ENGINEERING SCIENCES & APPLIED MATH--FEATURED SPEAKER

Emergent Dynamics in Active Spinner Materials

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Strongly interacting colloids driven out-of-equilibrium by an external periodic forcing often develop nontrivial collective dynamics. Active magnetic colloids proved to be excellent model experimental systems to explore emergent behavior and out-of-equilibrium phenomena. Ferromagnetic micro-particles, suspended at a liquid interface and energized by a uniaxial in-plane alternating magnetic field spontaneously form arrays of self-assembled spinners rotating in either direction. The spinners, emerging as a result of spontaneous symmetry breaking of clock/counterclockwise rotation of self-assembled particle chains generate vigorous vortical flows at the interface. An ensemble of spinners exhibits chaotic dynamics due to self-generated advection flows. Furthermore, erratic motion of spinners at the interface generates chaotic fluid flow reminiscent of two-dimensional turbulence. Rotational homogeneous alternating magnetic fields applied along the supporting interface, spontaneously form ensembles of synchronized self-assembled spinners. Experiments reveal nontrivial collective dynamics in large ensembles of synchronized magnetic spinners that can spontaneously form dynamic spinner lattices at the interface in a certain range of the excitation parameters.
Magnetic micro-particles immersed in water and sediment on the bottom surface of the turn into colloidal rollers when energized by a single-axis homogeneous alternating magnetic field applied perpendicular to the surface supporting the particles. The rolling motion emerges as a result of spontaneous symmetry breaking of the particle rotations in external field in a certain range of excitation parameters. Experiments reveal a rich collective dynamics of magnetic rollers. Flocking and spontaneous formation of steady vortex motion have been observed. The effects are fine-tuned and controlled by the parameters of the driving magnetic field.
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