凝縮系物理学ゼミナール
Condensed Matter Seminar

Date: 13:30-15:00, Wednesday, 7 December 2022

Title: Superconducting diode effect in disordered systems

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Abstract:

The acquisition of new functionalities in superconductors is essential not only for engineering development, such as the creation of more energy-saving devices but also for the development of the basic science of superconductivity. In recent years, nonreciprocal transport phenomena have attracted much attention as a new functionality of matter. In the field of superconductivity, the superconducting diode effect (SDE) has been observed in [Ni/V/Ta] artificial superlattice superconductors with inversion symmetry breaking [1]. The SDE refers to a current flow with zero electrical resistance in one direction and a finite resistance in the opposite direction. A theoretical explanation for the SDE was given in terms of the deparing current [2-5], i.e., SDE by intrinsic mechanism. Moreover, the theory shows an interesting result suggesting that the sign change of SDE is closely related to the helical superconductivity [2], in which Cooper pairs are stabilized with a finite center-of-mass momentum. On the other hand, the time-reversal symmetry breaking by an applied magnetic field violates the assumption of Anderson's theorem, and it is widely known that impurities have a significant effect on the physical properties of superconductivity [5, 6]. The evaluation of the effect of impurities on the SDE is interesting not only for the performance evaluation of superconducting diodes but also for the development of the fundamental theory of noncentrosymmetric superconductors.

In this work, we investigate the impurity effect on the SDE using a microscopic analysis based on the Rashba-Zeeman model and a self-consistent Born approximation. Our results show that the sign change of the SDE disappeared by applying the disorder. Furthermore, the similarity of the behavior with respect to impurity intensity supports the existence of a correspondence between the SDE and helical crossover.

Reference:

[1] F. Ando et al., Nature **584**, 373 (2020).
[2] A. Daido, Y. Ikeda, and Y. Yanase, Phys. Rev. Lett. **128**, 037001 (2022).
[3] J. J. He, Y. Tanaka, and N. Nagaosa, New J. Phys. **24**, 053014 (2022).
[4] N. F. Q. Yuan and L. Fu, PNAS **119** (15) e2119548119 (2022).
[5] S. Ilić and F. S. Bergeret, Phys. Rev. Lett. **128**, 177001 (2022).
[6] O. Dimitrova and M. V. Feigel'man, Phys. Rev. B **76**, 014522 (2007).