PHD QUALIFY EXAMINATION —
GALACTIC AND EXTRAGALACTIC ASTROPHYSICS

2nd October, 1997

(1) (15 points)

A disk-shaped rotating galaxy is seen edge on. By Doppler-shift spectroscopic measurements we can determine the speed V with which the stars near the edge of the galaxy rotate about its center. Show that the mass of the galaxy in terms of the observed velocity is $\sim V^2 R/G$. State the assumptions made. R is the radius of the galaxy.

Consider the observation of edge-on galaxy again. In above question, it was simply assumed that spectroscopic measurement would give the speed V at a given radius. In reality however, this is more complex for edge-on galaxies. Show that, for edge-on galaxies, the apparent rotation curve derived from maximum velocity at various radii would form a straight line regardless of the true shape of its rotation curve. Assume no extinction by dust.

(2) (20 points)

A stellar system of total mass M has lost some of its mass. The original radius of the system, R, will change as a result of that mass loss. If we assume the Virial Theorem holds throughout the dynamical evolution, what would be resultant radii for mass loss 10%, 20%, and 50%.

Above situation and the significant mass loss is a dominating factor for early dynamical evolution of globular clusters. At later stage, this kind of Virial consideration plays only minor role. Why? and what dynamical process then becomes most important?

(3) (15 points)

List and explain observational evidences of dark matter in each of the following cases:

(a) local disk;
(b) our galaxy and spiral galaxies in general;
(c) giant elliptical galaxies;
(d) groups and clusters of galaxies;
(e) universe.

(4) (20 points)

In a highly ionized cloud, the Bremsstrahlung cooling can be the most dominant cooling mechanism. Let us consider two optically thin clouds with identical masses and temperatures. If one cloud is twice of the other cloud in its linear dimension. Please estimate the ratio of the intrinsic luminosities of the two clouds. If, on the other hand, both clouds are optically thick, what is the new ratio?

(5) (20 points)

Star formation is now believed to be controlled by the presence of magnetic fields. In the conventional estimate for the Jeans mass, one may balance the gravitational force with the thermal pressure force. If the magnetic pressure in the gas is much larger than the thermal pressure, the Jeans mass can become significantly larger than the conventional estimate. In this strong field regime, please give a simple derivation showing that the new Jeans mass $M_{\rm J}$ is proportional to B^3/ρ^2, where B is the magnetic field strength and ρ is the gas density.

(6) (10 points)

The gases surrounding an ultra-violet, such as the O star, get heated by the radiation from the star. These gases often have temperature up to around 10^4 degrees and manifest themselves as the H II cloud. Please explain why the gas temperature is always maintained at this value, and does not reach a value as high as the surface temperature of the O star.