Qualifying Exam 2025.05.28(Wed.)
Galactic and Extragalactic Astrophysics(星系天文物理)

1. **(a)** Discuss why flat rotation curves in spiral galaxies suggest the presence of dark matter. Also, how is it mathematically different from the solid-body rotation and Keplerian rotation (15 points)**?**
   (b) Describe two alternative methods to measure the dark matter distribution in galaxies (either spiral or elliptical galaxies), and explain the assumptions and limitations (10 points).
   (c) Using the Oort constants, please calculate the relative velocity of a star located 500 pc away from us, with an angular separation of 30 degrees between the directions to the star and to the Galactic center (10 points).

2. **(a)** What is the color-magnitude relation for galaxies? What does it tell us about the galaxy populations? (10 points)
   (b) Describe the Faber-Jackson relation and its connection to galaxy formation theories. (10 points)
   (c) Describe the Tully-Fisher relation, and derive it using basic physical principles under the assumptions that all spirals have the same mass-to-light ratio and surface brightness. (10 points)

3. **(a)** Discuss the difference between a low-surface-brightness galaxy and a faint galaxy (i.e., with low total magnitude). (5 points)
   (b) Assuming two galaxies having the same apparent magnitude but different sizes, please discuss which one is harder (or equally hard) to be detected by imaging surveys. (5 points)
   (c) The surface brightness is defined as the flux per unit solid angle. Please show that the surface brightness of a galaxy is independent of its distance. (5 points)

4. **(a)** List two observational differences (either photometric or spectroscopic) between AGN host galaxies and non-AGN host galaxies, and the underlying mechanisms in causing such differences. Please also discuss the potential impact on constraining the galaxy properties (e.g., star formation rate) if we are unable to distinguish between AGN and non-AGN host galaxies. (10 points)
   (b) Consider spherical accretion of fully ionized hydrogen gas onto a black hole of mass M. Please determine the upper limit of luminosity at which the accretion can proceed (the so-called Eddington luminosity). Assume that radiation pressure mainly acts on electrons via Thomson scattering (with cross section), while the gravity acts mainly on the protons (with mass). Express this luminosity in terms of G, c (speed of light), , and M. (10 points)