PHYSICS

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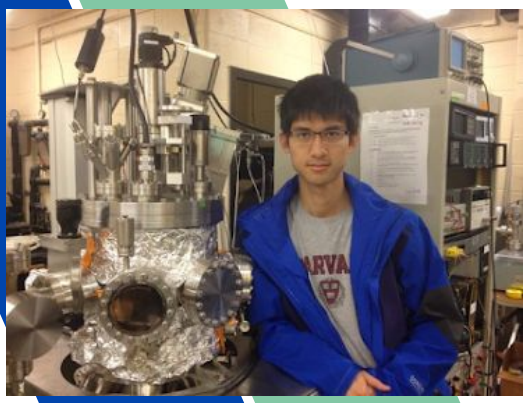

Coherent information processing with on-chip microwave magnonics

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In the race of post-CMOS computing technologies, coherent information processing with microwave circuits have demonstrated great potentials with the recent breakthrough in quantum computing, where both the quanta and the phase of the excitation states can be utilized for carrying and processing information. In this seminar, I will show that magnons—the collective excitations of exchange-coupled spins in magnetic materials —act as a new candidate for coherent information transfer and processing. Compared with other excitations, magnons exhibit special advantages: 1) their frequency are naturally in the microwave regime and can be noninvasively tuned by an external magnetic field, 2) they exhibit very strong coupling strength thanks to the large spin density in magneti materials, and 3) they can couple to various excitations for coherent quantum transduction. Furthermore, magnetic materials can be easily fabricated as nanodevices while still serving as excellent magnon resonators, which is convenient for on-chip integration and device miniaturization. In the first example [1], we realize strong magnon-photon coupling between a permalloy (Ni_{80} Fe_{20}) thin-film device and a coplanar superconducting resonator, which paves the way for on-chip quantum magnonics. In the second example [2], we show strong magnon-magnon coupling in a magnetic thin-film bilayer from the engineering of standing spin waves. In the third example [3], we demonstrate Rabi-like oscillations of magnons in a nanomagnet with a two-tone microwave excitations, which provides new approaches to coherently modify magnon populations. I will also discuss their links and potentials in quantum information processing.

[1] Yi Li, et al., "Strong magnon-photon coupling in ferromagnet-superconducting resonator thin-film devices", Physical Review Letters, 121, 107701 (2019)

[2] Yi Li, et al., "Coherent spin pumping in a strongly coupled magnon-magnon hybrid system", arXiv:1910.14470 (accepted by Physical Review Letters)

[3] Yi Li, et al., "Nutation spectroscopy of a nanomagnet driven into deeply nonlinear ferromagnetic resonance", Physical Review X, 9, 041036 (2019)