Lecture 18: Hubbard model, screening and plasmons

The Hubbard model is introduced. We argue that in the limit of strong repulsion $U \gg t$, the system with one electron per site is a Mott insulator with antiferromagnetic exchange $J = 4t^2/U$. The details will be derived in a homework problem of a 2-site Hubbard model.

We next introduce the notion of screening. We derive the Thomas Fermi screening length and the Yukawa form of the screened Coulomb interaction which is applicable in the static limit $\omega = 0$. On the other hand for $\omega \neq 0$, $k = 0$, the dielectric function takes the form

$$\varepsilon(\omega) = 1 - \frac{\omega_{\rm pl}^2}{\omega^2}$$

where $\omega_{\rm pl}^2 = 4\pi n e^2/m$ is the square of the plasma frequency. We emphasize that the $\omega = 0$,$k \to 0$ and $k = 0$, $\omega \to 0$ limits of $\varepsilon(k, \omega)$ are not the same. The plasma resonance shows up as a plasma edge in the reflectivity.

Reading: Marder 20.2.2, 23.1.1