Institute of Astronomy, National Central University

PHD QUALIFYING EXAMINATION — GALACTIC AND EXTRAGALACTIC ASTROPHYSICS

29th May, 2003

(1) (20 points)

One of the most well-known classifications for the galaxies is Hubble sequence, i.e., "Hubble tuning-fork diagram". Hubble suggested that galaxies evolved from the left-hand end of this sequence to the right. You might or might not agree with him. You might believe that the evolution of galaxies has nothing to do with the Hubble sequence.

(a) Please write down your opinion, i.e., agree or not agree or other choices.

(b) The astronomical reason for your opinion.

(c) Please write down a possible (observational) method to check if your answer is correct or not.

(2) (20 points)

For a homogeneous sphere, i.e., a sphere with constant density ρ with radius a,

(a) Please calculate the circular velocities $v_c(r)$, where $r < a$.

(b1) Calculate the orbital period T of a test mass on a circular orbit.

(b2) Calculate the "dynamical time", which is $T/4$.

(c1) A test mass is released from rest at radius r (where $r < a$) in the gravitational field of a homogeneous body. Please write down the equation of motion and solve it, i.e., get the radial location of the test mass as a function of time, $r_l(t)$.

(c2) Try to determine the time for the test mass to arrive at the center of the sphere from the initial radius r.

(3) (20 points)

To measure distance is one of the most important issues in astronomy.

(a) Please explain why "distance" is important, i.e., how it is related to stellar astrophysics, galactic astrophysics and cosmology.

(b) Why could we use "Surface Brightness Fluctuations" of a galaxy to measure distance? Please explain the key point of this method.

(c) Why could we use "Type Ia Supernova" to measure distance? Please explain the key point of this method.

(d) Why could we use "Tully-Fisher Relation" to measure distance? Please explain the key point of this method.

(4) (20 points)

Please write down the formula that related the kinetic, potential, and total energy of the universe, assuming an expanding spherical shell model in a dust-filled universe. (the dust here should not be confused with the physical dust grains in the ISM. It exerts no pressure, so gravity is the only force acting.)

(a) Express the 3 possible geometries of the universe using this formula: open, close, and critical, and explain the physical meaning of these 3 geometries.

(b) Please derive the formula for the critical density

$$\rho_0 = \frac{3H_0^2}{8\pi G}$$

(c) If we use a value of 0.68 for the dimensionless Hubble constant h, what is the critical density? (You don't need a calculator for this, just give an order of magnitude answer.) ($G = 6.67\times$ dyne cm^{-2} g^{-1})

(d) What is the ratio among "visible matter", "dark matter", and "dark energy" in our universe, as we know it most recently?

(5) (20 points)

Please draw two plots: the first one is a spectrum of a quasar, from X-rays to radio. The second one is the geometrical model of the current unification scenario.

(a) Please point out the correspondences between the spectrum and the model, i.e., point to the model where the prominent spectral features are formed. (E.g., Broad line region, Narrow line region, X-ray continuum, UV bump, IR emission, and radio emission.)

(b) What is the general consensus of the physical relation between higher redshift quasars and lower redshift active galaxies?