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Stochastic Krylov Dynamics: Revisiting Operator Growth in Open Quantum Systems

Mpho Tladi (University of Cape Town)

Friday, 5 June 2026 @ 14h00-15h00 SAST

Venues: NITheCS Seminar Room, Stellenbosch University; and Online

ABSTRACT:

In closed quantum systems, Krylov complexity admits a geometric description: operator growth is equivalent to Hamiltonian flow in an emergent phase space whose structure is fixed by the Lanczos coefficients. We show that this picture survives, albeit in a fundamentally altered form once the system is coupled to an environment. Using a Schwinger–Keldysh formulation of the full counting statistics of the Krylov position, we derive an effective action for operator growth under Lindblad dynamics. Even for the minimal case of pure dephasing, the phase-space dynamics ceases to be Hamiltonian: environmental coupling generates diffusion in the variable conjugate to Krylov depth, converting deterministic trajectories into stochastic ones. The hyperbolic mechanism underlying exponential complexity growth is therefore broadened and, beyond a parametrically controlled scale, destroyed. This identifies dissipation as a relevant perturbation of the chaotic Krylov fixed point and reveals operator growth in open systems as a problem of stochastic dynamics in an emergent phase space.

In this talk, Mpho Tladi will discuss recent advancements in mapping the boundaries of information scrambling and chaotic dynamics within open quantum systems. Specifically, the presentation will focus on the algebraic framework of operator growth and Krylov complexity, exploring how these dynamics evolve when a system interacts with an external environment. Tladi will introduce key insights from their recent work, “Stochastic Krylov Dynamics: Revisiting Operator Growth in Open Quantum Systems”, demonstrating how formal methods like Lindblad dynamics, and the Schwinger-Keldysh formalism can be utilised to analyse real-time, non-equilibrium quantum processes under environmental influence.

BIOGRAPHY:

Mpho Tladi is a PhD Candidate in the Department of Mathematics and Applied Mathematics in the Laboratory for Quantum Gravity and Strings (QGASLAB) at the University of Cape Town where he conducts his research under the supervision of Dr Shajid Haque and Professor Jeff Murugan. Tladi’s research sits at the intersection of modern quantum mechanics, high-energy theory, and mathematical physics. Their primary work investigates the fundamental mechanisms governing quantum systems, with a particular specialization in operator growth and quantum complexity to map the boundaries of information scrambling and chaotic dynamics.

Tladi’s expertise encompasses the algebraic framework of Krylov complexity, open quantum systems, and formal methods like the Schwinger-Keldysh formalism, which they use to analyse real-time non-equilibrium quantum processes, Lindblad dynamics. A notable contribution to the field is their recent paper, “Stochastic Krylov Dynamics: Revisiting Operator Growth in Open Quantum Systems” (arXiv:2604.20619), which advances the understanding of how complexity develops under environmental influence.

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