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Fluctuations in a magnetic metamaterial

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In recent years, artificial spin systems, consisting of elongated single-domain ferromagnetic nanomagnets placed on the nodes of two-dimensional lattices and coupled via their dipolar fields, have been used to address open questions in frustrated magnetism. However, the imaging techniques so far used, are severely constrained in terms of temporal and spatial resolution. Using soft resonant x-ray scattering [1,2] we measure magnetic fluctuations in square artificial spin ice (Fig. 1), known to order antiferromagnetically, providing information about the magnetic domain structure evolution beyond what state-of-the-art imaging techniques can. Glassy dynamics were reported in recent experiments with the same technique on similar arrays in which the nanomagnets are only weakly interacting [3], while, anomalous features in the dynamics for long time lags were seen in another similar study on strongly interacting nanomagnets [4]. In particular, the latter results suggest the presence of a crossover from a ballistic to free diffusion regime in the motion of the magnetic domain boundaries. In our data across the transition, we observe re-entrant effects that are not expected for a system with glassy behaviour and two-fold rotational symmetry that has not been observed previously [4]. With further analysis of the data, we aim to identify the nature of fluctuations for our model system, which may, for example, be a result of critical or depinning dynamics.

[1] J. Perron et al., Phys. Rev. B 88, 214424 (2013).
[2] O. Sendetskyi et al., Phys. Rev. B 93, 224413 (2016).
[3] Morley, S. A. et al. Phys. Rev. B 95, 104422 (2017).
[4] Chen, X. M. et al. arXiv:1809.05656 [cond-mat] (2018).

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