Graduate Institute of Astronomy, National Central University
PHD QUALIFYING EXAMINATION 2024 —Galactic and Extragalactic Astrophysics

1. **(a)** Assuming R_0 represents the distance of our solar system to Galactic center, please describe the method we used to measure the rotation curves under orbital radius $R < R_0$. (15 points) **(b)** Rotation curves of galaxies are widely used to constrain the dark matter properties. Please give one more method other than the rotation curve that we can use to constrain the existence of dark matter (either for disk or elliptical galaxies) and explain why. (5 points)

2. **(a)** What is the luminosity function of galaxies? (5 points) **(b)** Please show the galaxy luminosity function in mathematical form and describe (or plot) its shape and meaning. (10 points)

3. Please list two observational differences (could be either photometric or spectroscopic) between AGN host galaxies and non-AGN host galaxies, and the underlying mechanisms to cause these differences. (20 points)

4. **(a)** Please give two bright and common X-ray sources you would find in general on the sky if pointing the X-ray telescopes away from the Galactic disk. (5 points) **(b)** Please explain the physical mechanisms of producing the X-ray emissions of these two sources in detail. (20 points)

5. **(a)** Assuming the M and σ represent the mass of central supermassive black hole and velocity dispersion of a galaxy, respectively, what is the relation between M and σ found from the observations of a large sample of galaxies? (5 points) **(b)** Given such $M - \sigma$ relation, does that mean the velocity dispersion of a galaxy is significantly affected by the supermassive black hole in the center? Please give explanations of your answer. Are there other scenarios able to produce the observed $M - \sigma$ relation of galaxies? (15 points)