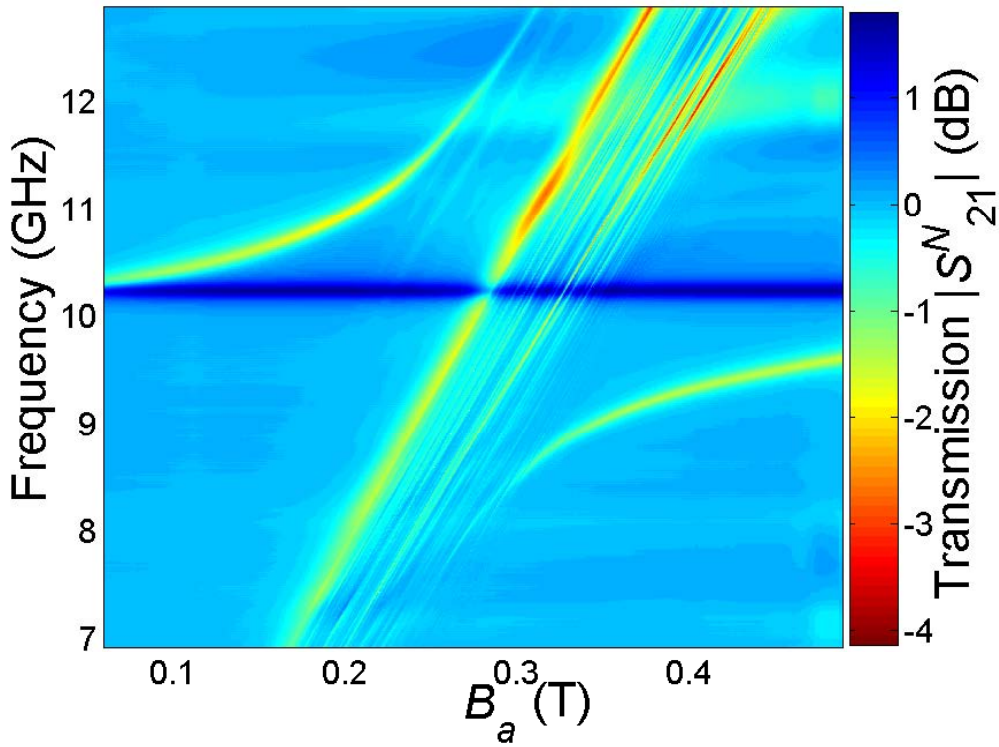

Fig. 6. As per Fig. 2 but with a 5 × 5 × 0.5 mm^3 thick bulk YIG crystal.

5. Conclusions

In summary, it has been demonstrated that CPW-based composite SRR metamaterials, incorporating a magnetic component (YIG), can be tuned by applying a magnetic field. The coupling between the SRR and the YIG gives rise to hybridization of the two resonances, yielding a frequency response similar to that of a Fano-resonance [26]. In particular, the anti-crossing regime allows tuning over a frequency range ~0.3 GHz, much wider than that of the SRR metamaterial taken in isolation. There is good agreement between experiment with electromagnetic simulations obtained using COMSOL, and the two-state model [7,8]. It has also been demonstrated that the anti-crossing region provides fertile ground for the creation of elementary excitations. Spin-waves, magnetostatic surface waves and backwards volume magneto-static waves have been observed. Finally, it has been shown that the orientation of the SRR with respect to the magnetization of the YIG and CPW is important. In particular, transmission, at the centre of the anti-crossing, could be increased by 1.6 to 4.0 dB, simply by rotating the SRR through 90°. Such experiments demonstrate that tunabilty is dependent not only on the strength of the magnetic field but also on the orientation of the SRR with respect to the CPW.

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