School of Physics
PHY3102/3305 Solid State Physics I

Lecture 2

Objectives. To revise the classical free electron gas (FEG) model and understand the assumptions made. To discuss the successes and failures of this simple model (heat capcity, Ohm's Law, Wiedemann-Franz Law)

To discuss the assumptions made in the description of the quantum FEG model. To employ the time-independent Schrodinger equation to derive the electron wave functions and energies.

To convey the concepts of electron density of states, Fermi energy and Fermi surface and to derive equations for $G(\varepsilon)$, ε_F, k_F, T_F and v_F.

To apply the Fermi-Dirac probability distribution to a (quantum) free electron gas, to discuss its form and its approximation to the Maxwell Boltzmann function.

Task 1. Visit the following online resources
http://britneyspears.ac/physics/dos/dos.htm
http://hyperphysics.phy-astr.gsu.edu/hbase/solids/fermi.html
http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
http://jas.eng.buffalo.edu/education/semicon/fermi/functionAndStates/functionAndStates.html
http://hyperphysics.phy-astr.gsu.edu/hbase/quantum/disfcn.html
and Wikipedia sites: Free electron model, density of states, Fermi energy, Fermi surface, Fermi-Dirac statistics, Schrodinger Equation.
http://230nsc1.phy-astr.gsu.edu/hbase/electric/ohmmic.html Microscopic View of Ohm's Law
http://en.wikipedia.org/wiki/Drift_velocity

Task 2. Revise quantum statistics and probability functions (PHY2201), and the Schrodinger equation (PHY1118).

Task 3. To memorise equations for the electrical conductivity, QFEG electron wavefunctions and energies, Fermi-Dirac probability function, and the Maxwell Boltzmann approximation.

Task 4. The electron concentration in lithium is 4.7×10^{22} cm^{-3}. Calculate the velocity of the electrons at the Fermi Surface. How does this figure compare to thermal velocities (say at 300K)?

Task 5. (i) Determine the probability that an energy level $3k_BT$ above the Fermi level is occupied by an electron.
(ii) If the Fermi energy for a particular metal is 6.25 eV, calculate the temperature at which there is a 1 per cent probability that a state 0.3 eV below the Fermi level will not contain an electron.

Task 6*. We have derived in the lectures the density of states for a free electron gas in three dimensions. Show that the density of states for a free electron gas in two dimensions in independent of the energy.

Asterix * indicates a more challenging problem