Qualifying Exam of Stellar Astrophysics (2024)

1. Please find out the definition of *brightness temperature*, T_b, and under Rayleigh-Jeans limit (i.e. $h\nu \ll kT$), show that

$$T_b = T_b(0)e^{-\tau_\nu} + T(1 - e^{-\tau_\nu})$$

(25%)

2. Please provide the governing equations for the stellar structure of a single star. (25%)

3. Electron degeneracy pressure will halt the gravitational collapse of a star if its mass is below the Chandrasekhar limit (1.4 $M_\odot$). 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) (25%)

4. For commercial fusion on Earth, we need to increase the fusion rate to a million times higher than the sun. Achieving this involves reaching temperatures or pressures well beyond natural states, such as torus reactors operating at about 100 million Kelvin — almost ten times the sun's core temperature — particularly with the use of efficient deuterium-tritium fuel. But the question remains: how do we initiate nuclear fusion similar to that in the sun's core? (25%)