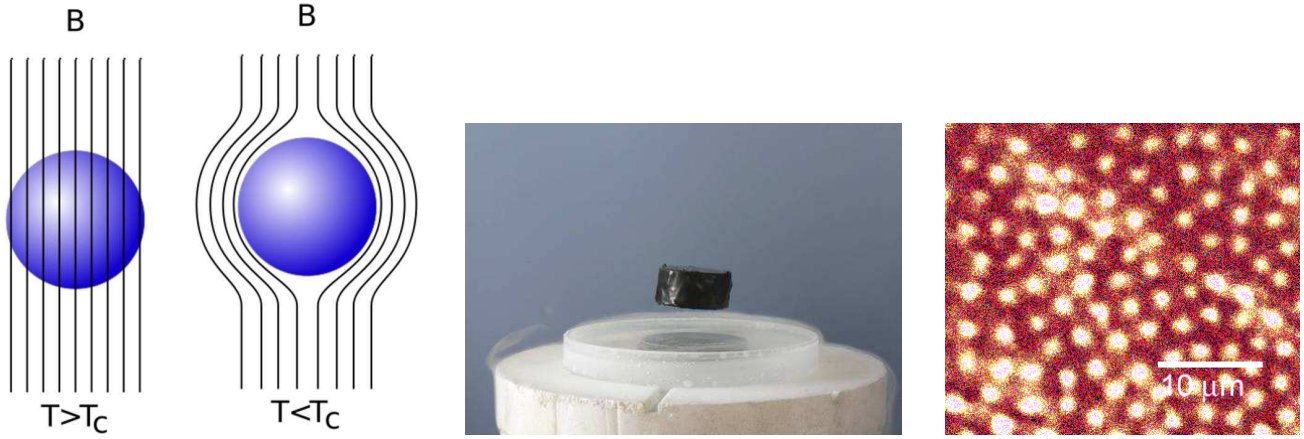
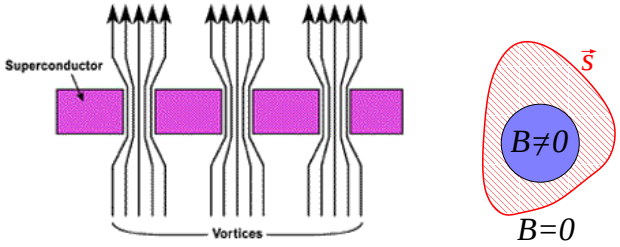
Supplement on Superconductivity



The Meißner effect (left) expels a magnetic field from a superconductor, leading to levitation in type-I superconductors (centre), and to Nielsen-Olesen flux tubes in type-II superconductors (right).

Meißner-Effekt in Type-II Superconductors

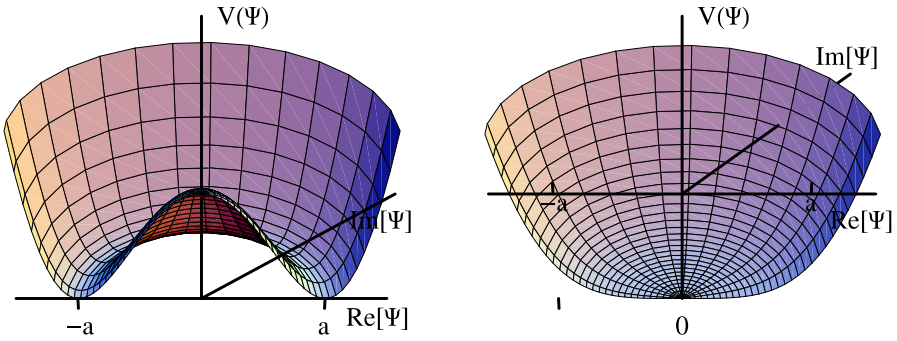


Vacuum Expectation Value of Cooper-pairs $|\langle\Psi\rangle| = a \neq 0 \Longrightarrow \vec{B} = 0 \Longrightarrow \vec{A}(\vec{r}) = \vec{\nabla}\chi(\vec{r})$

$\Phi_{\text{mag}} = \oint \mathrm{d}\vec{s} \circ \vec{A}(\vec{s}) = \chi(\phi = 2\pi) - \chi(\phi = 0) \in \dfrac{2\pi}{Q}\,\mathbb{Z}$ Abrikosov-Nielsen-Olesen flux quantisation

Ginzburg-Landau theory

$$\mathcal{H}_{\text{int}} = \frac{1}{2m}\left|\left(\mathrm{i}\hbar\vec{\nabla} + \frac{Q}{c}\,\vec{A}\right)\,\Psi\right|^2 + \lambda\left[|\Psi|^2 - a^2\right]^2$$



Ginzburg-Landau potential for the superconducting phase, $\lambda > 0$ (left); for the normal phase, $\lambda < 0$ (right).