MAR15-2014-020158

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

Ordering, thermal excitations and phase transitions in dipolar coupled mono-domain magnet arrays

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Magnetism has provided a fertile test bed for physical models, such as the Heisenberg and Ising models. Most of these investigations have focused on solid materials and relate to their atomic properties such as the atomic magnetic moments and their interactions. Recently, advances in nanotechnology have enabled the controlled patterning of nano-sized magnetic particles, which can be arranged in extended lattices. Tailoring the geometry and the magnetic material of these lattices, the magnetic interactions and magnetization reversal energy barriers can be tuned [1,2]. This enables interesting interaction schemes to be examined on adjustable length and energy scales. As a result such nano-magnetic systems represent an ideal playground for the study of physical model systems, being facilitated by direct magnetic imaging techniques [3]. One particularly interesting case is that of systems exhibiting frustration, where competing interactions cannot be simultaneously satisfied. This results in a degeneracy of the ground state and intricate thermodynamic properties [1-4]. An archetypical frustrated physical system is water ice. Similar physics can be mirrored in nano-magnetic arrays, by tuning the arrangement of neighboring magnetic islands, referred to as artificial spin ice. Thermal excitations in such systems resemble magnetic monopoles [4]. In this presentation key concepts related to nano-magnetism and artificial spin ice will be introduced and discussed, along with recent experimental and theoretical developments. [1] V. Kapaklis et al., New J. Phys. 14, 035009 (2012). [2] U. B. Arnalds et al., Appl. Phys. Lett. 105, 042409 (2014). [3] A. Farhan et al., Nature Physics 9, 375 (2013). [4] V. Kapaklis et al., Nature Nanotech 9, 514 (2014).