Doppler effect for spin waves: micromagnetic studies

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The Doppler (and Cherenkov) effect is the physical phenomenon existing for any kind of waves. To observe it one needs to move uniformly the source of the wave with a velocity comparable to (or larger than) the velocity of propagating waves. In 2013, Ming Yan et al [1] demonstrated (using micromagnetic simulations) the Doppler and Cherenkov effects for spin waves excited by the moving pulse of the magnetic field. The authors also found that for 2D and 3D ferromagnetic systems a bending of the wavefront forming a Mach cone can be observed.

In our work, we reproduced the results obtained by M. Yang, using the micromagnetic solver MuMax3. Our studies were supplemented by the case of pair of linearly oriented sources (generating plane waves), keeping the same distance from each other (i.e. moving with the same velocity). For the appropriately selected distance and the speed of the sources, we observed the destructive interference of the spin waves in the front (or in the back of moving sources). Such a system works as a unidirectional spin wave antenna, generating spin waves of different frequencies only in the forward (or only in the backward) direction.

One of the main problems in the experimental observation of Doppler for spin waves is the realization of a moving source that travels with the required velocity, i.e. in the range of single km/s. We are going to discuss such possibilities. One feasible realization is to use the stray field of superconducting vortices [2] (or Abrikosov lattices of such vortices), which can travel in the superconducting layer, placed above the ferromagnetic layer, with the velocity reaching single km/s.

References:

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