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The structure of dynamical quantum critical points

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Dynamical quantum phase transitions (DQPTs) are characterized by nonanalytic behavior in the return rate, a dynamical analogue of the equilibrium free energy. For a translationally invariant one-dimensional system (or 2D cylinder) we define the return rate per site as , which can be expressed via the dominant eigenvalue of the transfer operator. Analytically continuing to complex , each eigenvalue branch defines a sheet of a multivalued function, and together these sheets form a Riemann surface. The return rate corresponds to the dominant sheet, with nonanalyticies arising when different sheets intersect. These branch crossings mark dynamical critical points, and the resulting web of intersections defines the structure of the DQPT. This perspective highlights that DQPTs are governed by the branching geometry of the transfer-operator spectrum, rather than by the accumulation of Fisher zero lines onto the real axis, as in equilibrium phase transitions. Using MPS transfer matrix methods, we show how to compute the derivatives of the return rate function, which gives a series expansion representation of each eigensurface and directly reveals the nonanalytic structure.

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