

ASTR 592
M/W/F 3:00 - 3:50 PM
Due April 1

Problem Set #4

1. Protostellar Time Scales

(a) Consider a collapsing cloud, with a mass that is twice the Jeans' mass. Assume that the density and temperature are uniform, with an initial cloud density $n = 10^8 \text{ m}^{-3}$ and a temperature of 10 K. Show that the free-fall time for this cloud is shorter than the sound-crossing time.

(b) What is the CO cooling time for this cloud? (Use the formula from Table 3.2 in the textbook). What does a comparison of the CO cooling time and the sound-crossing time tell you about the collapse?

2. Stellar Time Scales

(a) Calculate a typical sound-crossing and free-fall time for the surface of the sun, and show that these are approximately equal, as expected for an object in hydrostatic (and Virial) equilibrium. For simplicity, you will want to assume the sun has a uniform density. You will also want to assume that an appropriate representative temperature for the sun is the **central** temperature: $T_c = 1.5 \times 10^7 \text{ K}$.

(b) If the sun were shining only due to the release of gravitational potential energy as it contracted and cooled, how long would it live? Assume a uniform density, and that the luminosity of the sun does not change.