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(G*) POS-E31 – Quantum Simulation of the Quantum Kicked Top

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The connection between quantum entanglement and classical chaos has puzzled physicists for decades. To understand chaos in the quantum context, it is necessary to explore signatures of chaos in the deep quantum regime, where the quantum-classical correspondence cannot be invoked. A common approach is to study the quantum kicked top, which is a finite-dimensional quantum system that displays chaotic dynamics in the classical limit. Few experimental realizations of the quantum kicked top have been achieved for small number of time steps and low chaoticity parameters. However, the problem of accurate experimental realization of long-term dynamics and large range of chaoticity parameter in the quantum kicked top is still unsolved. In this work we propose and demonstrate an exact simulation of the 2-qubit quantum kicked top on a universal quantum computer. Our proposal allows for arbitrary time steps and chaoticity parameter without compromising experimental fidelity. Using the IBM 5-qubit quantum chip we physically demonstrate the theoretical connection between delocalization and entanglement. We obtain a phase space plot of time-averaged entanglement in the deep quantum regime, which surprisingly reflects the classical phase space structure. Since chaos is known to generate entanglement in the quantum kicked top, our proposed method could be useful in Quantum Information Processing.

Authors: Mr ANAND, Amit (IIEST, Shibpur, India); Mr SRIVASTAVA, Sanchit (IISER, TVM, India); GANGOPADHYAY, Sayan (University of Waterloo); GHOSE, Shohini (Wilfrid Laurier University)

Presenter: GANGOPADHYAY, Sayan (University of Waterloo)

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