

   (b) (4 points) Same as above, but use Barnard's star (T = 3000 K, $R = 0.5\,R_\odot$).

2. (8 points) The inner (terrestrial) planets have relatively small amounts of hydrogen in their atmospheres, yet the outer (Jovian) planets are predominantly hydrogen. Following our discussion of planetary atmospheres, explain this difference. Base your argument on a quantitative calculation of hydrogen escape. Ah, it's getting away.

3. On the right is an image taken by the Chandra X-Ray Observatory (http://antwrp.gsfc.nasa.gov/apod/ap020824.html). Pictured is the remains of an exploded star in the constellation Cassiopeia (formally, the object is called the supernova remnant Cas A). The spectrum of X-rays from Cas A has been taken, and it is found to be thermal, with a peak at X-ray energies $E_\gamma \sim 5keV = 5 \times 10^3 eV$.



   (a) (5 points) What is the temperature of Cas A?

   (b) (5 points) Do you expect hydrogen in Cas A to be neutral or ionized?

   (c) (5 points) What is the average speed of hydrogen in Cas A?

4. (8 points) A star has a spectral line at a rest wavelength of $\lambda_{emit} = 500nm$. Calculate the Earth's orbital speed around the Sun. Use this to estimate the total variation in the observed wavelength of this star's line, as seen on Earth over the course of a year. For this problem assume the star lies on the ecliptic.

5. (8 points) Show that the Earth's temperature can be expressed solely in terms of the Sun's surface temperature $T_\odot$ and the angular diameter $\theta_\odot$ of the Sun as viewed from the Earth, ignoring the effects of albedo. Using that equation, use a thermometer and the observation that $\theta_\odot \sim 0.5^\circ$ to estimate the surface temperature of the Sun.