PHYSIK

Physikalisches Kolloquium

Phase transitions in magnetic metamaterials

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Patterning is a mean of engineering additional energy scales into magnetic materials. The obtained properties can be unique and strongly deviating form the parent material, as e.g. exemplified by the formation of permalloy based artificial spin ice structures[1]. The magnetic interactions of the material is characterised by two energy scales: Atomic interaction *within* and *between* the islands.

Consequently, the islands can be viewed as *mesospins*, interacting via their stray field, a close analogue to atomic spins.

When the inter-island interaction is sufficiently weak, the mesospins exhibit paramagnetic like behaviour [2] while bringing the mesospins close enough, their mutual interactions results in ordering [3]. Furthermore, the shape of the islands can be used to tailor their spin dimensionality. For example, mesospins fabricated as elongated islands can be made Ising like[2] while circular islands can result in a XY behaviour [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/restrictions as their atomic counterparts: It is possible to combine and design the properties of mesospins in almost arbitrary fashion. For w example, XY mesospins can be used as an interaction modifier, allowing the design of interactions between the Ising mesospins [6].

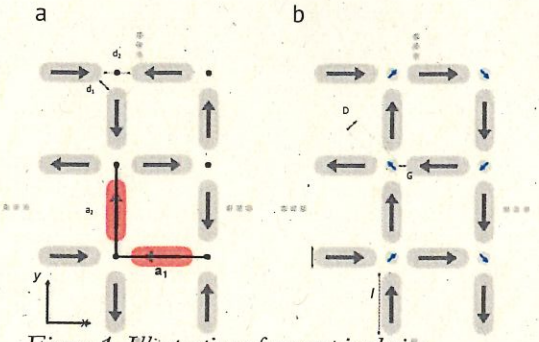

Figure 1. Illustration of mesospin design

The results clearly demonstrate the possibility to design new energy and length-scales in magnetic metamaterials. The nature of the emergent order in these structures is only rudimentarily explored. A brief outlook is given, emphasising the possibilities using the interplay between the energy and length scales involved.

[1] Artificial 'spin ice' in a geometrically frustrated lattice of nanoscale ferromagnetic islands. R. F. Wang, C. Nisoli, R. S. Freitas, J. Li, W. McConville, B. J. Cooley, M. S. Lund, N. Samarth, C. Leighton, V. H. Crespi, and P. Schiffer,, Nature 439, 303–306 (2006).

[2] Thermal transitions in nano-patterned XY-magnets, Unnar B. Arnalds, Martina Ahlberg, Matthew S. Brewer, Vassilios Kapaklis, Evangelos Th. Papaioannou, Masoud Karimipour, Panagiotis Korelis, Aaron Stein, Sveinn Olafsson, Thomas P. A.

Hase, and Björgvin Hjörvarsson, Appl. Phys. Lett. 105, 042409 (2014); http://dx.doi.org/10.1063/1.4891479 [3] Thermalized ground state of artificial kagome spin ice building blocks, Unnar B. Arnalds, Alan Farhan, Rajesh V. Chopdekar, Vassilios Kapaklis, Ana Balan, Evangelos Th. Papaioannou, Martina Ahlberg, Frithjof Nolting, Laura J.

Heyderman, and Björgvin Hjörvarsson, Applied Physics Letters 101 (11) , art. no. 112404

[4]Melting artificial spin ice, Vassilios Kapaklis, Unnar B. Arnalds, Adam Harman-Clarke, EvangelosTh. Papaioannou, Masoud Karimipour, Panagiotis Korelis, Andrea Taroni, Peter C. W. Holdsworth, Steven T. Bramwell, and Björgvin Hjörvarsson, New Journal of Physics 14 (2012) 035009 (10pp), IOP Select & highlight selection of 2012

[5] Thermal fluctuations in artificial spin ice, Vassilios Kapaklis, Unnar B. Arnalds, Alan Farhan,Rajesh V. Chopdekar, Ana Balan, Andreas Scholl, Laura J. Heyderman and Björgvin Hjörvarsson, Nature Nano DOI: 10.1038/NNANO.2014.104 [6] Interaction modifiers in artificial spin ices, Erik Östman, Henry Stopfel, Ioan-Augustin Chioar, Unnar B. Arnalds, Aaron Stein, Vassilios Kapaklis & Björgvin Hjörvarsson, Nature Physics (2018), doi:10.1038/s41567-017-0027-2

Der Gast wird betreut von Herrn Prof. Dr. Hillebrands
Gäste sind herzlich willkommen
Kaffeeausschank ab 17:00 Uhr

Montag, 27. Mai 2019, 17:15 Uhr
Gebäude 46 / Raum 46-270

TECHNISCHE UNIVERSITÄT KAISERSLAUTERN