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Ground state ordering of artificial spin ice

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Using electron beam lithography combined with appropriate imaging techniques, it became possible in recent years to design, pattern and imvestigate artificial spin ice systems, the 2-dimensional parallel to the pyrochlore spin ice, and which are considered to be ideal model systems to directly investigate the behavior of frustrated systems. In particular, using photoemission electron microscopy, it's possible to visualize the moment configuration and eventual fluctuations in such a system. Thus far, the systems investigated were patterned films with Curie temperatures far above room temperature, so that these systems could only be manipulated by applying magnetic fields, whether achieving low energy states via demagnetization [1] or the observation of emergent magnetic monopoles upon field reversal [2]. Inspired by the recent work of Morgan et al. [3], we present a thermal ground state ordering in the artificial kagome spin ice building blocks, consisting of a finite number of hexagonal rings of nanomagnets, which occurs during the early stages of film deposition. In infinite arrays of the artificial kagome spin ice, while a unique ground state is not observed, the ice rule is obeyed at every vertex. A strong dependence of the ordering on the film thickness and coupling strength is observed. With heating experiments we were able to apply direct thermal annealing on the building blocks and observed high frequencies of ground states achieved.

[1] E. Mengotti, L.J. Heyderman, A. Fraile Rodríguez, A. Bisig, L. Le Guyader, F. Nolting, and H.B. Braun, Phys. Rev. B 78, 144402 (2008)

[2] E. Mengotti, L.J. Heyderman, A. Fraile Rodríguez, F. Nolting, Remo V. Hügli, and H.B. Braun, Nature Physics Vol. 7 NPHYS1794 (2011)

[3] J. Morgan, A. Stein, S. Langridge, C.H. Marrows Nature Physics 7, 75-79 (2011)

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