Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **3665** Type: **Oral (Non-Student) / Orale (non-étudiant(e))**

Quantum many-body scars: Connections to classical stability and instability

Wednesday 21 June 2023 14:45 (15 minutes)

The discovery of non-thermal behaviour in a thermalizing quantum many-body system [Nature 551, 579-584 (2017)] led to the introduction of quantum many-body scars (QMBS). They are atypical eigenstates of chaotic systems and generally exhibit sub-volume or area law entanglement as opposed to the volume law present in the bulk of the eigenstates. The term, QMBS, was given using heuristic correlations with quantum scars (eigenstates with high probability density around unstable classical periodic orbits) in quantum systems with a semiclassical description. Through the study of entanglement in a multi-qubit system with a semiclassical description, we show that the properties of QMBS states strongly correlate with those of the eigenstates corresponding to the very few stable periodic orbits in a chaotic system rather than unstable periodic orbits in such systems.

We study the model, quantum kicked top (QKT), an experimentally realized, paradigmatic model for quantum chaos. It has a multi-qubit representation in the permutation symmetric subspace that carves a way to calculate entanglement. The QKT exhibits Wigner distribution level statistics, typical of quantum chaotic models, in most of the parameter regime. In permutation-symmetric multi-qubit systems, random states exhibit logarithmic scaling in entanglement. When the system is quantum chaotic, we see that the bulk of the eigenstates exhibits logarithmic scaling in entanglement as expected. Nonetheless, we find a few atypical eigenstates with sub-logarithmic entanglement scaling. Further investigation reveals that these eigenstates have high probability density around stable periodic orbits present in the system despite the system being chaotic. We use the term, QMBS-like state, for such atypical eigenstates with sub-logarithmic entanglement scaling and which have support on stable periodic orbits. Moreover, we find variational quantum states that have close to 99.9 percent fidelity with the QMBS-like states. On the other hand, we find that the quantum scar eigenstates in the system exhibit logarithmic entanglement. Thus, we show that QMBS-like states with support on stable periodic orbits are better analogs of QMBS states in quantum many-body systems. This study would be helpful in understanding the mechanism of non-thermal behaviour (whenever present) in quantum chaotic systems.

Keyword-1

Thermalization

Keyword-2

Quantum chaos

Keyword-3

Entanglement

Author: Dr KUMARI, Meenu (Perimeter Institute)

Co-authors: NEGARI, Amirreza (Perimeter Institute); Dr LIN, Cheng-Ju (Jacob) (University of Maryland)

Presenter: Dr KUMARI, Meenu (Perimeter Institute)

Session Classification: (DCMMP) W2-7 Condensed matter theory II | Théorie de la matière condensée II (DPMCM)

Track Classification: Technical Sessions / Sessions techniques: Condensed Matter and Materials Physics / Physique de la matière condensée et matériaux (DCMMP-DPMCM)