Qualification Examination: Galactic and Extragalactic Astronomy (2021)

1. Assuming an optically-thin gas cloud with mass M and radius R (here we assume the density profile of the gas cloud is uniform) is undergoing a pure gravitational collapse,
   (a) please show that the time-scale t for this gravitational collapse only depends on the density of the cloud ρ, in the form of $t \propto (1/\rho)^{1/2}$. **(20 points)**
   (b) Assuming the star formation is mainly controlled by the gravitational collapse of the gas, please show that the density of the star-formation rate ρ_{SFR} is proportional to the density of the gas cloud ρ in the form of $\rho_{SFR} \propto \rho^{1.5}$, which is in good agreement with the Kennicutt-Schmidt law if all the disk galaxies have approximately the same scale height. **(10 points)**

2. Please list 5 differences between the physical properties of elliptical and spiral galaxies. **(20 points)**

3. Sometimes, astronomers use ”dark matter” to explain observational results. Describe at least three different astronomical results that need ”dark matter” and explain why they need dark matter. (**15 points**)

4. Motion of the Galaxy:
   (a) How do we know the sun is moving with respect to the nearby stars, i.e., how do we know the motion of the sun relative to the Local Standard of Rest (LSR)? (**5 points**)
   (b) How can you determine the rotating velocity of the LSR rotating about the Galactic center? and what is the meaning of the Oort's constants? (**10 points**)
   (c) How can you determine the distance to the Galactic center? (**5 points**)

5 Atomic and Molecular gas:
   (a) There are atomic gas and molecular gas in the interstellar medium of galaxies. Describe the methods (i.e., spectral lines) we used to detect them. (**5 points**)
   (b) Why do we not detect the hydrogen molecular H_2 directly? (**5 points**)
   (c) What and why are the different behaviors of atomic gas and molecular gas in merging galaxies? (**5 points**)