Solid State Physics – Electronic structure – Tut. N°2

I – Free electrons gas – density of states (DOS) 2D

Let a surface electronic state of any solid be described by a 2D model of free electron gas. The area of the surface is defined by $\Sigma = L_x \cdot L_y$

- Calculate the DOS $g(\varepsilon, \Sigma)$. Remarks/comments ?

II – 2D Gas at T=0 K

Let's consider the temperature T=0 K

- Plot the distribution function which describes the occupancy of electronic energy levels at T=0 K.
- Determine the Fermi level ε_F using the relationship leading to the calculation of the total number of electrons.
- Deduce the internal energy U (use the classical approximation).

III – 2D Gas at T

Now we are at any temperature T.

- Plot the function describing the occupancy of the electronic energy levels at T.
- Determine the chemical potential μ as a function of the temperature, the fermi energy and the Fermi temperature defined as $\theta_F = \varepsilon_F/k_B$.
- Study the classical limit ($T \gg \theta_F$) as well as the limit $T \to 0K$
- Determine the specific heat and its dependence on T

Solid State Physics – Electronic structure – Tut. N°3

I – Free electrons gas – density of states (DOS) 3D

It is proposed to solve the problem of a system modeled by a 3D electron gas.

- Calculate the DOS $g(\varepsilon,V)$, deduce the Fermi energy.
- Calculate the internal energy of the 3D gas at T = 0K

II – 3D Gas at low T

We consider a case where the temperature is sufficiently low that $g(\varepsilon)$ is considered constant around ε_F.

- Calculate chemical potential and internal energy
- Determine the specific heat and its dependence on T
- Compare the electronic contribution and the phononic contribution to the specific heat of solids.

To be known: Sommerfeld development

$$\int_0^{+\infty} \frac{\Phi(\varepsilon)d\varepsilon}{e^{\beta(\varepsilon-\mu)}+1} = \int_0^{\mu} \Phi(\varepsilon)d\varepsilon + \frac{\pi^2}{6\beta^2}\Phi'(\varepsilon_F)$$

with $\Phi(\varepsilon) = g(\varepsilon)$ or $\Phi(\varepsilon) = \varepsilon\, g(\varepsilon)$