To thermalize or not?
Slow particle diffusion in Many-Body Localization

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Experience tells us that thermodynamics is universal: everything will approach equilibrium if we wait long enough. This is believed to be true also for isolated quantum systems, where all local properties will eventually mimic thermal equilibrium at least for generic interacting many-body systems. Thus no such system should be able to avoid thermalization. In 2006 Basko et al. argued to the contrary and described a phenomenon now known as Many-Body Localization (MBL). They showed that interacting particles in highly disordered one-dimensional lattices localize in space, thus withstanding thermalization. MBL is not only interesting for fundamental reasons but could also provide a new approach for robust memories of quantum information. In the following years a lot of research established the physical picture of MBL as that of an emergent integrability. Here local constants of motion constrain the dynamics after a quantum quench leading to the characteristic features of MBL such as a logarithmic growth in time of the entanglement entropy between partitions and the absence of particle transport. In the talk I will report about numerical evidence and analytical work during the last few years which question this picture of the MBL phase. In particular we found evidence that the particles show a very slow sub-diffusive transport, meaning that the system does thermalize eventually.