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Magnon Kerr effect in a cavity quantum electrodynamics system

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We report the experimental demonstration of the magnon Kerr effect in a cavity quantum electrodynamics system, where magnons in a small yttrium iron garnet (YIG) sphere are strongly but dispersively coupled to the microwave photons in a three-dimensional cavity. When considerable magnons are generated by pumping the YIG sphere, the Kerr effect gives rise to a shift of the cavity central frequency and yields more appreciable shifts of the magnon modes, including the Kittel mode (i.e., the ferromagnetic resonance mode), which holds homogeneous magnetization, and the magnetostatic (MS) modes, which have inhomogeneous magnetization. We derive an analytical relation between the magnon frequency shift and the pumping power for a uniformly magnetized YIG sphere and find that it agrees very well with the experimental results of the Kittel mode. In contrast, the experimental results of MS modes deviate from this relation owing to the spatial variations of the MS modes over the sample. To enhance the magnon Kerr effect, the pumping field is designed to directly drive the YIG sphere and its coupling to the magnons is strengthened using a loop antenna. Moreover, this field is tuned very off-resonance with the cavity mode to avoid producing any appreciable effects on the cavity. Our work is the first convincing study of a cavity QED system with magnon Kerr effect and paves the way to experimentally explore nonlinear effects in the cavity QED system with magnons.

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