Qualification Examination—Galactic and Extragalactic Astronomy
May 21, 2009

1. Please write all of major mechanism of astronomical objects with dividing into thermal, non-thermal and line emissions. Please list up astronomical object for each emission mechanism.

2. Please explain what is superluminal motion with drawing figure and equation. Please prove that the apparent velocity will become larger than light speed. Please list up what kind of astronomical objects showing this phenomena.

3. The spectrum of an X-ray burst (explosion at surface of a Neutron star) has an absorption line at 4.1 keV. The original source of the line is likely to be FeXXV (6.7 keV). (a) What is the effect that will make this energy shift? If the absorption takes place at the surface of a Neutron star, how the Neutron star radius will be expressed by the Schwarzschild radius of a Neutron star? (c) Assuming the mass of the Neutron star is 1.4 $M_\odot$, what is the radius of the Neutron star? ($M_\odot = 2 \times 10^{33}$ g, $G = 6.6726x10^{-8}$ cm^3 s^{-2} g^{-1})

4. Gamma-ray Burst (GRB) is now the most distant object ($z = 8.1$!) in the universe. (a) How to estimate their distance? Please explain the ways as much as possible. (b) Is the prompt gamma-ray emission come from annihilation? The answer fully related with so-called compactness problem. Please explain what is compactness problem. (c) How to solve this problem? Please evaluate the emission region for this mechanism. (hint: consider about two shells)

5. Please describe two-phase and three-phase models of the ISM? What is the physical origins of these phases? What is the principal assumption in these models?, and Why? What and why are the differences between atomic clouds and molecular clouds in ISM? (10 points)

6. Show that the velocity dispersion of stars in a globular cluster is $< v^2 >= GM/2R$, M is the total mass of the cluster. (5 points) Show that the escape velocity of stars in the globular cluster is twice the velocity dispersion of the stars in the cluster. (5 points)

7. Please describe, explain, and compare the Tully-Fisher relation and the Faber-Jackson relation. (10 points)

8. An elliptical galaxy contains hot gas and stars. Assume that both the ram pressure of the stars (i.e. $\rho_* v_*^2$) and the thermal pressure of the hot gas are in equilibrium with the gravitational force of the galaxy. Show that the density of the hot gas ρ_g is related to the density of the stars ρ_* with

$$\partial \ln \rho_g = \partial \ln \rho_*^\beta$$

where β is the ratio of the energy per unit mass in stars to the energy per unit mass in the hot gas. (10 points)

9. Show that the emission of a galaxy will appear to be redshifted if the size of the Universe was smaller when the photons were emitted. (10 points)