Contribution ID: **5** Type: **Talk**

Unraveling the emergence of quantum state designs in systems with symmetry

Quantum state designs enable efficient sampling of random quantum states, with applications ranging from circuit design to black hole physics. While symmetries are known to reduce randomness, their role in generating state designs remains unclear. The projected ensemble framework [2, 3], which uses local projective measurements and many-body quantum chaos, has recently been introduced to generate efficient approximate state t-designs. In this framework, projective measurements are applied to the larger subsystem (bath) of a single bipartite state undergoing quantum chaotic evolution. This process generates a set of pure states on the smaller subsystem. These states, along with the Born probabilities, form the projected ensembles. Remarkably, when the measured subsystem is sufficiently large, the projected ensembles converge to state designs. This phenomenon, known as emergent state designs, is closely related to a stringent generalization of the well-studied eigenstate thermalization hypothesis.

In our work 1, we probe how symmetries influence the emergence of state designs from random generator states. Our main findings involve identifying a sufficient condition on the measurement bases when the generator states are eigenstates of an arbitrary symmetry operator. Failing to satisfy this condition can lead to the localization of projected states in the Hilbert space, as illustrated in Fig. 1. By considering the translation symmetric generator states, we derive this condition and identify bases that fail to generate the designs when the condition is violated. To solidify our results, we study the emergence of designs from a generator state evolving under the dynamics of a chaotic tilted field Ising chain with translation symmetry with the Hamiltonian:

\begin{equation}
H=\sum_{j}\sigma^{x}*{j}\sigma^x*{j+1}+h_x\sum_{j}\sigma^{x}*{j}+h_y\sum*{j}\sigma^{y}_{j}
\end{equation}

We find faster convergence towards designs compared to when translation symmetry is broken. We extend these findings to other symmetries, offering insights into deep thermalization and equilibration in quantum many-body systems.

Due to the generality of our formalism, we extend the results to other symmetry classes,s including Z2 and reflection symmetries. We further obtain the moments of the projected ensembles under the symmetry constraints.

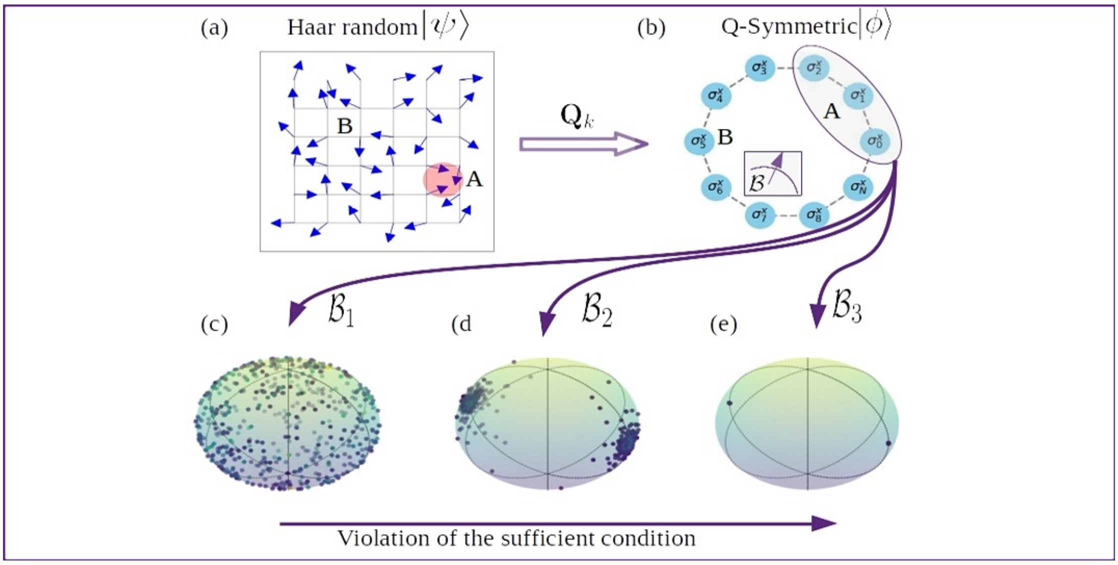

Figure 1: Schematic representation of the projected ensemble framework for a Q-symmetric state (an eigenstate of a symmetry generator Q), showcasing the interplay between measurement bases and symmetry.

References
1. Naga Dileep Varikuti and Soumik Bandyopadhyay, Quantum 8, 1456 (2024).
2. Cotler et al., PRX quantum 4, 010311 (2023)
3. Choi et al., Nature 613, 468 (2023)

Author: VARIKUTI, Naga Dileep (Pitaevskii BEC Center, CNR-INO and Department of Physics, University of Trento)

Co-author: Dr BANDYOPADHYAY, Soumik (Pitaevskii BEC Center, CNR-INO and Department of Physics, University of Trento)

Presenter: VARIKUTI, Naga Dileep (Pitaevskii BEC Center, CNR-INO and Department of Physics, University of Trento)