Cooper Pairs, Superconductivity and Flash Mobs

PHYS 498 ART Spring 2018

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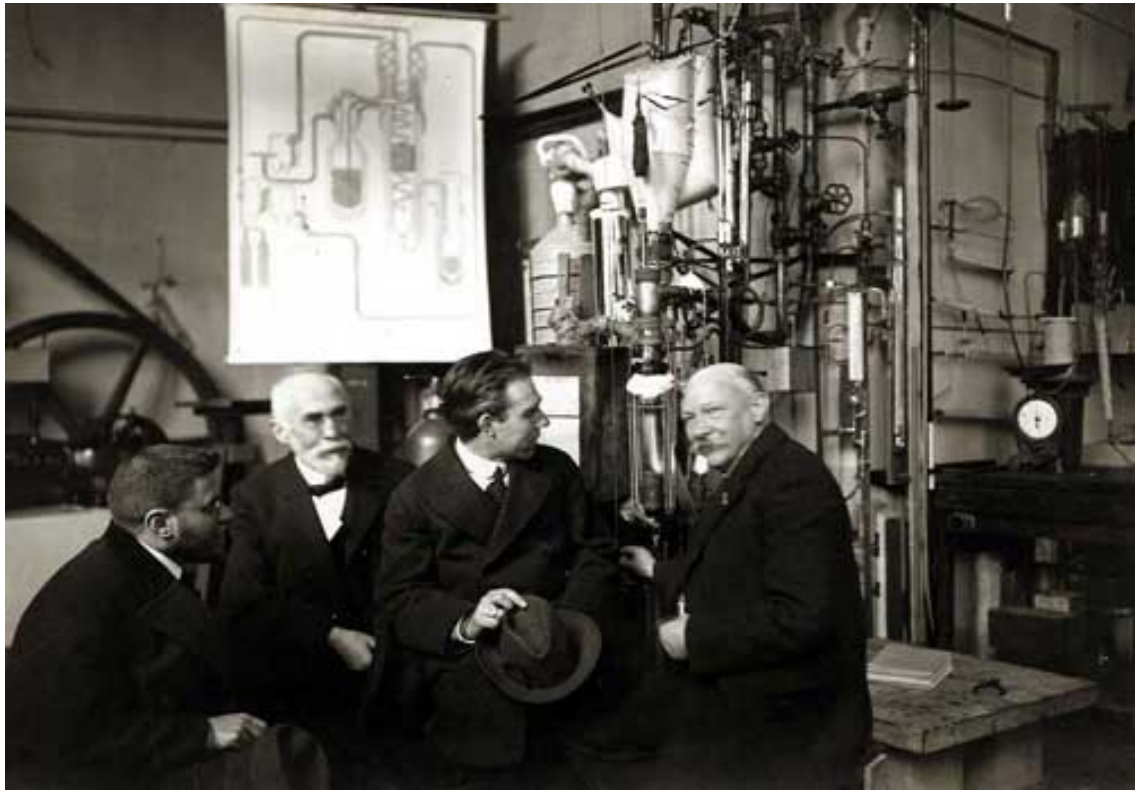
Superconductivity: History

- Heike Kamerlingh Onnes, 1911, "*Kwik nagenoeg nul*"

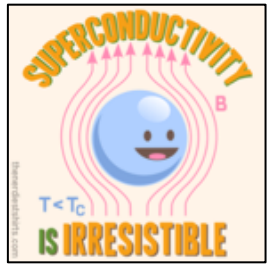


Heike Kamerlingh Onnes (right), the discoverer of superconductivity.
Paul Ehrenfest, Hendrik Lorentz, Niels Bohr stand to his left. (from Wikipedia)

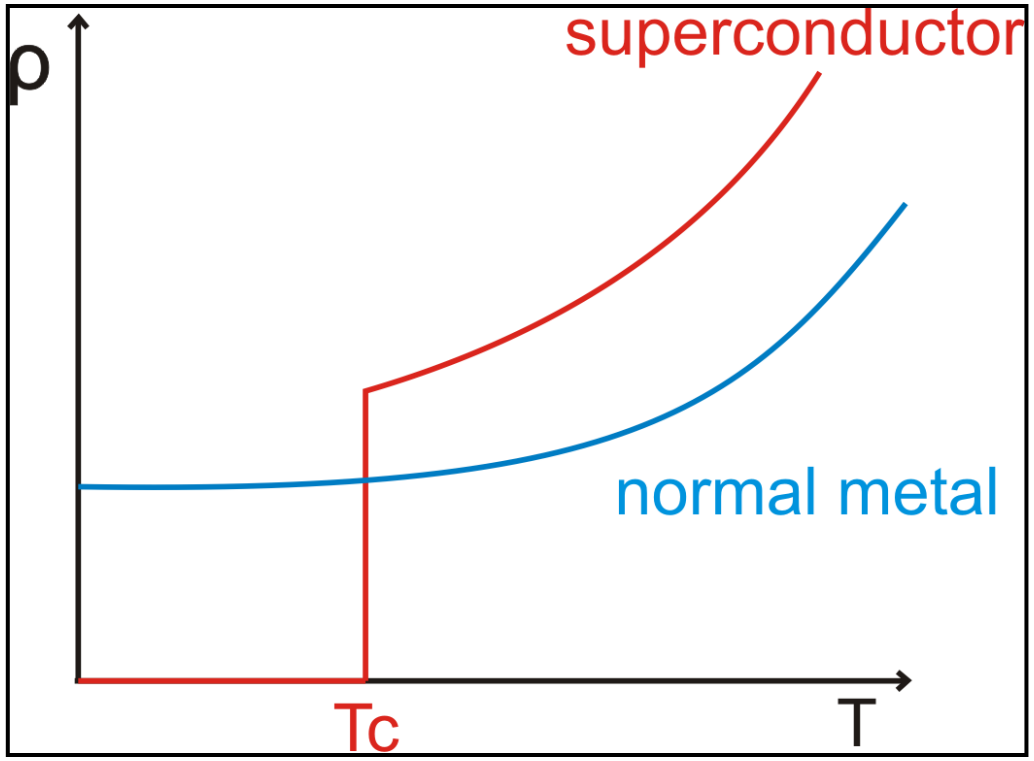
Nobel Prizes for superconductivity:

- Heike Kamerlingh Onnes (1913), "for his investigations on the properties of matter at low temperatures which led, inter alia, to the production of liquid helium"
- John Bardeen, Leon N. Cooper, and J. Robert Schrieffer (1972), "for their jointly developed theory of superconductivity, usually called the BCS-theory"
- Leo Esaki, Ivar Giaever, and Brian D. Josephson (1973), "for their experimental discoveries regarding tunneling phenomena in semiconductors and superconductors, respectively," and "for his theoretical predictions of the properties of a supercurrent through a tunnel barrier, in particular those phenomena which are generally known as the Josephson effects"
- Georg Bednorz and K. Alex Müller (1987), "for their important break-through in the discovery of superconductivity in ceramic materials"
- Alexei A. Abrikosov, Vitaly L. Ginzburg, and Anthony J. Leggett (2003), "for pioneering contributions to the theory of superconductors and superfluids"

Superconductivity: Experimental Signatures



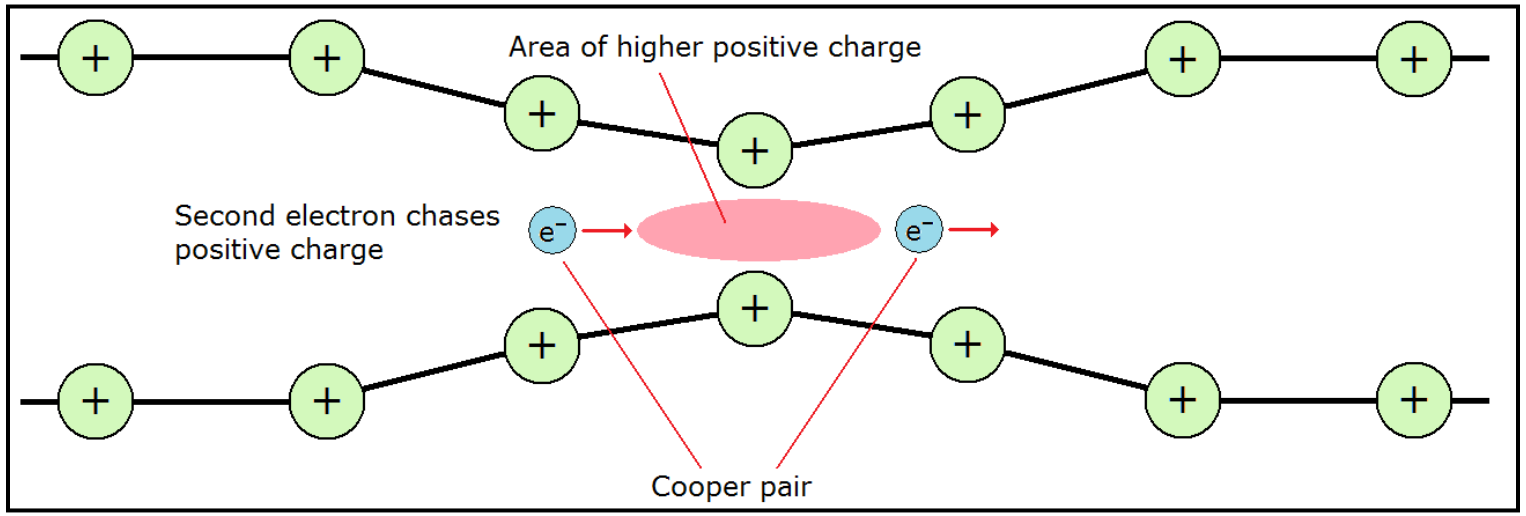
No dissipation below critical temperature



Meissner effect

Superconductivity: Cooper Pairs (BCS theory)

- Two electrons (fermions) can interact due to the presence of a crystal lattice and form a **bosonic pair** – these bosonic pairs condense into one common ground state
- Wikipedia: *"Although Cooper pairing is a quantum effect, the reason for the pairing can be seen from a simplified classical explanation. An electron in a metal normally behaves as a free particle. The electron is repelled from other electrons due to their negative charge, but it also attracts the positive ions that make up the rigid lattice of the metal. This attraction distorts the ion lattice, moving the ions slightly toward the electron, increasing the positive charge density of the lattice in the vicinity. This positive charge can attract other electrons. At long distances, this attraction between electrons due to the displaced ions can overcome the electrons' repulsion due to their negative charge, and cause them to pair up. The rigorous quantum mechanical explanation shows that the effect is due to electron–phonon interactions, with the phonon being the collective motion of the positively-charged lattice"*



https://dc.edu.au/wp-content/uploads/cooper-pair-phonon.png

Superconductivity: Cooper Pairs

(Forget theory and just dance)

https://www.youtube.com/watch?v=O6sukIs0ozk