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Ergodic phase in many body quantum chaos

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Chaotic many body quantum systems can be in a phase of (many body) localized or extended eigenstates. In recent years, the seemingly less enigmatic delocalized phase has become a subject of controversy. It has been suggested that quantum many body eigenstates may be Non Ergodic yet Extended (NEE) in Hilbert space, with exotic multifractal distributions. In this talk I discuss how a blend of concepts developed in different fields — including matrix integral techniques pioneered by the French school of field theory, lessons learned from the SYK model, and concepts of quantum information applied to random many body states — may shed light on the situation.
Our bottom line will be that (i) the delocalized quantum states of chaotic systems (subject to long range interactions) are ergodically distributed over (ii) an energy shell nontrivially interlaced into Hilbert space. We do not see room for the emergence of an NEE phase. At the same time (iii), the ergodic states of many body systems show entanglement exceeding that of thermal states, and of the (Page) entanglement of pure random states. We will argue that these entanglement signatures are sensitive probes into the many body physics of chaotic chaos.

Orateur: ALTLAND, A.