

Superconductivity

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Superconductivity is something discovered *before* modern day solid state physics. The motivation was like this: if you cool down a metal towards $T \rightarrow 0$, what will happen? If the temperature is low enough, it seems the kinetic energy of electrons will be quenched and electrons will stall – not necessarily, since we have a Fermi sea and there are always electrons with non-zero kinetic energy (but people at the end of 19th century of course couldn't have realize this). But if the temperature is low enough, it seems scattering will also be weak, so then the resistivity will go to zero, although Ohm's law still works.

None of these claims proved to be true, however. On 4/8/1911, mercury was cooled to a low temperature, and resistivity *suddenly* drops to zero. Almost permanent current can be established, which costs thousands of years to be damped. But this permanent current results in no permanent magnet: superconductors have perfect diamagnetism.