

Subtle mechanisms of spin-wave mode hybridisation in two-dimensional magnonic crystals

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Spin-wave mode hybridisation is one of the key mechanisms governing the dynamical properties of complex magnetic systems and the functionality of modern magnonic structures [1]. This contribution presents an analysis of mode hybridisation in two-dimensional, bi-component permalloy-cobalt (Py/Co) magnonic crystals. The study is based on calculations of spin-wave spectra performed using the plane-wave method (PWM) for geometries feasible with current experimental fabrication techniques, with particular emphasis on the influence of the external magnetic field and geometric deformation of the structure [2].

A central element of the analysis is the introduction of an excitation energy concentration coefficient, which describes the fraction of spin-wave energy concentrated in one of the constituent components of the composite [3]. It is shown that the exchange of this coefficient between modes provides a sensitive and unambiguous indicator of hybridisation, even in situations where classical signatures of coupling—such as pronounced dispersion-branch anti-crossings or a complete interchange of spatial mode profiles—are weakly expressed or practically absent. Examples of hybridisation are presented in which energy transfer between Py and Co occurs without a clear swapping of mode profiles, as well as cases of more complex, multimode hybridisation.

Particular attention is devoted to a comparison between the base structure and a system subjected to compression along the direction of the external magnetic field. It is demonstrated that compression leads to non-uniform shifts of mode frequencies, depending on the degree of their concentration in Py or Co. This results in a shift of the hybridisation conditions towards higher magnetic-field values and in the emergence of new pairs of coupled modes. These findings indicate that controlled geometric modification constitutes an effective tool for engineering mode coupling in magnonic crystals.

References:

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