Hydrodynamic modes and out-of-time-order correlators in a long-range center-of-mass-conserving Brownian SYK model

Abstract: We study a center-of-mass-conserving Brownian complex Sachdev-Ye-Kitaev model with long-range (power-law) interactions characterized by $1/r^\eta$. The kinetic constraint and long-range interactions conspire to yield rich hydrodynamics associated with the conserved charge, which we reveal by computing the Schwinger-Keldysh effective action. Our result shows that charge transport in this system can be subdiffusive, diffusive, or superdiffusive, with the dynamical exponent controlled by η. We further employ a doubled Hilbert space methodology to derive an effective action for the out-of-time-order correlator (OTOC), from which we obtain the phase diagram delineating regimes where the lightcone is linear or algebraic. Interestingly, while the real part of OTOC arising from the squared norm of the anticommutator typically exhibits behaviors rather distinct from transport, we find that the imaginary part of OTOC nevertheless captures the hydrodynamics of charge transport. Our results provide a concrete example of a quantum many-body system with kinetic constraint in which the emergent hydrodynamic modes and OTOC can be computed analytically.