凝縮系物理学ゼミナール
Condensed Matter Seminar

(※ seminar is held online via zoom)

Date: **13:30-15:00**, Wednesday, 1st July 2020

“Collective Excitations and Nonequilibrium Phase Transition in Dissipative Fermionic Superfluids”

Speaker:

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Abstract:

Collective excitations of superconductors and superfluids have been widely studied in condensed matter physics [1,2]. For example, a sudden quench of an attractive interaction or a periodic modulation of the amplitude of the order parameter excites the Higgs amplitude mode, which has been observed with ultracold fermions [3-5]. As for collective phase modes, the Nambu-Goldstone mode exists in neutral superfluids, and the relative-phase Leggett mode has been predicted for multiband superfluids [6]. Especially, ultracold atoms allow for a dynamical control of various system parameters, offering an ideal playground to investigate collective modes. However, they inevitably suffer from atomic loss due to inelastic scattering, which has received little attention in literature.

The effect of particle loss in fermionic superfluids has been studied in the framework of the non-Hermitian BCS theory [7]; however, it does not take account of the change in the number of particles due to quantum jumps. Thus, it is necessary to go beyond the non-Hermitian framework to describe the long-time dynamics of a superfluid and associated collective modes of order parameters.

Considering the backgrounds mentioned above, We predict a new mechanism to induce collective excitations of a fermionic superfluid via sudden switch-on of two-body loss, for which we extend the BCS theory to fully incorporate quantum jumps [8]. We find that such dissipation induces an amplitude oscillation of the superfluid order parameter accompanied by chirped phase rotation, which highlights the role of dissipation in a superfluid

as a consequence of particle loss. We demonstrate that when the dissipation is introduced to one of the two superfluids coupled via a Josephson junction, it gives rise to a relative-phase mode analogous to the Leggett mode, which can be detected from time evolution of the Josephson current. We find that the coupled system exhibits a nonequilibrium dissipative phase transition characterized by the vanishing dc Josephson current. The dissipation-induced collective modes can be realized with ultracold fermionic atoms undergoing inelastic collisions.

References:

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