DAMOP17-2017-020110

Abstract for an Invited Paper
for the DAMOP17 Meeting of
the American Physical Society

Quantum Lyapunov Exponent of an Atomic Kicked Rotor[1]

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One of the most intriguing phenomena in the studies of classical chaos is the butterfly effect, which manifests itself in that small changes in initial conditions lead to drastically different trajectories. It is characterized by a Lyapunov exponent that measures divergence of the classical trajectories. The question how/if this prototypical effect of classical chaos theory generalizes to quantum systems (where the notion of a trajectory is undefined) has been of interest for decades, but became more popular recently, when it was realized that there exist intriguing connections to string theory and general relativity in some quantum chaotic models. At the center of this activity is the so-called out-of-time-ordered correlator (OTOC) - a quantity that in the classical limit seems to approximate the classical Lyapunov correlator. However, there are very few solvable models where one can actually calculate Lyapunov exponent and/or OTOC. In this talk, I will discuss the standard model of quantum and classical chaos - kicked rotor - calculate the correlator and Lypunov exponents, and show how classical chaos and Lyapunov divergence develop and cross-over to the quantum regime. We will see that the quantum out-of-time-ordered correlator exhibits a clear singularity at the Ehrenfest time, when quantum interference effects sharply kick in: transitioning from a time-independent value to its monotonous decrease with time. In conclusion, I will discuss possible experimental realizations of the model and predicted phenomena in ultracold quantum kicked rotors.

[1]NSF-DMR 1613029 and US-ARO