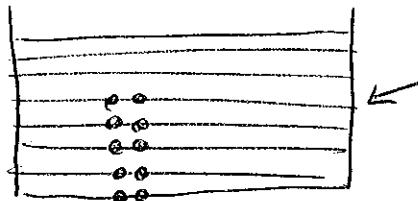


Another topic where
dipole layers are important:

Work function in metals

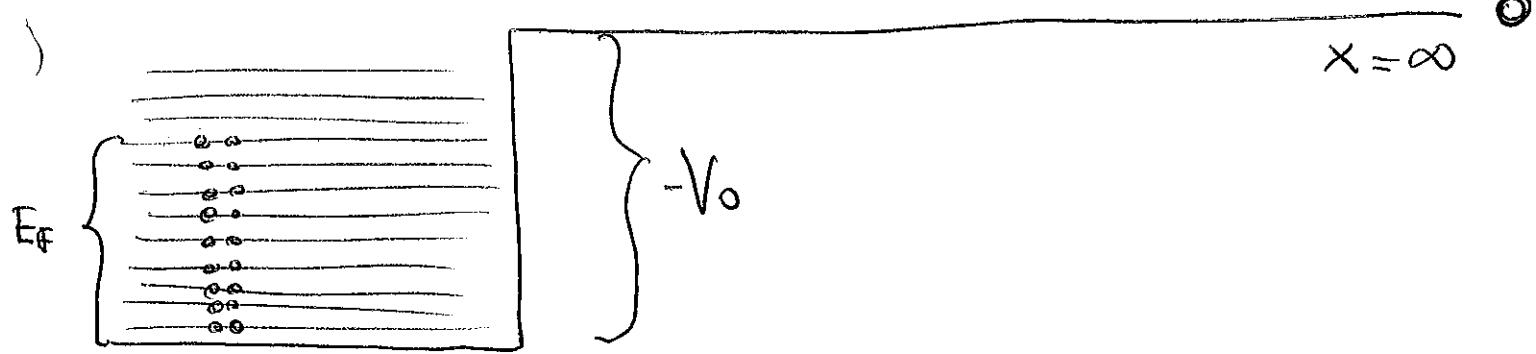
What is the energy ^{needed} to remove an electron from a metal and move it to infinity?

Let us use the standard description of good metals using non-interacting electrons & we fill levels of the problem of a single electron in a large box.



The top is the Fermi energy: $E_F = \frac{\hbar^2 k_F^2}{2m}$

To do the actual estimation, we must take into account the fact that the electrons are actually trapped inside the metal because of the presence of the positive charge. We will represent this by a negative potential V_0 (which is difficult to calculate, so this is phenomenological only):



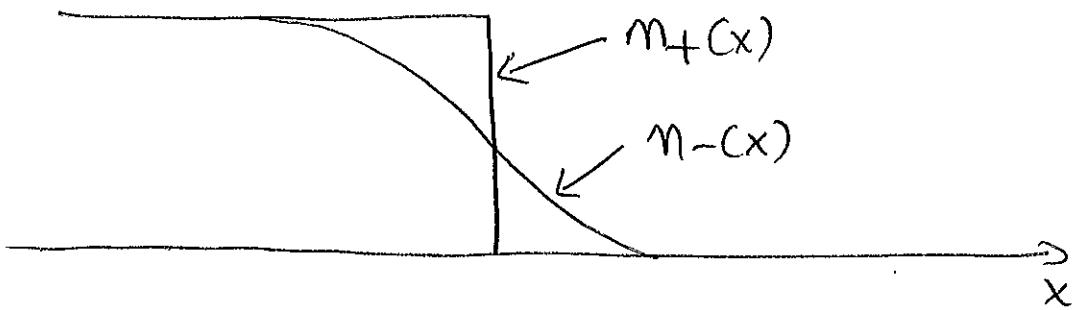
) Thus, at first sight it appears that the cost in energy to go from the metal to ∞ is $(V_0 - E_F) > 0$.

However, there is an extra subtlety at the surface.

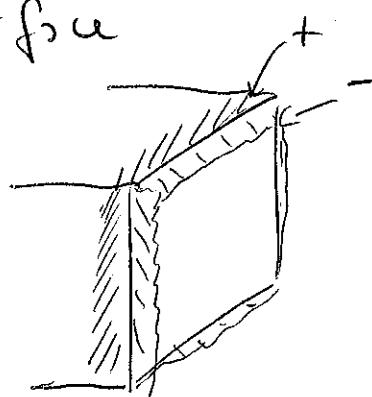
) We can safely assume that the positive charge is rigid and even if we cut the metal to form a surface only minor modifications will occur.

Thus, a box distribution with a step function is fine for " $n_+(x)$ " (the (+) charge density).

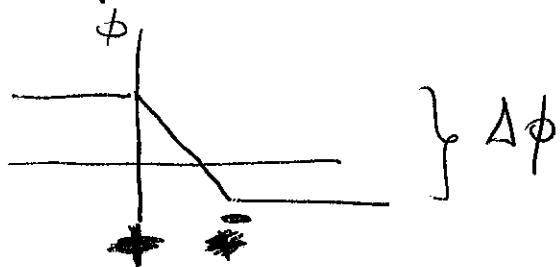
But for the electrons, which are mobile, this is not true. They tend to "spill out" a small distance. Calling " $n_-(x)$ " their distribution a more realistic profile is:



This is equivalent to having a dipole layer at the surface



We have seen before that the potential across a dipole layer goes as:



Thus, the true cost of moving an electron from the bulk of the metal to ∞ is

$$E = (V_0 - E_F) + e\Delta\phi$$

) It is extremely difficult to calculate these numbers, because in reality electrons interact with one another via Coulomb forces and also with the phonons of the lattice. But for our purposes it is sufficient to know that the "work function" has 2 terms: one related with E_F and another related with a surface dipole layer effect.

) For typical metals, the measured "work functions" are in the 2-5 eV range.