Qualifying Exam of Stellar Astrophysics (2022)

1. (20%)Knowing that the apparent visual magnitude of the Sun is –26.73, calculate its absolute magnitude.

2. (20%) Calculate the potential gravitational energy of a star of mass M_* and radius R_* assuming it possesses a constant density.

3. (20%) (a) Calculate Jeans' mass for an average molecular cloud. Typically, molecular clouds have masses on the order of 1000 $M_\odot$ or more, temperatures on the order of 10K and number densities of approximately 1000 H_2 molecules per cm3. Discuss the results in relation to star formation. (b) Calculate Jeans' density for a diffuse hydrogen (or HI) cloud. Typically, diffuse hydrogen clouds have masses of less than 100 M_⊙, temperatures on the order of 100K and number densities of less than 1000H atoms per cm^3. Discuss the results in relation to star formation.

4. (20%) Find the pressure stratification $P(r)$ inside a star with mass M_* and radius R_* in which the density decreases linearly with r via the expression.
$$\rho(r) = \rho_c\,(1 - r/R_*)$$
where ρ_c is the central density.

5. (20%) Electron degeneracy pressure will halt the gravitational collapse of a star if its mass is below the Chandrasekhar limit (1.44 $M_\odot$). This is the pressure that prevent a white dwarf star from collapsing. Please use the dimension analysis to derive the equation of states under the cases of relativistic and non-relativistic. (Hint: $dE = E_k V d^3k/\pi^2$ in Fourier space)