Shaping the spectrum of 2D magnonic crystal by modification of surface anisotropy

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The dynamics of spin waves in a magnetic medium can be shaped by the geometry of the system, i.e. by changing the shape and sizes of its components. This is the basic design strategy for any system that processes signals in the form of waves and it is commonly used in photonics, phononics, and plasmonics. Wave dynamics, its localization and propagation, can also be influenced by modifying the boundary conditions on the surfaces of the structure. This approach offers particular opportunities in the case of spin waves, where the freedom of the spin wave on the surface of a magnonic system can be controlled by many factors.

Generally, the exchange spin waves are unpinned on the surface of the magnetic body and their dynamics can be changed by the application of magnetic surface anisotropy, as shown in pioneering work by Rado and Weertman [1]. A further significant factor influencing the magnetisation dynamics at the surface is the so-called dipolar pinning [2,3]. The origin of dipolar pinning can be explained by the interplay between magnetic surface and volume charges [4].

In our research, we consider a perpendicularly magnetized 2D planar magnonic crystal. The magnonic crystal is composed of CoFeB square dots arranged into a square lattice. Therefore components of the magnonic crystal are coupled by dipolar interactions. We consider the forward volume configuration to not break the symmetry of the lattice, i.e. to keep the reference system where both principal directions of the lattice are equivalent. Then, we demonstrate that the introduction of surface anisotropy at the lateral faces of dots can release spin wave dynamics and compensate dipolar pinning, which noticeably affects the spin wave spectrum of the magnonic crystal. Finally, we introduce surface anisotropy only on one pair of lateral surfaces of each dot which makes two principal directions of magnonic crystals distinguishable for spin wave propagation. It is worth noticing that for both studies the geometry of the structure remains unaltered.

References:

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