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Critical dynamics and finite-time scaling in spin ice systems

CLAUDIO CASTELNOVO, JAMES HAMP, University of Cambridge, ANUSHYA CHANDRAN, Perimeter Institute, RODERICH MOESSNER, MPIPKS — Spin ice materials such as Dy2Ti2O7 and Ho2Ti2O7 provide a rare instance of emergent gauge symmetry and fractionalisation in three dimensions. Magnetic frustration leads to highly degenerate yet locally constrained ground states. Their elementary excitations carry a fraction of the magnetic moment of the microscopic spin degrees of freedom and can be thought of as magnetic monopoles. One of the distinguishing manifestations of this emergent "Coulomb phase" is a liquid-gas phase diagram that appears in an applied magnetic field–a feature that is expected in itinerant charge liquids but unprecedented in localised spin systems. Monopoles act as facilitators to the spin dynamics. At low temperatures they are sparse and dynamics becomes slow, leading to an interplay between emergent topological properties and lattice scale physics in response and equilibration properties. In this work, we investigate the dynamics in spin ice close to the critical end point of the liquid gas phase diagram. Critically divergent length scales give rise to finite time scaling properties that reflect the universal scaling exponents at the critical point. We use our results to obtain these exponents by tuning the approach direction in the field-temperature plane.

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