1st Spintronics Research Network Seminar

Longitudinal Spin Pumping in a Magnetic Phase Transition

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Previous spin pumping studies have focused solely on transversal spin pumping arising from classical magnetization dynamics, which corresponds to precessing atomic moments with constant magnitude. However, longitudinal spin pumping arising from quantum fluctuations, which correspond to a temporal change in the atomic moment's magnitude, remains unexplored.

We experimentally investigate longitudinal spin pumping using FeRh [1], which undergoes a first-order antiferromagnet-to-ferromagnet phase transition during which the atomic moment's magnitude varies over time. By injecting a charge current into a FeRh/Pt bilayer, we induce a rapid phase transition of FeRh in nanoseconds, leading to the emission of a spin current to the Pt layer. The observed inverse spin Hall signal is about one order of magnitude larger than expected for transversal spin pumping, suggesting the presence of longitudinal spin pumping driven by quantum fluctuations and indicating its superiority over classical transversal spin pumping.

We will also discuss orbital exchange-mediated current control of magnetism, which uncover a previously unrecognized route for electrical control of magnetism and extend current-induced effects to a broader class of materials beyond conventional dipolar magnets [2].

[1] T. Lee et al. Signatures of longitudinal spin pumping in a magnetic phase transition. Nature 638, 106 (2025).

[2] G.-H. Lee, K.-W. Kim, and K.-J. Lee, submitted (2025).

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