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Quantum magnonics in a ferromagnetic sphere

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A 1-mmϕ sphere of yttrium iron garnet, a well-known ferro(ferri)magnetic insulator, contains $\sim 10^{19}$ net electron spins aligned in one direction. The spins, rigidly ordered by the exchange interaction and also interacting via the dipole forces, support collective excitations in the magnetostatic modes [1]. We control the quantum state of one of such modes coherently at the single magnon level by using a superconducting qubit. The qubit and the Kittel mode, the magnetostatic mode with spatially uniform spin precessions in the sphere, are strongly coupled via a microwave cavity mode, which results in the magnon-induced vacuum Rabi splitting of the qubit as well as Rabi oscillations between the qubit and the single-magnon excitation at resonance [2]. When the qubit and the Kittle mode are detuned, the dispersive interaction allows us to determine the magnon number distributions through the qubit spectroscopy [3]. These experiments demonstrate the potential of magnons as a quantum information carrier in the microwave domain. Coherent interaction of magnons with infrared light is also investigated [4,5].

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