Qualifying exam 2022
Stellar astronomy

1. (45%) Explain the following terms as elaborately as possible: (3 points each) (1) Roche limit; (2) Oort limit; (3) Schönberg-Chandrasekhar limit; (4) Eddington limit; (5) Parker instability; (6) Jeans instability; (7) Faraday rotation; (8) Zeeman effect; (9) Stark effect; (10) dispersion measure; (11) emission measure; (12) rotation measure; (13) cosmological red shift; (14) gravitational red shift; (15) Fermi-Dirac distribution

2. (5%) Write down the equations governing the processes inside a star that describe (1) the hydrostatic equilibrium; (2) the energy generation, and (3) the radiative energy transport. State clearly the meaning of each symbol in the equations.

3. Hydrostatic equilibrium equation

a. Consider a small cylindrical mass element in a star. Give the equation of motion for this mass element. Mention all the forces you consider. Describe the meaning of each symbol you use. (5 points)

b. Assume hydrostatic equilibrium, and derive following relation.
$$dP/dr = -Gm\rho / r^2$$
where r is the distance from the centre of the star, P is the pressure at position r, G is the gravitational constant, m is the mass enclosed in a sphere of radius r, ρ is the density at distance r from the centre. (5 points)

4. mass measurement of stars

The total mass of a binary system can be estimated from the orbital motion of stars. Consider a binary system, and describe a method to estimate the total mass of this system. Mention physical principle(s) and/or law(s) you use. Describe each symbol you use. (10 points)

5. dynamical timescale

a. What is the escape velocity from a star of mass M and radius R? When you use symbols other than M and R, describe the meaning of each symbol you use. (5 points)

b. The timescale τ for a physical quantity φ is defined to be the ratio of φ to the rate of change of φ, dφ/dt. Consider escape velocity and radius R of a star to estimate dynamical

timescale τ_{dyn} of a star. The mass of a star is M. (5 points)

c. The dynamical timescale τ_{dyn} of the Sun is about 1000 sec. What are implications from this? (5 points)

6. Site of star formation

How can we identify sites of star formation where new stars are forming? Describe your answer. (10 points)

7. Spectra of stars

Spectra of stars exhibit a peak at ultraviolet to near-infrared wavelength range. Some stars show a weaker peak at mid-infrared to far-infrared wavelength range in addition to the primary peak at ultraviolet to near-infrared wavelength range. What does cause this secondary peak at mid- to far-infrared? How is this secondary peak formed? What is the physical principle / law behind it? Describe your answer. (5 points)