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Creation and applications of reconfigurable artificial magnetic charge ices

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Artificial spin ices are arrays of lithographically created nanoscale single domain bar magnets. They are introduced to mimic the behavior of naturally occurring frustrated magnetic materials and enable the study of geometrical frustration by design and through direct observation. Among them, the artificial square spin ice consisting a square lattice with the bar magnets perpendicular to its sides is the first and the most investigated artificial ice system. It has proven difficult to achieve tailored long-range ordering of its diverse configurations including the degenerate ground states. Instead of focusing on the spins, we broke up each magnetic bar into a positive and negative magnetic charge and designed an artificial spin structure that produces a magnetic charge ice with the same charge distributions as those of the conventional square spin ice but with reconfigurable charge configurations. By precisely manipulating the single artificial spin/charge using a tip of magnetic force microscope, we demonstrated write-read-erase multi-functionality at room temperature. We also applied these reconfigurable artificial magnetic charge ices to control the properties of other material systems, as shown by our recently realized in-situ tunable magneto-transport properties in a superconducting-film/magnetic-charge-ice hybrid.

Reference:
Yong-Lei Wang, Zhi-Li Xiao, Alexey Snezhko, Jing Xu, Leonidas E. Ocola, Ralu Divan, John E. Pearson, George W. Crabtree, Wai-Kwong Kwok, Rewritable artificial magnetic charge ice, Science 352, 962 (2016).