PHD QUALIFY EXAMINATION —
GALACTIC AND EXTRAGALACTIC ASTROPHYSICS

3rd March, 1998

(1) (25 points)

Because of the differential rotation of the Galaxy, a celestial object (star, cloud) viewed at another location within the Galaxy in general has both the radial ($v_{\rm R}$) and transverse ($v_{\rm T}$) components with respect to the solar neighborhood.

(a) (10 points) Assuming circular orbits around the Galactic center in all cases, derive the expression for $v_{\rm R}$ and $v_{\rm T}$.

(b) (5 points) The well-known Oort constants, A and B are useful quantities in studying galactic kinematics, and their approximated values are $A \approx 14$ km s^{-1} kpc^{-1} and $B \approx -12$ km s^{-1} kpc^{-1}. How are $v_{\rm R}$ and $v_{\rm T}$ related to A and B?

(c) (10 points) Give a physical interpretation for the Oort constants. Specifically, $(A-B)$ and $-(A+B)$ each describes a local physical parameter of the Galaxy. What are they?

(2) (25 points)

Consider a cloud of temperature T_C and optical depth τ_ν in front of a background source of temperature T_0. Find the brightness temperature T_b detected at the frequency ν by an observer if

(a) (5 points) $\tau_\nu \ll 1$ and $T_0 = 0$;

(b) (5 points) $\tau_\nu \approx 1$;

(c) (5 points) $\tau_\nu \gg 1$;

(d) (5 points) $T = T_0$ for and τ_ν;

(e) (5 points) What is the highest T_b that can be possibly detected?

(3) (25 points)

King's models for stellar distribution produce the surface brightness that often fits the globular clusters and elliptical galaxies quite well. King's model is in fact a modification to the isothermal model.

(a) (10 points) Please describe the differences in the stellar phase-space distribution functions for the two models.

(b) (10 points) The isothermal model has no parameter to adjust and it produces an unique density profile. Please explain why it is so.

(c) (5 points) Instead, the King's model has one parameter to adjust and hence it can produce a family of different density profiles. What can be this adjustable parameter in the king's model?

(4) (25 points)

Consider a spiral galaxy whose gravity is entirely dominated by the central *spherical* bulge and the extended *spherical* halo. Given the facts that in the bulge part the galaxy rotation law is solid-body rotation and that in the outer part of the galactic disk the rotation law is a flat rotation. Please derive the density profile of the bulge and the density profile of the halo as functions of radial distance.