Institute of Astronomy, National Central University

PHD QUALIFYING EXAMINATION — GALACTIC AND EXTRAGALACTIC ASTROPHYSICS

9:00–13:00, 30th May, 2013

(1) (25 points)
Rotational velocity of the Milky Way.
(a) (5 points) How do you obtain the velocity of the sun with respect to the Local Standard of Rest (LSR)?
(b) (10 points) How do you measure the Oort constants A and B, and the angular velocity of the LSR with respect to the Galactic center?
(c) (5 points) How do you measure the distance to the Galactic center?
(d) (5 points) How do you know that there is a dark halo component in the Milky Way?

(2) (15 points)
There are molecular clouds and neutral atomic clouds in the ISM of galaxies.
(a) (5 points) How do you observe neutral atomic clouds and molecular clouds?
(b) (5 points) What is the difference between the general dynamical behaviors of the atomic clouds and the molecular clouds during a galaxy merging process?
(c) (5 points) What is the origin of the different dynamical behaviors between atomic and molecular clouds?

(3) (10 points)
Spiral Galaxies.
(a) (5 points) Why cannot spiral arms of galaxies be material arms?
(b) (5 points) How do you explain the existence of spiral arms in galaxies?

(4) (17 points)
Gamma-Ray Bursts (GRBs) are among the most powerful explosions in the Universe.
(a) (2 points) The size of the emitting region of GRB can be estimated by the pulse width of the light curve. Figure 1 shows one of the GRB light curve in the prompt phase. Please estimate the emitting region "R".
(b) (3 points)The luminosity is also calculated from the observed energy flux, f. Then the number density of gamma-ray is calculated as $n_\gamma = 2 \times 10^{27}(\delta t/10\,\mathrm{ms})^{-2}$ cm^{-1}. Here typical energy of gamma-ray photons is 1 MeV. What will happen if there is a suddenrelease of a large quantity of gamma-ray photons into the emitting region that you estimated with (a)?
(c) (6 points) If your calculation is correct, observer cannot observe any gamma-ray photons. This is the well-known compactness problem. How to solve this problem? Please explain the detail.
(d) (6 points) Blazers share basic physics with GRBs. One of the main characteristics of Blazers is their rapid time variability with large amplitude. What physical process do we need to introduce to explain this rapid time variability? Please explain the detail.

(5) (8 points)
The origin of Dark Matter (DM) is totally unknown. To explain the observational results (e.g. rotation curves of spiral galaxies, X-ray observations for cluster of galaxies), Cold Dark Matter (CDM) is required. Please describe four requirements of DM.
[Each "requirement" carries 2 points.]

(6) (25 points)

Figure 2 shows the different views of a cluster of galaxies in X-ray and optical.

(a) (5 points) Please describe the physical differences between X-ray and optical.

(b) (10 points) Cluster of galaxies plays one of important roles on cosmology. Please pick up two topics that are related with cosmology and describe their physical backgrounds.
[Each "topic" carries 5 points.]

(c) (10 points) Please also describe actual observations with detail analysis method to perform these two topics.
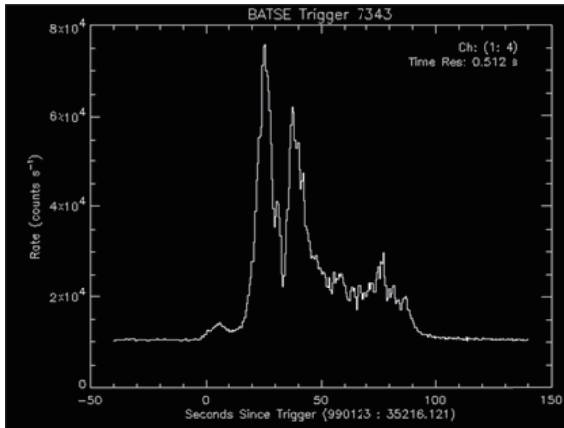[Each "topic" carries 5 points.]

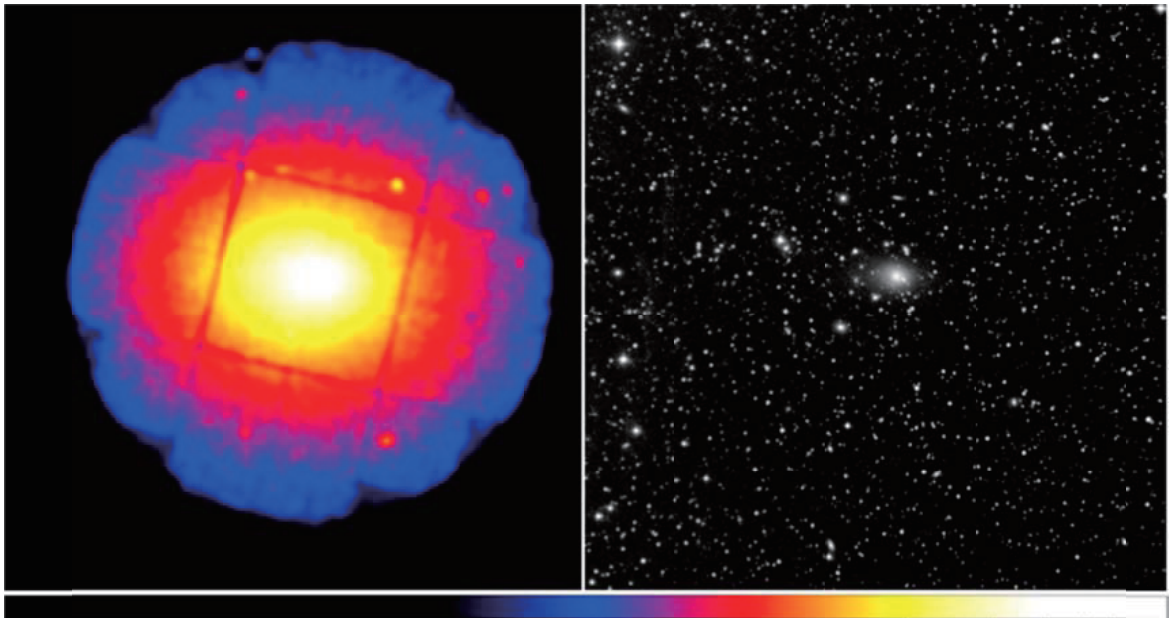Fig. 1. Figure for question (4). Light curve of an Gamma-Ray Burst.

Fig. 2. Figure for question (6). X-ray and optical views of a cluster of galaxies.