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Attached Split-Ring Resonator Cavity for Magnon–Photon Coupling

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Abstract

We present a chip-scale planar cavity platform based on an attached split-ring resonator (ASRR) integrated with yttrium iron garnet (YIG) structures to achieve strong magnon–photon coupling in a compact hybrid system. The ASRR geometry was numerically optimized by tuning inter-ring spacing, gap width, substrate thickness, and permittivity, resulting in a high quality factor of Q ≈ 190 at 5.48 GHz, enabling strong microwave magnetic-field confinement and reduced radiative losses. The optimized cavity was coupled to YIG elements of three different geometries—full ring, half ring, and disk—under identical in-plane bias magnetic-field conditions to isolate geometric effects on ferromagnetic resonance and coupling strength. We found in full electromagnetic simulation that the full-ring geometry exhibits balanced performance with coupling strength 115 MHz and cooperativity C ≈ 105, while the half-ring shows coupling strength 108 MHz but slightly higher cooperativity C ≈ 108 despite edge-induced demagnetization. In contrast, the disk geometry couples at lower bias magnetic fields and achieves the strongest interaction with 135 MHz and C ≈ 203, enabled by superior microwave-field overlap. These results demonstrate that magnetic geometry, rather than volume alone, is a key design parameter for tailoring magnon–photon coupling, providing a practical framework for lithography-compatible, on-chip hybrid magnonic and quantum devices.

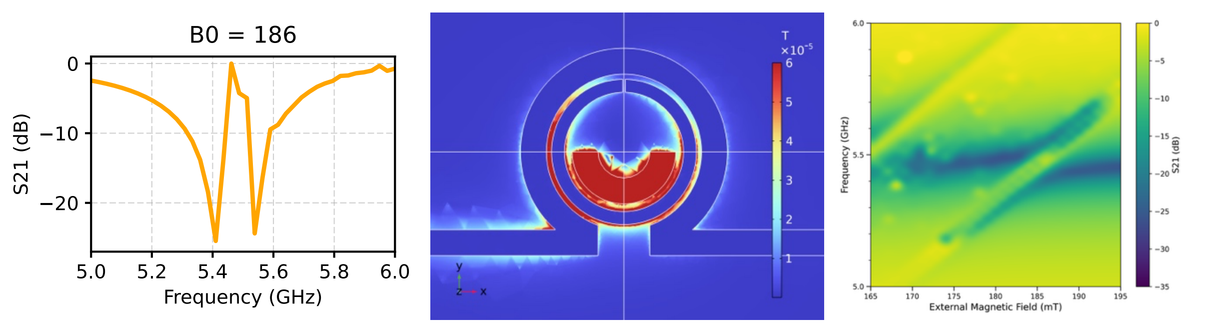

Figure 1: (a) the S21 spectra for the microwave cavity coupled to the YIG ring at 186 mT. Evolution of the YIG ferromagnetic resonance (FMR) frequency relative to the SRR resonance across different bias magnetic fields. (b–c) Clear mode splitting appears due to hybridization between magnon and photon modes.