

Topological transport of magnetic colloids on a spatially modulated square lattices

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We investigate topological transport phenomena in paramagnetic colloids or colloidal systems (self-assembled paramagnetic colloidal particles) driven by adiabatic cyclic rotations of a homogeneous external magnetic field above spatially modulated magnetic square patterns. Nontrivial periodic rotations of the homogenous magnetic field drive particles along the evolving energy landscape of the magnetic pattern, leading to robust transport governed by topological invariants rather than microscopic details. Depending on the topology and symmetry of the driving loop and on the geometry of the magnetic pattern, colloids exhibit different kinds of motion including quantized transport, edge transport and protected corner modes. Transport characteristics such as direction, velocity, and step width depend discretely on particle properties and pattern parameters, enabling robust transport of colloids. Our findings establish a general framework for topologically protected transport and manipulation of soft matters, with potential applications in microfluidics, particle sorting, and lab on chip devices.