PHD QUALIFY EXAMINATION —GALACTIC AND EXTRAGALACTIC ASTROPHYSICS

2nd March, 2001

(1) (10 points)
The current cosmic black body radiation has a temperature T =2.7 K, and the current matter density is $\rho_{mo} = 3 \times 10^{-31}$ gm cm^{-3}.
(a) (5 points) What is the red shift when the universe changed from radiation-dominated to matter-dominated?
(b) (5 points) If the recombination temperature of the proton and electron is 4000 K, what is the red shift at the recombination era?

(2) (10 points)
Assume that the Universe is 10^{10} years old. How long ago was the light from a quasar with redshift $z = 2$ emitted? (Assume the Einstein-de Sitter model.)

(3) (10 points)
Show that without interstellar absorption, the number of stars with apparent magnitude equal to m is proportional to $10^{0.6m}$ in a uniform Universe.

(4) (10 points)
(a) (5 points) Suppose that the mass of a disk galaxy is determined by measuring the rotation curve out to some given radius from the center of the galaxy. Show that the mass contained within the radius is proportional to H_o^{-1} (inverse of Hubble constant).
(b) Show that the mass-to-light ratio of a group of galaxies determined from the virial theorem is proportional to H_o.

(5) (10 points)
Please explain the unification model of AGNs.

(6) (10 points)
How did astronomers come to a conclusion that there must be black holes accreting mass in the center of the Galaxy and in M87? Explain this in terms of "gas kinematics" and "light-travelling argument".

(7) (10 points)
Why can't we observe H_2 directly in radio wavelengths? What molecule is used to trace the content of H_2 in galaxies? Why? Whats the typical abundance ratio of this molecule to H_2?

(8) (15 points)
Write down the expression of velocity for a Keplerian rotation. What's the relation between $V(r)$ and r in Keplerian motion? If $V(r)$= constant, what's the relation between $M(r)$ and r, assuming spherical distribution? What's the relation between $\rho(r)$ and r?

(9) (15 points)

From conservation of energy, derive the kinetic equation of the universe in terms of H_o, ρ_o, and a constant κ. Derive the critical density for a flat universe. What is the age of the universe for a flat geometry, in terms of $t_H (= 1/H_o)$ and redshift z? For a quasar at $z = 5.0$, what is its look-back time?