Circularly polarized microwave measurements for condensed matter physics

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A cavity resonator in the microwave band is indispensable technology in condensed matter physics. The extremely high Q value of the microwave resonance mode enables us sensitive detection of the electron spin resonance of a small sample [1]. More recently, such a method has been utilized in spintronics to investigate the spin transport and in quantum information to control quantum qubits. As a microwave is an electromagnetic wave, it has polarization such as linear polarization and circular polarization. However, only linearly polarized microwaves are mainly used in condensed matter physics.

In optical and terahertz regime, a circularly polarized electromagnetic wave has been used for the various purpose: the creation of spin accumulation, investigation of circular photogalvanic effects, circular dependent spin pumping with an antiferromagnetic material. This is because a circularly polarized electromagnetic wave has a net spin of ±1, which is suitable for investigating electron spin-related phenomena.

If we can control the circularly polarized microwave in a cavity resonator, this technique will stimulate efforts towards further research in condensed matter physics. Therefore, we recently established a technique for selectively exciting left and right circularly polarized microwaves and irradiating them to a sample with a cylindrical cavity resonator [2] (Fig. 1). To demonstrate the performance of the cavity resonator, we measured the ferromagnetic resonance of Yttrium Iron Garnet (Fig. 2) and estimated the polarization of left- and right-handed microwave excitation as more than 80%.

In this symposium, I will present the overview and potential of the circularly-polarized cavity resonator method. I will also present our recent results obtained by using this method.

Reference

1) O. Klein *et al*., International Journal of Infrared and Millimeter Waves **14**, 2423 (1993).
2) T. Arakawa *et al*., The Review of scientific instruments **90**, 084707 (2019).

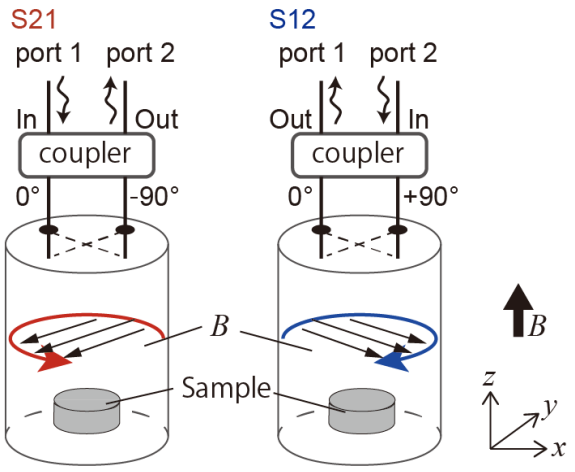

Fig. 1 Schematic image of the circularly-polarized microwave excitation. A rotating magnetic field of right-(left-) handed circularly-polarized microwave are excited by S21(S12), respectively.

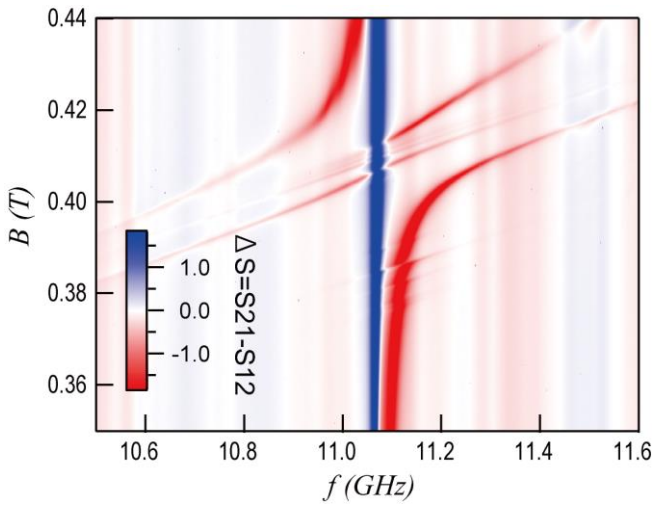

Fig. 2 Mmeasured ferromagnetic resonance of Yttrium Iron Garnet as a function of f and B. Red(Blue) rejoin corresponds to the right-(left-) handed circularly-polarized mode, respectively.