Condensed Matter Theory Seminar

Bose-Einstein Condensation in Magnetic Insulators: Transport Signatures and Nonequilibrium Quantum Criticality

Speaker: Prof. So Takei

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Thursday, July 17, 2025
Lecture Room, Collaboration Bldg.（3F）

2025年 7月17日（木）16:00−17:00
コラボレーション棟 講義室（3F）

Magnetic insulators provide an ideal platform for studying Bose-Einstein condensation (BEC) due to the bosonic nature of their low-energy spin excitations — e.g., magnons — which can condense under applied magnetic fields. The magnetic field serves as a tunable excitation gap, enabling precise control over quasiparticle density and facilitating the exploration of quantum critical phenomena. In the first half of the talk, I will consider a dissipative magnon gas near the BEC instability. Different transport regimes near the instability are identified. I will also discuss how a spin Hall-based magnon injection can lead to a full damping compensation of the magnon gas and discuss the impact of this compensation on the magnon transport. In the second half, I will explore how spin fluctuations in a ferromagnetic insulator near the BEC instability influence electronic transport in a disordered two-dimensional metal placed in proximity. Focusing on quantum conductivity corrections, I will show that the coupling to critical spin fluctuations leads to a non-singular but sharp enhancement in the metal’s magneto-conductivity. This behavior offers a new window into the interplay between coherent magnetic order and electronic quantum transport, and suggests that spintronic heterostructures can serve as a sensitive probe of BEC phenomena.

References:

1. S. Takei, “Spin transport in an electrically driven magnon gas near Bose-Einstein condensation: Hartree-Fock-Keldysh theory,” Phys. Rev. B **100**, 134440 (2019)
2. J. Aftergood and S. Takei, “Conductivity Enhancement in a Diffusive Fermi Liquid due to Bose-Einstein Condensation of Magnons,” Phys. Rev. Lett, **130**, 086702 (2023)

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