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.