Superconductivity

- Discovered earlier (1911) than superfluidity due to higher $T_c$ (Hg, 4.2K?)
- Many similar properties to superfluidity
  - zero resistance $T<T_c$
  - persistent currents
- Differences
  - Perfect diamagnetism: the Meissner effect
  - Energy gap - for measurements involving single electrons, a SC often behaves like a semiconductor
Superconductivity

- Similarity to superfluidity suggests BEC
- But electrons are fermions!
- What happens is that electrons bind into Cooper pairs. A pair of fermions is a boson, so Cooper pairs can condense.
- Why should they bind? Electrons repel by Coulomb force! This is the question of the “mechanism” of superconductivity
Mechanisms

• There is no one mechanism

• BUT most superconductors arising from simple metals (i.e. which are simple metals above $T_c$) are understood from the BCS theory of pairing due to electron-phonon coupling

• Roughly, this arises because an electron distorts the lattice, and this distortion lasts a relatively long time, so that it can attract a second electron, even after the first has left

• “Retardation”: two electrons bind but do not occupy the same position at the same time, so their Coulomb repulsion is minimized.