Answer on Question #62880-Physics-Other

In superconductivity we use the term "Meissner ochsenfeld effect". What is this and its significance?

Answer

The Meissener-Ochsenfeld effect discovered in 1933 revealed something new about superconductors: They aren't just perfect conductors (as Onnes showed) but perfect diamagnets, expelling a magnetic field that e.g., existed in the sample before being cooled below T_c.

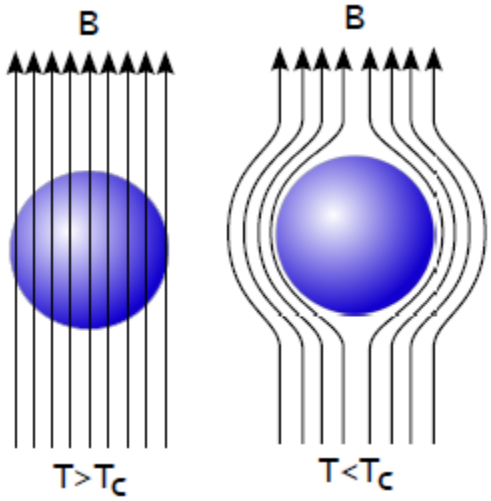

Figure 1: The Meissner-Ochsenfeld effect: a magnetic field in a metal is expelled when the temperature is lowered below T_c and the metal superconducts.

A perfect conductor with zero resistivity will expel a magnetic field incident upon it. However, if one could take a real metal with nonzero resistance, apply a magnetic field and then “turn off” the resistivity, the magnetic field would be frozen inside. In contrast, if the metal is cooled below its superconducting transition temperature T_c, *the magnetic field is expelled*. Herein lies the difference between a perfect conductor and a superconductor. While this distinction might seem academic, it has profound consequences. As Fritz and Heinz London argued, it can only be understood quantum mechanically, a result of the “phase rigidity" of the quantum mechanical wavefunction describing the superconducting state, hinting at the robustness of the perfect conductivity to the presence of weak impurities. It is also the first concrete example of what is commonly referred to as the “Higgs mechanism": In the superconducting state, U(1) gauge symmetry is spontaneously broken and the photon acquires an energy gap, leading to its expulsion.