Nonlinear Magnetic Modeling for RF Applications

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A multiphysics modeling technique based on FDTD is proposed, to accurately model the dynamic interaction between nonlinear spin dynamics and electrodynamics. The proposed method provides clear understanding on the role of nonlinear magnetics in RF devices, compared to existing micromagnetics solvers and EM simulators.

As can be seen in Fig. 1, when the excited RF magnetic field is low, the simulated permeability matches with the theory based on small signal perturbation. When the RF field increases to be larger than $0.016\ [Oersted]$, the FMR frequency down-shifts due to lower M_y. In addition, the dispersive permeability suffers peak value suppression and linewidth broadening as the RF field further increases. This phenomenon has been experimentally discovered by the magnetics society, however, is first reported numerically by this work. The simulated nonlinear permeability can demonstrate the potential of the proposed modeling for design of nonlinear devices such as FSL. With further extension into 3-D unconditionally stable algorithm, such as alternating-direction-implicit (ADI) FDTD, one is able to include magneto-crystalline anisotropy, exchange coupling and spin transfer torque. Therefore, the proposed algorithm can be potentially used to design realistic nonlinear RF magnetic and spintronic devices. Fig. 2 verifies the accuracy of the 3-D linear modeling, which provides the basis of nonlinear algorithm.

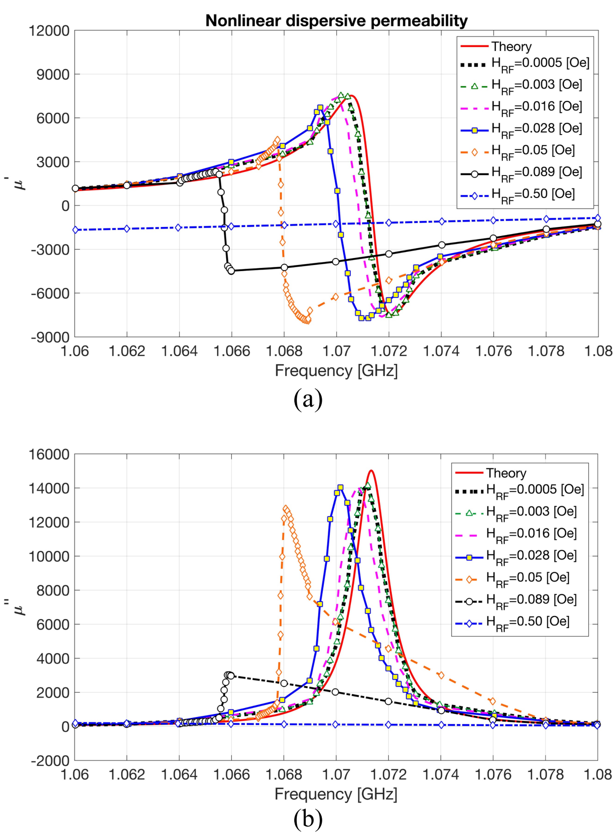

Fig. 1. Simulated dispersive permeability of infinite YIG thin film backed by PEC ground. (a) real part μ', (b) imaginary part μ''.

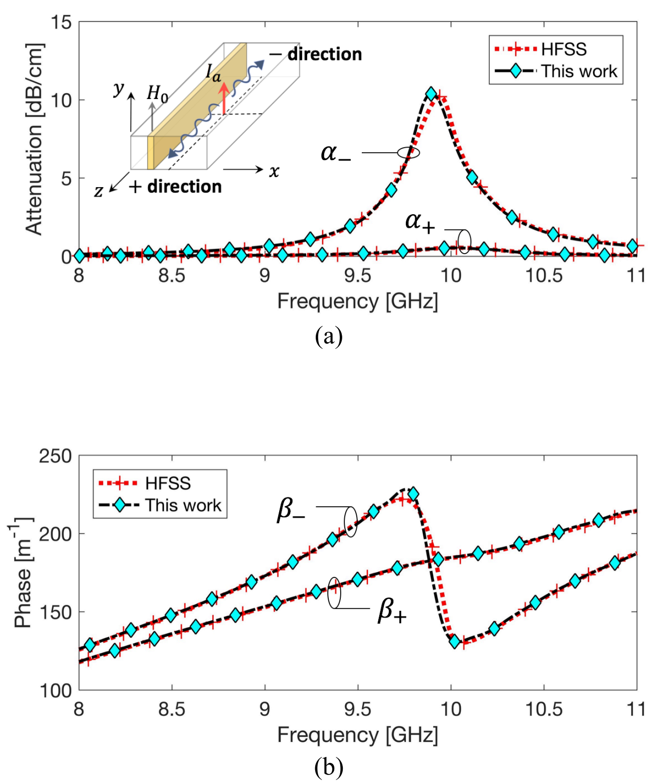

Fig. 2. (a) Attenuation constants and (b) phase constants of forward and reverse propagation direction for the resonance isolator specified by the inset.