ASTR 592
M/W/F 3:00 - 3:50 PM
Due April 15

Problem Set #5

1. The Effects of Sudden Mass Loss on Star Clusters

(a) Assume an isolated cluster of stars with mass M is initially in virial equilibrium. Write expressions for the velocity dispersion v_{RMS} and the total energy E_0 of this cluster as a function of M and R_0. You can ignore the constants in the expressions for U and KE.

(b) Imagine that suddenly, a fraction f of its mass is removed (assume that f does not change as a function of radius in the cluster). Write an expression for the new total energy E_f. Eventually (without losing energy) the cluster regains a state of virial equilibrium. How much mass did the cluster have to lose in order to become unbound (such that the new cluster radius R_f goes to infinity?)

(c) In the context of a star cluster, 'suddenly' means an event faster than the cluster can respond to by finding a new equilibrium. You can approximate this as less than t_c, the 'crossing time' or the time it takes a star to move a distance equal to the cluster diameter. For a young, massive protocluster with mass 10^4 $M_\odot$ and radius 2 pc, how does t_c for this cluster compare to the typical lifetime of a massive star?

2. Interstellar Distances

(a) The nearby galaxy NGC 4258 has a central rotating disk of gas which is traced by water megamasers. Water maser emission occurs at a rest frequency of 22.23508 GHz, however the masers in this disk are blueshifted to a maximum frequency of 22.31666 GHz. If the disk is observed edge-on, what is the rotational velocity of the disk?

(b) The inner edge of this disk is seen to be 0.004" from the center. How far away is this in parsecs?

(c) How much mass is enclosed inside this disk?

(d) Assume that the region inside the disk is filled entirely by solar-type stars in a virialized cluster. How often would a typical star in this cluster undergo a collision? Is it reasonable to assume that the central mass could be a star cluster?