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Time Evolution of Krylov Complexity in the Schrödinger Field with Robin Boundary Condition

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Abstract

In this work, Krylov complexity is investigated within the framework of quantum field theory as a diagnostic for characterizing the growth and spreading of operators in quantum systems. The focus is on a nonrelativistic fermionic field defined on a half-line rather than an unbounded space, such that the presence of a boundary plays a decisive role in the system's evolution. We first review the structure of thermal Wightman functions and the momentum-mode expansion of the Schrödinger field on the full line in order to establish the computational framework required to define the spectrum, the thermal inner product, and the relevant correlation functions. We then impose Robin boundary conditions and demonstrate how reflection from the boundary modifies the structure of the correlation functions and, consequently, the quantities governing operator growth. The limiting behaviors corresponding to a transparent boundary and a fully reflecting boundary are also analyzed to clarify under which conditions the half-line effectively reproduces the full-line results and under which conditions it leads to a significant modification of complexity growth. Our numerical results show that, depending on the physical parameters of the system, the boundary can either suppress or enhance the growth rate of complexity, thereby acting as a controlling factor in the dynamical evolution of Krylov complexity.

Keywords: Krylov complexity, time evolution, Schrödinger field, Robin boundary condition, half-line, full line, Lanczos algorithm, energy spectrum.

For full article, refer to the Persian section