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Berry phase, Aharonov–Casher effect and electric field tunable Snell's law for spin waves in ferromagnetic nanostripes

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An example of a topological effect in magnetization dynamics is the presence of an extra additional geometric phase, the so-called Aharonov–Casher (AC) phase [1], acquired by the quantum orbital motion of neutral magnetic moments - spin waves (SWs) - in mesoscopic rings in an external electric field. It manifests itself in a shift of the dispersion and the direction of the group velocity of the SWs by the electric (**E**) field. The AC effect can be considered within a linear approximation by adding the Dzyaloshinskii-Moriya-like interaction between neighboring spins. This topological quantum phenomenon has been directly detected experimentally for SWs propagating in the classical magnetic insulator $Y_3Fe_5O_{12}$ [2]. The magnitude of the AC phase was two orders larger than previously estimated theoretically for centrosymmetric ferromagnet insulators. This finding provides the opportunity of tuning the properties of SWs by a direct E-field, which is an essential ingredient for magnonic waveguides [3-5]. Through analytical calculations and micromagnetic simulations, we demonstrated that in ferromagnetic nanostripes, it is possible to control the refraction of SWs at the interface formed by the regions under the action t of different **E**-fields. We show that the **E**-field control of SW refraction regimes in magnetic film can be helpful for the development and design of new magnonic nanodevices. From the fundamental point of view, the discussed peculiar phenomena open a new avenue for quantifying topological effects in magnetization dynamics.

Reference list

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