PhD Qualifying Exam (2011) – Galactic and Extragalactic Astronomy

1. Rotation velocity:
   a) How do we measure the rotation velocity of the sun around the center of the Milky Way? (5 points)
   b) How can we measure the distance to the center of the Milky Way? (5 points)

2. Spiral Arms:
   a) Why cannot spiral arms of galaxies be material arms? (5 points)
   b) How do you explain the existence of spiral arms in galaxies? (5 points)

3. Dark Matter:
   a) Describe at least three different astronomical results that need ”dark matter” and explain why they need dark matter. (5 points)
   b) What are the possible candidates of dark matter? (5 points)

4. Distance:
   a) What is the difference between the luminosity distance and angular-diameter distance? (5 points)
   b) What is the distance that you derived using the Hubble’s law? Why? (5 points)

5. Galaxy Clusters:
   a) Describe at least two different methods to measure the mass of a galaxy cluster? (5 points)
   b) What is the beta model? What is the physical meaning of the “beta”? (5 points)

6. For various measurements, systematic errors are always sensitive to obtain accurate values. In the astronomy & astrophysics case, one of the good examples is the estimation of the Hubble constant. The first estimation of the Hubble constant was 530 km/s/Mpc. Current one is 70.5 km/s/Mpc. This is because there were huge systematic errors on the first measurement.
   (a) Please explain what the systematic error is.
   (b) Please write down the ways to reduce systematic error as much as possible. You can also write previous trial of cosmological observations (e.g. WMAP etc.)

   (10 points)

7. Estimations of distance and redshift are important keys in Astronomy and Astrophysics.
   (a) There are three redshift for astronomical use; kinematic, gravitational and cosmological. Please explain the physical backgrounds of these redshift.
   (b) 3C273 is one of the well-known astronomical jet sources. The observed emission lines of 3C273 are 15.8% shifted from those of rest frame. Please estimate how much the recession velocity is (m/s).
   Assuming that the recession velocity is caused by cosmological expansion, please estimate the distance of 3C273. Hubble constant is 70.5km/s/Mpc. (Mpc)
   (c) Please list up methods for distance estimation of astronomical objects. For selected two methods, please also explain the physical background of their estimation.
   (16 points)

8. Our Universe began with BigBang, and then cooled down. The observational evidences are Hubble's law, abundance of light elements, and Cosmic Microwave background (CMB).
   (a) Please explain what CMB is.
   (b) The first CMB temperature measurement was performed with only two SED data points. Please explain what is Black Body radiation with drawing spectrum (with various temperature) and equation.
   (c) why/how can they estimate the temperature only using two data points? Please explain the physical backgrounds.
   (14 points)

9. Various observations require the existence of the Dark Matter. One of the sources is cluster of galaxies.
   (a) What are the main radiation processes of Cluster of galaxies in X-ray range?
   (b) Please list up components of Cluster of galaxies with their mass ratio.
   (c) Please explain what is the Virial theorem.
   (d) Using Virial theorem please explains how to estimate the mass of cluster of galaxies.

(e) What are the physical requirements of Dark Matter? (10 points)