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Magnetic microstructures for regulating Brownian motion[1]

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Nature has proven that it is possible to engineer complex nanoscale machines in the presence of thermal fluctuations. These biological complexes, which harness random thermal energy to provide functionality, yield a framework to develop related artificial, i.e., nonbiological, phenomena and devices. A major challenge to achieving positional control of fluid-borne submicron sized objects is regulating their Brownian fluctuations. In this talk a magnetic-field-based trap that regulates the thermal fluctuations of superparamagnetic beads in suspension will be presented. Local domain-wall fields originating from patterned magnetic wires, whose strength and profile are tuned by weak external fields, enable bead trajectories within the trap to be managed and easily varied between strong confinements and delocalized spatial excursions. Moreover, the frequency spectrum of the trapped bead responds to fields as a power-law function with a tunable, non-integer exponent. When extended to a cluster of particles, the trapping landscape preferentially stabilizes them into formations of 5-fold symmetry, while their Brownian fluctuations result in frequent transitions between different cluster configurations. The quantitative understanding of the Brownian dynamics together with the ability to tune the extent of the fluctuations enables the wire-based platform to serve as a model system to investigate the competition between random and deterministic forces.

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