

凝縮系物理学ゼミナール

Condensed Matter Theory Seminar

Date: 13:30-15:00, Wednesday, 28 May 2025

Title: Interplay between Coulomb interaction and disorder in the superconducting diode effect

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Language: Japanese

Abstract:

The role of Anderson localization in superconductors (SC) has been extensively studied for a long time and remains a hot topic to this day. From the so-called Anderson theorem, the properties of dirty superconductors at zero magnetic field do not change much by non-magnetic disorder in the weak localization (WL) regime. However, the concept becomes harmful if the electron-electron (e-e) interactions are present or if the disorder strength is strong. For example, the presence of Coulomb interaction can result in significant suppression of the SC critical temperature in the WL regime [1]. The interplay between e-e interactions and disorder in dirty superconductors has been extensively investigated by the renormalization group of the nonlinear sigma model (NLSM) [2], which is the effective low-energy model of dirty metals. However, the situation is still unclear in the presence of both Zeeman and spin-orbit couplings (SOC), as well as supercurrent flow.

In this seminar, I would like to discuss our latest work [3], which addresses those topics. We study the phase diagram and the nonreciprocity of critical currents, or *superconducting diode effect*, in a two-dimensional dirty superconductor coupled with the interactions from the Cooper and Coulomb channels, Rashba SOC, and in-plane Zeeman fields. We use the approach of the NLSM to derive the *modified Usadel equation* [4]. Unlike many works formulated in the replica formalism, our theory is formulated by the Keldysh functional formalism [5]. The procedure to do in this formalism is also planned to be introduced in this talk.

References:

- [1] S. Maekawa and H. Fukuyama, J. Phys. Soc. Jpn. 51, 1380 (1982).
- [2] For example, A. M. Finkel'stein, Zh. Eksp. Teor. Fiz. 84, 168 (1983).
- [3] N. Nunchot and Y. Yanase (in preparation)
- [4] I. S. Burmistrov, I. V. Gornyi, and A. D. Mirlin, Ann. Phys. 435, 168499 (2021).
- [5] A. Kamenev and A. Andreev, Phys.Rev. B 60, 2218 (1999); M. V. Feigel'man, A. I. Larkin, and M. A. Skvortsov, Phys. Rev. B 61, 12361 (2000)