Magnon–Photon Coupling in the Attached Split-Ring Resonator Cavity

Aram Akoi, Maciej Krwaczyk

Institute of Spintronics and Quantum Information, Faculty of Physics and Astronomy, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznań, Poland

Abstract:

We report a planar microwave cavity-magnonic platform based on an optimized attached split-ring resonator (ASRR) that enables strong magnon–photon coupling with yttrium–iron–garnet (YIG) structures of different geometries. The ASRR cavity is engineered to provide strong in-plane microwave magnetic-field confinement and a high quality factor. The cavity geometry is optimized through full-wave electromagnetic simulations by adjusting the inter-ring spacing, gap width, substrate thickness, and dielectric permittivity, resulting in a resonance frequency of 5.48 GHz and a quality factor of approximately 190. Ferromagnetic resonance fields for full-ring and half-ring YIG geometries are obtained using a linearized Landau–Lifshitz–Gilbert eigenvalue formulation that includes exchange and demagnetizing fields, while the thin-disk resonance is confirmed using the Kittel relation. When the magnon mode is tuned by change of the bias magnetic field into resonance with the photon cavity mode, the hybrid ASRR–YIG system exhibits pronounced avoided crossings in the transmission spectra. For the full-ring geometry, a coupling strength of 50 MHz and cooperativity of about 25.2 are achieved. The half-ring geometry shows a higher coupling rate of 70 MHz but reduced cooperativity. The disk geometry provides the strongest interaction, with a coupling strength of 145 MHz and cooperativity of about 47, arising from superior spatial overlap between the cavity microwave magnetic field and the uniform magnon mode. These results highlight geometric engineering as an effective approach for maximizing coherent magnon–photon interactions in planar high-frequency magnonic systems.

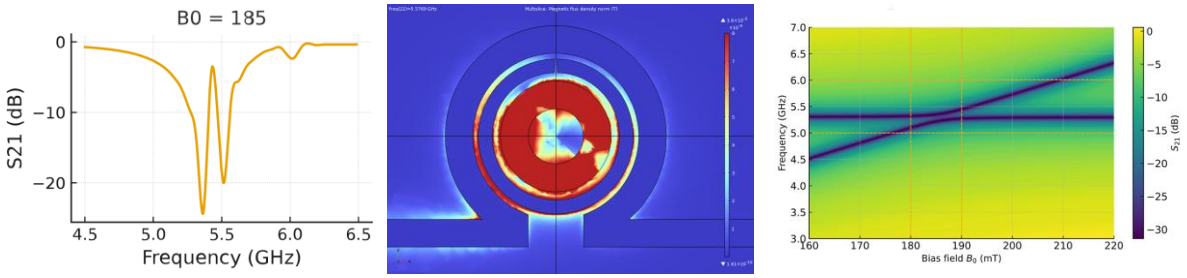

Figure 1 *(a) The spectra created in the ASRR with the YIG ring showing repelling of the magnon and photon modes at field 185mT. (b) The magnetic field distribution on the surface of the YIG ring in the ASRR at the resonance frequency. (c) A heatmap showing the anti-crossing of the magnon and photon for the same structure.*