

Modular Krylov Complexity as a Boundary Probe of the Entanglement Island

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We show that the area operator of a quantum extremal surface (generalization of the Ryu-Takayanagi area) can be reconstructed directly from boundary dynamics without reference to bulk geometry. Our approach combines the operator-algebra quantum error-correction (OAQEC) structure of AdS/CFT with modular Krylov complexity. Using Lanczos coefficients of boundary modular dynamics, we extract the spectrum of the modular Hamiltonian restricted to the algebra of the entanglement wedge and isolate its central contribution, which is identified with the area operator. The construction is purely boundary-based and applies to superpositions of semiclassical geometries as well. As an application, we diagnose island formation and the Page transition in evaporating black holes using boundary modular evolution alone, bypassing any bulk extremization. More broadly, our results establish modular Krylov complexity as a concrete and computable probe of emergent spacetime geometry, providing a new route to accessing black hole interiors from boundary quantum dynamics.