Physics 8510

Problem Set 3

1) Problem 3 from Chapter 2 of Ashcroft & Mermin.

2) NaCl crystallizes as a cubic structure. If the molecular weight of NaCl is 58.46 and the density at room temperature is $2.167 g/cm^3$ find the distance between adjacent atoms. (Ans: half of lattice constant 5.64A)

3) *Fermi gases in astrophysics.*

(a) Given $M_0 = 2 \times 10^{33}$ g for the mass of the Sun, estimate the number of electrons in the Sun. In a white dwarf star this number of electrons may be ionized and contained in a sphere of radius 2×10^9 cm; find the Fermi energy of the electrons in electron volts.

(b) The energy of an electron in the relativistic limit $\varepsilon >> mc^2$ is related to the wave vector as $\varepsilon = pc = \hbar kc$. *Show* that the Fermi energy, in this limit, is $\varepsilon_f \cong \hbar c(N/V)^{1/3}$.

(c) If the above number of electrons were contained within a pulsar of radius 10 km, *show* that the Fermi energy would be $\sim 10^8$ eV.

This value explains why pulsars are believed to be composed largely of neutrons rather than of protons and electrons, for the energy release in the reaction $n \rightarrow p + e$- is only 0.8 X 10^6 eV, which is not large enough to enable many electrons to form a Fermi sea. *The* neutron decay proceeds only until the electron concentration builds up enough to create a Fermi level of 0.8 X 10^6 eV, at which point the neutron, proton, and electron concentrations are in equilibrium.

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