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Title: Breaking quantum speed limit and creating super-quantum correlations with PT symmetry.

Abstract: Quantum theory provides rules governing much of the microscopic world, and among its counter-intuitive consequences are correlations that exceed the bounds from local, classical theories. In two-level quantum systems, unitary and dissipative dynamics theoretically limit the spatial quantum correlations, quantified by the Bell parameter B_2, to $2\sqrt{2}$. These two dynamical models also limit the temporal quantum correlations, quantified by the Leggett-Garg (LG) parameter $K_3(t)$ to 1.5 - the Luder bound. After reviewing its history, I will present theoretical results showing that when the dynamics of a single qubit are governed by a non-Hermitian, PT-symmetric Hamiltonian, the LG parameter K_3 exceeds the Luder-bound value of 1.5 over a wide parameter range across the exceptional point of the Hamiltonian. Distinct evolution speeds for antipodal qubit states, which violate the unified (Mendelstam-Tamm or Margolus-Levitin) bound τ_{QSL} for the transit time based on quantum speed limit, result in the super-quantum K_3 values observed over a wide parameter range. I will then show experimental results demonstrating these predictions in a single, trapped $^{40}Ca^+$ ion governed by a two-level, non-Hermitian Hamiltonian. Our results demonstrate that their post-selected, coherent dynamics pave the way for enhanced quantum correlations that exceed protocols based on unitary or dissipative dynamics. (Work carried out in collaboration with Prof. David Allcock's group, University of Oregon [1] and Prof. Sourin Das' group, IISER Kolkata [2].)

Reference:

1. A. Quinn et al. , arXiv:2304.12413.

2. A. V. Verma et al., arXiv:2203.04991.