Summer School on Gravitational Wave Astronomy
17-28 July 2017. ICTS, Bangalore
Lectures by G. Srinivasan
Material for Tutorials related to Lectures 1, 2, 3

1. Derive the expression for the Degeneracy Pressure of an electron gas in the nonrelativistic and ultrarelativistic regime.
2. Using simple scaling arguments – such as replacing dP/dr by P/R, etc. – derive mass – radius relation for a nonrelativistic white dwarf. Repeat this for a relativistic white dwarf. Use the expressions derived above.
3. Derive the Tolman – Oppenheimer – Volkoff equation.
4. Calculate the Fermi energy of the neutrons, protons, and electrons and convince yourself that even at a temperature of 10^9 Kelvin, a neutron star can be regarded as a very cold object. Assume a density of 10^{14} g cm^{-3}; 5% protons and and equal number of electrons.
5. Calculate the depth at which the pressure in a neutron star will be equal to the pressure at the centre of the earth.
6. Why don't the neutrons in the core of a neutron star 'decay'? In other words, why is a neutron star stable?
7. Relate the "minimum mass" of a neutron star to the previous question. In other words, WHY is there a minimum mass?
8. Chandrasekhar ignored the interaction between the electrons in his theory, even though he was dealing with matter at very high density. Can you justify why de did that? After all, most interesting things in solids can be traced to electron-electron interaction!
9. But Oppenheimer was worried about the neglect of the interaction between the neutrons in his theory. Why? Contrast this with the above question.
10. Estimate the melting temperature of the crust. Assume a density of 10^6 g cm^{-3}.
11. Calculate the Bose-Einstein condensation temperature by assuming a density of 10^{14} g cm^{-3} .
12. Convince yourself that the URCA process is suppressed when degeneracy sets in.
13. Calculate the luminosity of the black body radiation from a neutron star at a temperature of 10^7 K, and compare it with the luminosity of the Sun.

14. Imagine an electron is dropped on to the surface of a neutron star. Show that the energy released will be roughly 10% of the rest mass energy.

15. Calculate the "Light Cylinder" distance – in units of the radius of a neutron star – for the Crab pulsar with a period of 33 millisecond.

16. Derive the expression for the Alfven radius, and the Equilibrium period of a neutron star accreting from a companon.