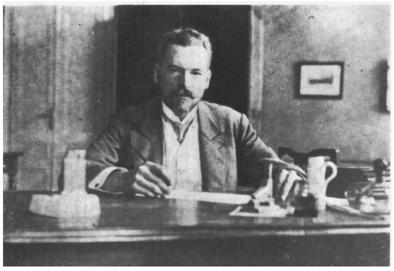

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A Deeper Look into Many-Body Localized Phases: Ergodic Bubbles and Correlation Function Differences

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We present two approaches to explore the dynamics of many-body localization (MBL) in disordered interacting quantum systems using experimentally measurable single- and two-site correlation functions.

First [1], we propose an algorithm based on neural networks that uses two-site correlation functions to detect ergodic bubbles, i.e., delocalized regions surrounded by a localized phase, with a spatial and temporal resolution. In the MBL regime, we observe that ergodic bubbles grow in size logarithmically with time and their size distribution follows an exponential decay. In the ergodic phase, the bubble size distribution is a power law. This supports the scenario of delocalization through an avalanche mechanism, providing insights into the thermalization mechanisms of disordered many-body systems.

Second [2], we introduce a correlation function difference (CFD) based on local density correlations in a one-dimensional spin system. By studying CFD in ergodic, Anderson, and MBL regimes of a disordered XXZ spin chain, we analyze the dynamics of information transfer. In the ergodic phase, CFD propagates faster than spin transport but slower than the limit dictated by the Lieb-Robinson bound. In localized cases, we observe exponentially slow relaxation of CFD. The connections between CFD and other observables detecting non-local correlations are discussed.

[1] T. Szołdra, P. Sierant, K. Kottmann, M. Lewenstein, J. Zakrzewski, Phys. Rev. B 104, L140202 (2021)

[2] T. Szołdra, P. Sierant, M. Lewenstein, J. Zakrzewski, Phys. Rev. B 107, 054204 (2023)

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