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Cavity QED with ferromagnetic magnons in a small YIG sphere

DENGKE ZHANG, Beijing Computational Science Research Center, XIN-MING WANG, Research Center of Laser Fusion, CAEP, TIE-FU LI, Institute of Microelectronics, Tsinghua University, XIAO-QING LUO, Beijing Computational Science Research Center, WEIDONG WU, Research Center of Laser Fusion, CAEP, FRANCO NORI, Center for Emergent Matter Science, RIKEN, J. Q. YOU, Beijing Computational Science Research Center — Hybridizing collective spin excitations in ferromagnetic crystals and a cavity with high cooperativity provides a new research subject in the field of cavity quantum electrodynamics and can also have potential applications to quantum information. In contrast to spin ensembles based on dilute paramagnetic impurities, these spins are strongly exchange-coupled and have a much higher density. Here we report a direct observation of the strong coupling between magnons and microwave photons at both cryogenic and room temperatures by using the same small yttrium-iron-garnet (YIG) ferromagnetic sphere in a 3D copper cavity. We observed strong couplings of the same cavity mode to both ferromagnetic-resonance (FMR, uniform precession) mode and a magnetostatic (MS, non-uniform precession) mode in the quantum limit at 22 mK. Then, at room temperature, we observed a strong coupling of the cavity mode to the FMR mode with slightly increased damping rate. This reveals the robustness of the FMR mode against temperature. However, the coupling to MS mode disappears at room temperature and numerically simulations show that this is due to a drastic increase of the damping rate of the MS mode. Our work unveils quantum-coherence properties of the magnons.

Dengke Zhang
Beijing CSRC

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