GENERATION OF CIRCULATING CAVITY MAGNON POLARITONS IN A COMPACT GEOMETRY RESONATOR

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INTRODUCTION


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Generation of Circulating Cavity Magnon Polaritons
Jeremy Bourhill, Weichao Yu, Vincent Vlaminck, Gerrit E. W. Bauer, Giuseppe Ruoso, and Vincent Castel
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▶ **Generation** of circularly polarised unidirectional cavity magnon polaritons in a torus cavity [1]

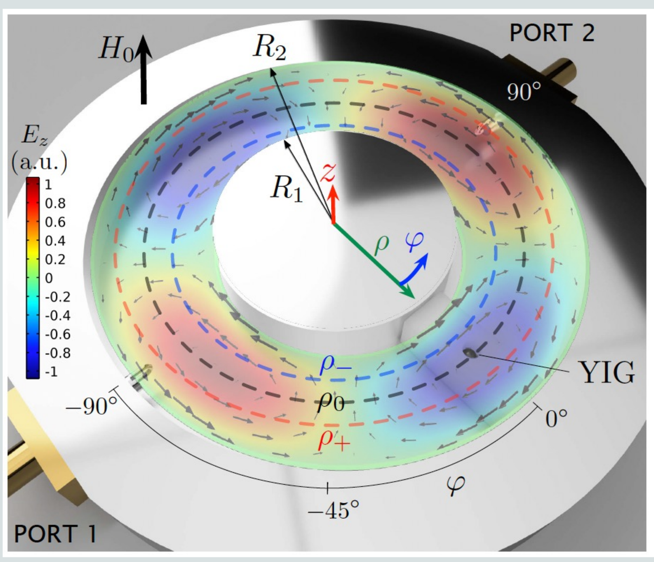
▶ **Achieved** by the observation of a three-mode interaction picture when the magnetic resonance of a 1.8 mm YIG sphere and a cavity resonance were tuned coincident in frequency and the sphere is positioned at precise radial locations

▶ **Torus-shaped microwave cavity:**

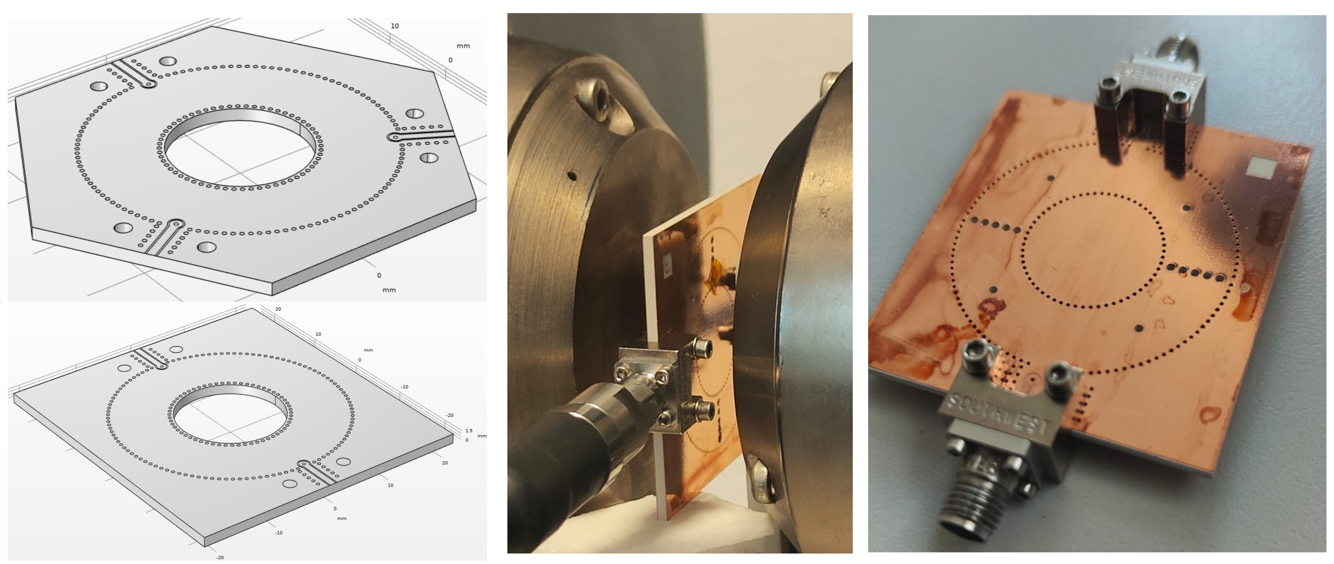
- Machined from high purity aluminium in two parts (lid and base)
- The inner and outer radii R1 (15 mm) and R2 (30 mm) and the height h (6 mm)
- 2 magnetic loops around the radial axis at $\varphi = \pm 90°$ that couple to H_φ
- Pure YIG sphere couples to a clockwise (cm, m>0) or counterclockwise (ccw, m<0) photon

▶ **Multiple sphere setup**: How to demonstrate the generation of high-power unidirectional photon beam with high coherence and narrow bandwidth [2] in such big device?

SIW CAVITY



SIW integration: Towards multiple YIG sphere setup



▶ Substrate Integrated Waveguide (SIW)
▶ Increasing the dielectric permittivity of the medium carrying the electromagnetic waves: reduction the device dimension
▶ From 60 to 36 mm for the external diameter
▶ Substrate: RO3003 (h=1.52 mm)

Microwave magnetic field of the TE modes is circularly polarized

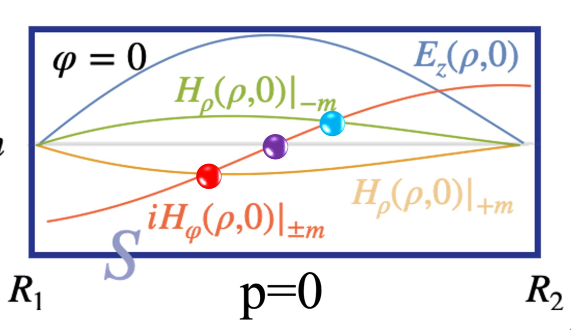
$H_z = 0$ and $\partial_{\mathbf{n}} E_z \mid s = 0$ **TE mode**

$$E_z = \psi(\rho,\varphi)\cos\left(\frac{p\pi z}{h}\right), \quad p = 0,1,2,\ldots$$

$$\psi(\rho,\varphi) = R_m(\rho)e^{im\varphi}, \; m = 0, \pm 1, \pm 2\ldots$$

$$R_m(\rho) = J_m\left(\gamma_{p,m}\rho\right) + CN_m\left(\gamma_{p,m}\rho\right)$$

Rectangular Cross-Section



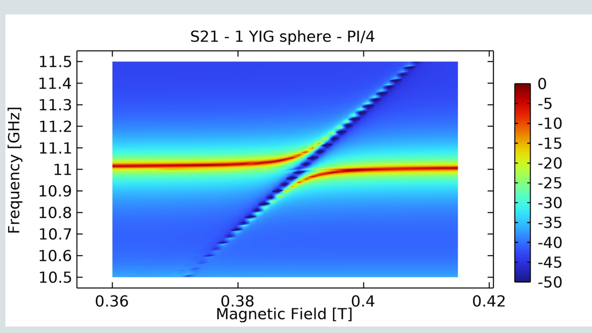
$$E_z(\rho,\phi,z) = \left[J_m\left(\gamma_{p,m}\rho\right) - \frac{J_m\left(\gamma_{p,m}R_1\right)}{N_m\left(\gamma_{p,m}R_1\right)}N_m\left(\gamma_{p,m}\rho\right)\right]e^{im\varphi}\cos\left(\frac{p\pi z}{h}\right)$$

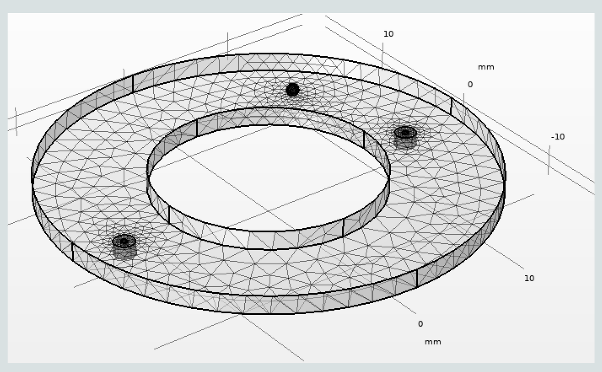
$$H_\rho(\rho,\varphi) = \frac{1}{\mu_0\gamma_m c}\frac{m}{\rho}E_z,$$

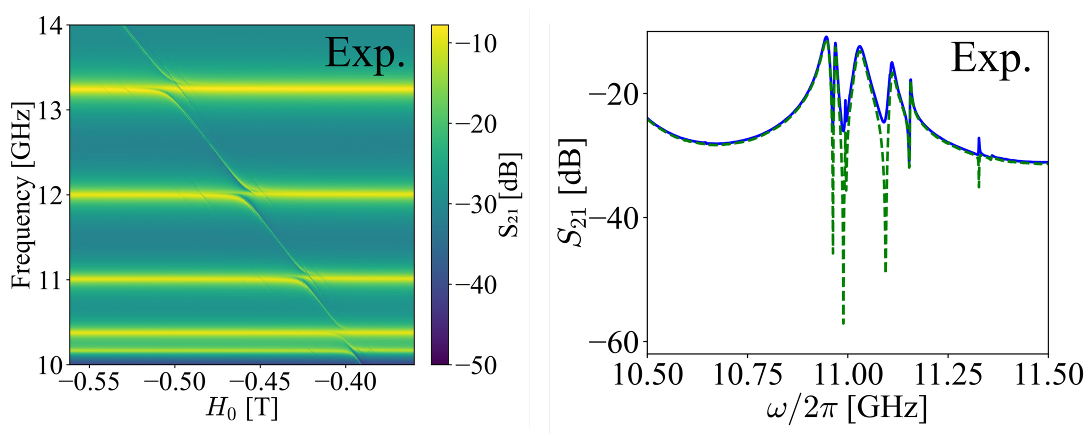
$$H_\varphi(\rho,\varphi) = -i\frac{1}{\mu_0\gamma_m c}\frac{\partial E_z}{\partial\rho}$$

	-m	+m
ρ_+	$H_\varphi = -iH_\rho$	$H_\varphi = iH_\rho$
ρ_-	$H_\varphi = iH_\rho$	$H_\varphi = -iH_\rho$
ρ_0	$H_\varphi = 0$	$H_\varphi = 0$

SIMULATION & MEASUREMENT



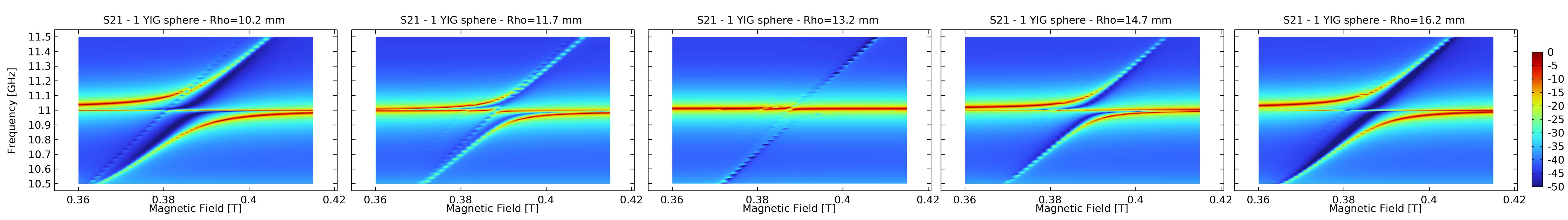




Simulation:

▶ We calculate the microwave-induced dynamics of the Kittel mode by solving the coupled Maxwell and linearized Landau-Lifshitz-Gilbert (LLG) equation in the frequency domain in the macrospin by an electromagnetic FEM

▶ Simulated microwave transmission amplitudes for m = 2 TE mode of the SIW chiral cavity as a function of the radial sphere position.



CONCLUSION & PERSPECTIVES

▶ Simple sphere setup: 2 and 3 ports configuration, frequency and magnetic field dependence as function of the radial position

▶ The confirmation of predicted results [2] demonstrates the feasibility of a proposed multiple sphere setup, in which the magnets are placed along the same radial line and will coherently couple to one another

▶ New design configuration: low loss dielectric substrate and working frequency at 20, 30 and 40 GHz

REFERENCES

[1] Jeremy Bourhill, Weichao Yu, Vincent Vlaminck, et al. Generation of Circulating Cavity Magnon Polaritons, Phys. Rev. Appl. 19, 014030 (1 2023)
[2] Weichao Yu, Tao Yu, and Gerrit E. W. Bauer. Circulating cavity magnon polaritons. Phys. Rev. B 102, 064416 (6 2020)

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