PhD Qualifying Exam (2010) --- 星系天文物理

1. Show that without interstellar and intergalactic absorption, the number of galaxies with fluxes greater than $\boldsymbol{f}$ is proportional to $\boldsymbol{f}^{-3/2}$ (5 points). How do you explain Olbers' paradox? (5 points)

2. In a globular clusters of $\boldsymbol{N}$ stars, show that the escape velocity $\boldsymbol{v_e}$ is twice the typical random velocity $\boldsymbol{v}$ ($\boldsymbol{v_e} = 2\boldsymbol{v}$) (5 points). What is the typical size of the cluster if $\boldsymbol{N} = 10^6$ and typical star mass $\boldsymbol{m}$ = 0.5 solar mass, and $\boldsymbol{v}$ = 20 km/sec? (5 points) (One solar mass = 2×10^{33} g and the gravitational constant $\boldsymbol{G}$ = 6.67×10^{-8} $cm^3s^{-2}g^{-1}$.)

3. In the beam model to explain superluminous expansion, what is the maximum apparent velocity that we can observe if two blobs are separated at a physical speed of 0.8*c*? (*c* is the speed of light) (10 points)

4. If the values of the Oort's constants are $\boldsymbol{A}$ = 14.5 km s^{-1} kpc^{-1} and $\boldsymbol{B}$ = -12 km s^{-1} kpc^{-1} in the solar neighborhood and the distance to the Galactic center is $\boldsymbol{R}$=8.5 kpc, what is the rotation velocity of the sun around the Galactic center? (10 points)

5. Why cannot spiral arms of galaxies be material arms? (5 points) How do you explain the existence of spiral arms in galaxies? (5 points)

6. Please explain what is the Black body radiation.
   Please draw the shape of the spectrum with various temperatures (write as fig1).
   Please also draw the shapes of thermal bremsstrahlung and Blackbody spectrum at the same temperature (write as fig2).
   Please explain what is the thermal bremsstrhlung radiation.
   Please list up the astronomical objects, which have Blackbody and thermal bremsstrhlung radiations.
   (15 points)

7. 3C273 is one of the well-known jet sources. The observed emission lines of 3C273 are 15.8% shifted from those of rest frame.
   (a) Please estimate how much is the recession velocity (m/s)
   (b) 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) These jet sources show superluminal motion. Please explain what is the superluminal motion with drawing figure and equation. Please also prove the apparent velocity will become larger than light speed.
(15points)

8. Please explain what is Virial theorem. When we consider gravity and electromagnetic force cases ($U \sim r^{-1}$ case), please proof $2\langle K\rangle + \langle U\rangle = 0$. Here K, $\langle X\rangle$ and U are kinematic energy, long term time average of parameter "X" and potential energy, respectively. When we use the Virial theorem, we can estimate mass of cluster of galaxies. Please explain how to estimate from observations using this theorem.
(20points)