学　位　論　文　内　容　の　要　旨

博士の専攻分野の名称　　博士（工学）　　氏名　鈴木 修

学　位　論　文　題　名

Paramagnetic Meissner effect of small topological superconductors
(微小なトポロジカル超伝導体における常磁性マイスナー効果)

The perfect diamagnetism is the most fundamental property of all superconductors. In the presence of an external magnetic field, the coherent motion of Cooper pairs generates the electric current along a surface of a superconductor and screens the magnetic field. Consequently, the superconducting condensate deep inside the superconductor can keep its phase coherence and minimize the free energy. Every standard textbook explains this phenomenon called Meissner effect. Several experiments, however, have reported the paramagnetic response of small superconductors and mesoscopic proximity structures. At present, the mechanism of the paramagnetic property is an open question in physics of superconductivity.

Recent theoretical investigations have suggested the existence of novel types of Cooper pairs called odd-frequency pairs in a spatially inhomogeneous superconductor. In the mean-field theory of superconductivity, an odd-frequency pair appear as the local pairing correlation induced by the spatial variation of the pair potential. For instance, an odd-frequency Cooper pair exists at surfaces of a superconductor, in vortex cores, at interfaces between a superconductor and another material. Surprisingly, to our knowledge, an odd-frequency pair exhibits the paramagnetic response to an external magnetic field. Such paramagnetic pairs are thermodynamically unstable because they attract a magnetic field. Unfortunately, only a few experimental studies have caught signs of an odd-frequency pair.

In this thesis, on the contrary to the description in standard textbooks, we theoretically demonstrate that a small unconventional superconductor can be paramagnetic at low temperature. On the basis of the quasiclassical Green function formalism, we calculate magnetic susceptibility of a small superconductor which belongs to unconventional pairing symmetry classes such as spin-singlet d-wave and spin-triplet p-wave. The magnetic response at low temperature is dominated by odd-frequency Cooper pairs appearing at a surface of the superconductor. Our numerical results show that a small superconductor changes its magnetic response from the usual diamagnetic response at high temperatures near the transition temperature to the unusual paramagnetic one at low temperature. In addition, we discuss the effects of surface roughness on the paramagnetic Meissner effect and the stability of the paramagnetic phase. We also discuss a role of an odd-frequency pair in the topological edge current in chiral superconductors.