Artificial Atoms and Magnetic Metamaterials

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When forming patterned structures, the resulting 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 magnetic interactions can be characterized by two energy scales: Atomic interaction *within* the islands and stray-field-based interaction *between* the islands. Consequently, the islands can be viewed as *mesospins,* interacting via their stray field, in a close analogue to the atomic spins. For example, when the inter-island interaction is sufficiently weak, the mesospins exhibit paramagnetic like behavior [2]. By bringing the mesospins close enough, their mutual interactions can be large enough to give rise to ordering [3]. Furthermore, the shape of the islands can be used to tailor their effective spin dimensionality. Consequently, mesospins fabricated as elongated islands can be made Ising like [2,3] while circular islands can result in a XY behavior [4].

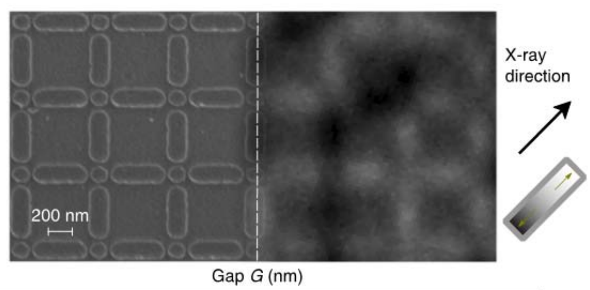

Figure 1. Illustration of a magnetic metamaterial and the magnetic imaging using

When large arrays are formed, an order disorder transition can be obtained, resembling an ordinary phase transition [5,6]. However, islands constituting magnetic metamaterials are not restricted to the same rules as their atomic counterparts: It is possible to combine and design the properties of mesospins in almost arbitrary fashion. For example, XY mesospins can be used as an interaction modifier, allowing the design of interactions between *e.g.* Ising mesospins [7]. The nature of the emergent order in these structures is only rudimentarily explored and even the conceptual framework is only partially formed.

A brief description is given on some of the properties of magnetic metamaterials. The use of synchrotron-based scattering and imaging techniques will be addressed, with an emphasis on how phase and spatial coherency could be used when exploring the ordering and dynamics of magnetic metamaterials.

References:

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