Probing spin-wave nonreciprocity in ferromagnet/superconductor multilayers

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With quantum computing on the rise, there is an increased need to deal with cryogenic environments, often involving superconducting materials. Hybrid systems utilizing spin waves at cryogenic temperatures could benefit from increased conversion efficiency of electrical and magnonic signals and feature tunable devices, changing their functionality upon crossing the critical temperature of the superconductors involved. The ferromagnet/superconductor (FM/SC) heterostructures also offer enhanced nonreciprocity of the group velocity of Damon-Eshbach spin waves unmatched by other approaches [1,2]. This could be utilized in switchable isolators or non-reciprocal couplers, which are essential components of modern microwave circuits.

In the past years, theoretical models of FM/SC systems have been developed [2, 3], predicting the nonreciprocal upshift in the spin-wave dispersion relation. While there were reports on the frequency upshift [4], the nonreciprocity is yet to be observed.

We will present a proof-of-concept variable-gap propagating spin-wave spectroscopy [5] experiment of FM/SC multilayers, determining the spin-wave dispersion relation in a wide frequency and wavevector range. The experiments were performed in a 2–300 K temperature range in a commercial cryogenic setup using custom-made high-frequency (0.1–50 GHz) sample holders. The measured dispersion relations will be compared to COMSOL simulations and analytical models. Further, a typical performance of such an experimental setup will be evaluated and compared to other existing solutions [6].

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