Cooperative magnetic phenomena in artificial spin systems

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Complex architectures of nanostructures are routinely elaborated using bottom-up or nanofabrication processes. This technological capability allows scientists to engineer materials with properties that do not exist in nature, but also to manufacture model systems permitting the exploration of fundamental issues in condensed matter physics. One- and two-dimensional frustrated arrays of magnetic nanostructures are one class of systems for which theoretical predictions can be tested and revisited experimentally [1,2]. These systems have been the subject of intense research in the last few years and allowed the investigation of a rich physics, including the study of the extensively degenerate ground-state manifolds of spin ice systems, the evidence of new magnetic phases in purely two-dimensional lattices, and the observation of pseudo-excitations involving classical analogues of magnetic monopoles.

This talk aims at providing two examples of two-dimensional frustrated arrays of magnetic nanostructures, in which the low-energy physics of two exotic Ising systems was probed. The first example is related to the seminal six vertex model and shows that a scan through the phase diagram of this model can be achieved experimentally, provided that the artificial spin system is designed appropriately [3]. In particular, the symmetric point of the square ice is recovered, and signatures of an algebraic Coulomb spin liquid are observed. The second example refers to a recent proposal [4], the fragmentation of magnetization [4-7], in an Ising kagome model. The magnetic configurations we image in a thermally active artificial system [5] reveal the fingerprints of this fragmentation process, which corresponds to a splitting of the spin degree of freedom into two independent sectors. The first sector is identified as an incipient antiferromagnetic crystal of an all-in/all-out spin configuration, despite the ferromagnetic nature of the system, in which spins carry 1/3 of their total magnetic moment. The second sector corresponds to a diffuse organization of the remaining (2/3 and 4/3) fragmented spins.

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