

Modern Physics

Tutorial 11

Free Fermi Gas

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1 Fermi Energy of Relativistic Gas

Calculate the Fermi energy for N neutrinos, particles of spin $1/2$, confined to a cubic volume with sides of length L . Since neutrinos have very small mass, use the relativistic expression for the energy $E = pc$ rather than the non-relativistic one $E = \frac{p^2}{2m}$.

2 Pressure of an Electron Gas

Consider a system of free electrons in a box of volume V

a) Show that the total energy E_{tot} of a three-dimensional gas of N free electrons is given by $\frac{3}{5}N\epsilon_F$.

b) Find the pressure of this free electron gas. Show that the pressure can be expressed as $\frac{2}{3}E_{tot}/V$. (*Hint: $P = -\frac{\partial E_{tot}}{\partial V}$*)

3 One Dimensional Gas

In one dimensional system the number of energy states per unit energy is $\frac{l}{h}\sqrt{2m/E}$, where l is the length of the sample and m is the mass of the particles. There are N particles in the sample.

a) Determine the fermi energy

b) Find the average energy per particle