Exotic superconducting phases in locally non-centrosymmetric crystals

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We investigate the superconducting states in the locally non-centrosymmetric systems. The superconductivity in the crystal structure without inversion symmetry is called "non-centrosymmetric superconductivity" and attracted much interest after the discovery of superconductivity in the heavy fermion system $CePt_3Si$ [1]. Recent progress in this field has been summarized in the lecture note [2]. On the other hand, there are many crystal structures which do not have local inversion symmetry. Simple examples are diamond and graphene. Another intriguing examples include recently fabricated superlattice of $CeCoIn_5$. We show that several intriguing properties appear in such locally non-centrosymmetric superconductors. A part of such phenomena are similar to those in the non-centrosymmetric superconductors, while another part is distinguished from the non-centrosymmetric superconductors as well as conventional superconductors.

We first study the superlattice of $CeCoIn_5$ in which the superconductivity occurs in the multilayer structure of $CeCoIn_5$ [3]. The spin singlet superconductivity is admixed with the staggered spin triplet superconductivity owing to the spatially inhomogeneous Rashba spin-orbit coupling. Our results on the magnetic susceptibility show the crossover from the conventional superconductors to the non-centrosymmetric superconductors with increasing the Rashba spin-orbit coupling [4]. We also study the superconducting state induced by the magnetic field [5]. Since the high field superconducting phase of bulk $CeCoIn_5$ is a candidate for the FFLO state, such inhomogeneous superconducting state may be stabilized in the superlattice of $CeCoIn_5$ by the paramagnetic effect. Indeed, we find that novel superconducting states are stabilized by the Rashba spin-orbit coupling. The pair-density-wave (PDW) state is stabilized for H//c, while the complex stripe phase is stabilized for H//ab. These exotic phases are induced by the Rashba spin-orbit coupling.

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