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Emergent responses in magnetic ring arrays of different lattice arrangements for reservoir computing

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Stochastic behaviour has traditionally been a limiting factor in developing nanomagnetic technology. Recently, we have shown complex probabilistic, emergent behaviour in interconnected nanowire ring arrays [1-3] that is particularly useful for ‘reservoir computing’(RC), a highly efficient computation scheme for time domain signal processing [4]. We have also simulated RC with such arrays for recognising spoken digits [2] and anticipate a need to derive additional complex behaviour from the arrays for processing more tasks and data.

Here we vary the lattice arrangements of $\mathrm{Ni_{80}Fe_{20}}$ rings (as square, trigonal and Kagome) to achieve alternative responses. Different lattices show rich ground states (for example pinning sites in the trigonal array in Fig. (a)) and can show diverse dynamics. Magneto-optic Kerr effect (MOKE) measurements with in-plane rotating fields (H_{rot}) were used to characterise the arrays [2] and gave the propagating DW state population Nprop (Fig. (b)). The different behaviours are due to interactions at junctions and are seen in X-ray photoemission electron microscopy (XPEEM) images at intermediate fields. The square and trigonal arrays show multiple magnetic states while the Kagome shows vortices. We are now benchmarking computation with these arrays and expect that these varied responses are essential for obtaining additional processing capabilities in reservoir computing.

[1] Negoita et al., J. Appl. Phys. 114, 013904 (2013).
[2] Dawidek et al., Adv. Funct. Mater., 2008389 (2021).
[3] Vidamour et al. arXiv preprint arXiv:2206.04446 (2022)
[4] Jensen et al., ALIFE 2018: The 2018 Conference on Artificial Life 15, (2018).

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