Tutorial 1: Neutrino and Astroparticle Physics

Exercise 1

The cross section for an electron neutrino to undergo a charged current interaction with an electron is

$$\sigma_{CC}(\nu_e e \to \nu_e e) = \frac{2 m_e E_\nu G_F^2}{\pi}$$

where m_e is the mass of the electron, E_ν is the energy of the neutrino and G_F is Fermi's constant. Use this cross section to find the probability that a 10 MeV solar electron neutrino will undergo a charged-current weak interaction with an electron in the Earth if it travels along a trajectory passing through the centre of the Earth. Take the Earth to be a sphere of radius 6400 km and uniform density $\rho \sim 5520\,\mathrm{kg\,m^{-3}}$.

Exercise 2

Show that when L is given in km and Δm^2 is given in eV^2, the two-flavour oscillation probability expressed in natural units becomes:

$$\sin^2(2\theta)\sin^2\left(\frac{\Delta m^2[\mathrm{GeV}^2]\mathrm{L}[\mathrm{GeV}^{-1}]}{4E_\nu[\mathrm{GeV}]}\right) \to \sin^2(2\theta)\sin^2\left(\frac{1.27\Delta m^2[\mathrm{eV}^2]\mathrm{L}[\mathrm{km}]}{E_\nu[\mathrm{GeV}]}\right)$$