ARTIFICIAL MAGNETIC ATOMS

Björgvin Hjörvarsson[*] and **Vassilios Kapaklis**
Uppsala University, Department of Physics and Astronomy
[*] *Corresponding author and presenter: bjorgvin.hjorvarsson@physics.uu.se*

Patterning can be used to engineering additional energy scales into magnetic materials. The obtained properties can be unique and strongly deviating from the parent material, as e.g. exemplified by the formation of permalloy based artificial spin-ice-structures[1]. The shape of the islands can be used to tailor their magnetic meso-spin dimensionality: Elongated islands can be made Ising-like[2] while circular islands can result in a XY-like behaviour [3]. The magnetic interactions in this type of metamaterials are characterised by two energy scales: Atomic interactions within islands and stray field caused interactions between the islands. Consequently, the islands can be viewed as mesospins, interacting via their stray field, in a close analogue to atomic spins. If the inter-island interaction is sufficiently weak, the mesospins exhibit paramagnetic like behaviour [2]. By the same token, if the mesospins are close enough, their mutual interactions can be strong enough to result in ordering [3]. When large arrays of interacting mesospins are formed, an order disorder transition can be obtained, resembling an ordinary phase transition [4,5]. However, the magnetic metamaterials are not restricted to the same rules as their atomic counterparts. For example, it is possible to combine and design the properties of magnetic metamaterials made from magnetic mesospins in almost arbitrary fashion. For example, XY mesospins can be used as an interaction modifier of Ising spins, due to the large difference in activation energies [6]. The results clearly demonstrate the possibility to design energy and length-scales in magnetic metamaterials in a completely new way. A brief outlook is given, emphasising the possibilities of using the interplay between the energy and length scales in artificial magnetic atoms.

References:

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