

One of the central questions of quantum statistical physics is how isolated many-body systems reach thermal equilibrium. Two decades ago, the eigenstate thermalization hypothesis (ETH) was proposed as a mechanism accounting for the validity of the statistical mechanics in isolated quantum systems. In contrast, many-body localization (MBL) that arises from the competition between disorder and interactions, has opened the door to the investigation of breakdown of quantum ergodicity. This raises the appealing prospect of protecting quantum order as well as storing and manipulating coherent information in out-of-equilibrium many-body states. But in the conventional wisdom the presence of disorder and complete isolation are necessary for the appearance of MBL. In this talk we abolish these common beliefs and show that self-induced localization in a clean system can emerge solely due to exotic braiding statistics between particles. We also investigate a family of models in which disorder-free MBL can coexist with ergodic phase, as a result of entanglement structure of gauge degrees of freedom.