

Physics 125c
Problem set number 7
Due Wednesday, May 19, 2004

Notes about course:

- There is a web page for this course, which should be referred to for the most up-to-date information. The URL:
<http://www.hep.caltech.edu/~fcp/ph125/>

READING: Read the “Electromagnetic Interactions” course note.

PROBLEMS:

24. We discussed the notion of the “Fermi sea” in class, according to which the energy levels occupied by the electrons in a metal are filled up under the restriction of the Pauli exclusion principle. In superconductivity, such as exhibited by niobium, there is a notion that zero resistance coherent motion can be achieved by pairing electrons into “Cooper pairs”. This is possible if there exists a long-range attractive force between two electrons in the metal. Knowing the critical temperature, T_c , below which superconductivity is achieved, make a crude estimate for how large a Cooper pair is. That is, make an estimate for the average distance between the two electrons of a Cooper pair. [Hints: The significance of the critical temperature is that it sets the scale of the attractive force, since if the temperature is large compared with the energy of attraction, the pairing will be broken by thermal excitations. Note that it is the electrons near the Fermi surface that are important, since they are the only ones where small energies could induce transitions among states. You may wish to attempt an argument based on the uncertainty principle.]

Make a numerical evaluation of your estimate for niobium. Roughly how many lattice spacings does your answer correspond to?

25. Do exercise 1 of the “Electromagnetic Interactions” course note.
26. Do exercise 2 of the “Electromagnetic Interactions” course note.
27. Do exercise 3 of the “Electromagnetic Interactions” course note.