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On Krylov complexity in open systems: an approach via bi-Lanczos algorithm

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Abstract: Continuing the previous initiatives [1, 2], we pursue the exploration of operator growth and Krylov complexity in dissipative open quantum systems. In this paper, we resort to the bi-Lanczos algorithm generating two bi-orthogonal Krylov spaces, which individually generate non-orthogonal subspaces. Unlike the previously studied Arnoldi iteration, this algorithm renders the Lindbladian into a purely tridiagonal form, thus opening up a possibility to study a wide class of dissipative integrable and chaotic systems by computing Krylov complexity at late times. Our study relies on two specific systems, the dissipative transverse-field Ising model (TFIM) and the dissipative interacting XXZ chain. We find that, for the weak coupling, initial Lanczos coefficients can efficiently distinguish integrable and chaotic evolution before the dissipative effect sets in, which results in more fluctuations in higher Lanczos coefficients. This results in the equal saturation of late-time complexity for both integrable and chaotic cases, making the notion of late-time chaos dubious.

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