Chirality−Dependent Vortex Pinning in Chiral Type−II Superconductors

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We discuss the elementary vortex pinning in type−II superconductors within the framework of the quasiclassical theory of superconductivity. The following two points are focused on. One is an enhancement of the vortex pinning energy in unconventional superconductors. We present numerical results to show explicitly that at high temperatures the vortex pinning energies in unconventional pairing cases are about 10 times larger than those in s−wave pairing cases. This enhancement of the vortex pinning energy occurs due to the breakdown of the Anderson's theorem in unconventional superconductors far away from the vortex core. The other is an effect of the chirality on the vortex pinning potential in chiral superconductors. We show that the vortex pinning energy depends on the sense of the chirality of the Cooper pairs relative to the vorticity of a vortex in a chiral p−wave superconductor. Mutual cancellation of the vorticity and chirality around the vortex is physically crucial to the effect of the pinning center inside the vortex core.

The enhancement of the pinning energy is due to the breakdown of the Anderson's theorem and therefore it must be a common feature of unconventional superconductors. In the case of high−T_c cuprates, it may be one of the reasons why small point defects such as Zn atoms and oxygen vacancies are efficient pinning centers.

The two chiral states, in which the vortex pinning energies are different each other, can coexist as domain structure in a sample under magnetic fields. The spatial gradient of the magnetic field in a sample is proportional to the local strength of the vortex pinning in the critical state. The chirality dependence of the vortex pinning is then expected to have influence on the hysteresis of the magnetization and the distribution of the magnetic field in samples, which might be observed with SQUID and magneto−optical imaging techniques for Sr_2RuO_4.

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