Electric field control of magnon power flow in thin ferromagnet films

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External electric field can modify the strength of the spin-orbit interaction between spins of ions in magnetic crystals. This influence results in a spin wave frequency shift, which is linear in both the applied electric field and the wave vector of spin waves. We apply these findings to examine theoretically how the spin wave power flow is affected by the external electric field in ultrathin ferromagnets. We also analyze how the spin wave caustics can be tuned by the electric field. In particular, the spin wave focusing pattern is obtained from the slowness surfaces by finding the normal to the slowness surface and then evaluating the curvature at each point of the curves. We show that the combination of the dipole-dipole interaction and field-induced nonreciprocity of spin wave propagation can result in unidirectional caustic beams of dipole-exchange spin waves. Our findings open a novel important avenue for spin wave manipulation and development of electrically tunable magnonic devices.

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