Introduction to Astronomy
Exercises week 7

22 November 2019

1. An interstellar gas cloud (which we approximate as a homogeneous sphere) has a mass of $1\,M_\odot$ and density of 10^{10} atoms per cm^3. Its rotation period is 1000 years.

   (a) What is the rotation period after the cloud has condensed (in its entirety) into a star of solar size?

   (b) In class we saw that the Sun's actual rotation is of the order of a month. The mismatch with the value from the previous question can be explained in two ways: either the assumed rotation period of the cloud is grossly incorrect, or the conservation of angular momentum during the collapse, does not work perfectly. Given that typical values for gas motions in the interstellar medium are tens of km/s – and noting that these are *random* velocities, i.e. that the variance of the velocity is of the same order, explain if the rotation of the gas cloud could be grossly overestimated; and whether this could explain the mismatch. (Hint: calculate the typical velocity such a rotation corresponds to and check if that is comparable to (i.e. of the same order as) the typical gas motions in the interstellar medium.)

2. The nuclear time scale for a particular star, scales (only) with M/L; and the thermal time scale is proportional to $M^2/(RL)$ (only), where M is the mass of the star, L is its luminosity and R is its radius.

   (a) Given that for the Sun the nuclear time scale is 10 billion years (10^{10} yrs) and its thermal time scale is 20 million years, derive exact equations for both quantities. (Hint: choose your units carefully.)

   (b) Given for Vega its mass of $2\,M_\odot$, radius of $3\,R_\odot$ and luminosity of $60\,L_\odot$, calculate its nuclear and thermal timescales. If you know that Vega is a star of spectral class A0V, what do you expect for those timescales?