Anomalous Transport and Operator Growth in Constrained Quantum Matter

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The far from equilibrium dynamics of generic interacting quantum systems is characterized by a handful of universal guiding principles, among them the diffusive transport of globally conserved quantities and the ballistic spreading of initial local operators. Here, we discuss that in certain constrained many-body systems the structure of conservation laws can cause a drastic modification of this universal behavior. In particular, we focus on a dipole conserving “fracton” chain which exhibits a localization transition separating an ergodic dynamical phase from a frozen one. Even in the ergodic phase, transport is anomalously slow and exhibits subdiffusive scaling. We explain this finding by a developing general hydrodynamical model, that yields an accurate description of the scaling form of charge correlation functions. Furthermore, we investigate the operator growth characterized by out-of-time correlations functions (OTOCs) in this dipole conserving system. We identify a critical point, tied to the underlying localization transition, with unconventional sub-ballistically moving OTOC front. We use the scaling properties at the critical point to derive an effective description of the moving operator front via a biased random walk with long waiting times and support. Our arguments are supported numerically by classically stimulable automaton circuits.

References:

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