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Entanglement and universal dynamics in many-body localized systems

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We are used to describing systems of many particles by statistical mechanics. However, the basic postulate of statistical mechanics – ergodicity – breaks down in so-called many-body localized systems, where disorder prevents particle transport and thermalization. In this talk, I will describe a phenomenological theory of the many-body localized (MBL) phase, based on new insights from quantum entanglement [1]. I will argue that, in contrast to ergodic systems, MBL eigenstates are not highly entangled, but rather obey so-called area law, typical of ground states in gapped systems. I will use this fact to show that MBL phase is characterized by an infinite number of emergent local conservation laws, in terms of which the Hamiltonian acquires a universal form. Turning to the experimental implications, I will describe the behavior of MBL systems following quantum quenches: surprisingly, entanglement shows logarithmic in time growth [1,2], reminiscent of glasses, while local observables exhibit power-law approach to "equilibrium" values [3]. I will support the presented theory with the results of numerical experiments. I will close by discussing experimental implications and other directions in exploring ergodicty and its breaking in quantum many-body systems, including many-body localization in periodically driven systems.

[1] M. Serbyn, Z. Papic, D. A. Abanin, Phys. Rev. Lett. 110, 260601 (2013); Phys. Rev. Lett. 111, 127201 (2013)
[2] D. A. Huse, V. Oganesyan, arXiv:1305.4915 (2013).
[3] M. Serbyn, Z. Papic, D. A. Abanin, Phys. Rev. B 90, 174302 (2014).