Massachusetts Institute of Technology
Department of Physics

Condensed Matter Theory Seminar

"Phenomenology and mechanisms of Quantum many-body scarring"

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Abstract: A central postulate of statistical mechanics is ergodicity -- a generic interacting, quantum many-body system initialized out of equilibrium is expected to explore its allowed phase phase and eventually thermalize. Known exceptions to this behavior include strongly disordered, many-body localized (MBL) systems, and finely-tuned integrable systems. In this talk, I will discuss a different mechanism pertaining to a weak form of ergodicity breaking: Quantum many-body scarring (QMBS) [1]. Motivated by recent quench experiments with Rydberg atom arrays [2] which observed surprisingly slow thermalizing dynamics from certain simple initial states, QMBS is tied to the presence of special, eigenstate thermalization hypothesis (ETH)-violating eigenstates in the many-body spectrum. I will first discuss how a variational description of the many-body dynamics seen in the experiments, using the time-dependent variational principle (TDVP) over a manifold of entangled matrix-product states, can capture this non-thermalizing dynamics and furthermore provide some insight into the connection to the similarly named phenomenon of quantum scars in single-particle chaos in terms of isolated, unstable, periodic orbits [3]. I will also discuss a complementary approach in which the scarred states can be understood as arising from an embedded su(2) symmetric subspace [4]. More generally, I will discuss physical mechanisms giving rise to QMBS in other settings that can be analytically understood, such as the idea of embedded Hamiltonians [5] and the dynamics of virtual entangled pairs [6].

[1] Nat. Phys. 14, 745–749 (2018)
[2] Nature 551, 579–584 (2017)
[3] Phys. Rev. Lett. 122, 040603 (2019)
[4] Phys. Rev. Lett. 122, 220603 (2019)
[5] Phys. Rev. Lett. 119, 030601 (2019)
[6] arXiv:1910.08101

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