The electron-phonon interaction

- The Frölich Hamiltonian
- Perturbation theory
- Polarons
- The effective attraction between electrons

The Fröhlich Hamiltonian

In a crystal, the electrons and the ions rely heavily on each other. The electrons form energy bands due to the periodic potential created by the ions. And the ions are held together and may vibrate due to the presence of the electrons, which mediate the interatomic interaction.

But so far we have treated these two effects as independent (which is called the Born - Oppenheimer approximation). As a first approximation, this is not too bad. The masses of the electrons and ions are quite different so the time scales of their motion are usually well separated: the electrons adapt themselves quickly, so during a vibration of the ions, the electrons simply go along adiabatically.

Notwithstanding, there are situations where the electron-phonon interaction plays an important role. The simplest effect is the introduction of a temperature dependence on the electrical conductivity of metals. In ionic crystals, like NaCl (salt), the interaction of an electron with optical phonons cause the electron to carry with it a cloud of charge due to the ions (which is what we call a polaron). This modifies the mass of the electron considerably.