ASTRONOMY 160 FINAL

December 11, 2004

1. The L1551 molecular cloud has a temperature of 20K and is 4000 AU diameter.

   (a) Explain why there is no line emission from the cloud due to molecular hydrogen, H_2.

   (b) There is however line emission from ^{13}CO. Explain how the ^{13}CO : H_2 ratio is calibrated.

   (c) Write down an expression for ^{13}CO column density as a function of brightness.

   (d) Describe an observing plan to find the mass of L1551.

2. A clump within L1151 has a mass M = 2 M_{sun}, radius R = 800 AU, and temperature T = 9 K

   (a) Calculate the virial of the clump. Assume an isothermal sphere with density r^{-2}.

   (b) Is the clump gravitationally bound, expanding or stable?

   (c) Without calculating the Jeans mass M_J, is M greater equal or less than M_J?

3. Consider the fusion of two protons.

   (a) Sketch the fusion probability as a function of energy of approach. Label the Gamow peak, most likely interaction energy E_0, and the fusion window.

   (b) Calculate E_0 for two protons at 2 x 10^7 K.

   (c) Now consider the interaction of two helium atoms. By what factor must the temperature be increased to give the same probability of fusion as for 2 protons?

4. Consider 2 stars in a cluster: One is an A star of magnitude 3.36 and the other is a K star of magnitude 5.12 . (Note that these are absolute magnitudes.) The sun is 4.72 magnitudes.

(a) What is the luminosity of each star in units of solar luminosity?

(b) What is the mass of each star in units of solar mass?

(c) Draw an HR diagram. Indicate the locations of the main sequence, red giants and white dwarfs. Plot the approximate location of the A star and the K star.

(d) Calculate the time each star may remain on the main sequence.

(e) Describe the pre-main sequence evolution of the K star.

(f) Describe the evolution of the K star from main sequence to end state object. Name the end state object.

5. Dust particles in the interstellar medium preferentially absorb shorter wavelength photons. This effect is called interstellar reddening.

   (a) Write down the equation of radiative transfer for starlight traveling through a column of absorbing material with absorption coefficient κ_ν. The dust is very cold compared to the temperature of the star.

   (b) Change variables to τ_ν and integrate. What is the ratio of the apparent stellar flux (after dust absorption) to the flux of the star?

6. Scanning measurements of the solar brightness show that it decreases as the detector scans from the center of the solar image to its edge at both 500 nm and at 10,000 nm. The decrease at the longer wavelength is less than at the shorter wavelength. What can you conclude from these observations about (a) the variation of temperature in the solar atmosphere with depth and (b) the relative atmospheric absorption at the two wavelengths.