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Title: POLFED - a new diagonalization approach to study non-equilibrium phenomena: application to many-body localization

Abstract: I will introduce polynomially filtered exact diagonalization method (POLFED) of computing eigenvectors of large sparse matrices at arbitrary energies - a task that often arises when studying non-equilibrium phenomena in quantum many-body systems. The algorithm finds an optimal basis of a subspace spanned by eigenvectors with eigenvalues close to a specified energy target using a high order polynomial of the matrix. The memory requirements scale much better with system size than in the state-of-the-art shift-invert approach, while the total CPU time used by the two methods is similar. Also, the performance of POLFED is not severely impeded when the the number of nonzero elements in the matrix is increased allowing to efficiently study models with long-range interactions.

I will demonstrate the potential of POLFED examining many-body localization (MBL) transition in 1D interacting quantum spin-1/2 chains. Spectral statistics encode Thouless and Heisenberg time scales whose ratio determines whether the system is chaotic or localized. Similarities in the scaling of the Thouless time with the system size and disorder strength in one-body Anderson models and in disordered quantum many-body systems suggest a slowing-down of dynamics at large disorder strengths in many-body systems but access to small system sizes only prevents one from reaching unambiguous conclusions about MBL transition. This is further supported by system size dependence of bipartite entanglement entropy and of the gap ratio which highlights the importance of finite-size effects in the system. Possible scenarios regarding the MBL transition along with estimates for the critical disorder strength will be discussed. Finally, I will present results regarding MBL in highly constrained one-dimensional quantum spin chains. The increase of Hilbert space dimension with system size is slower than in the usually considered spin-1/2 chains which allows to investigate considerably larger system sizes.

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[3] P. Sierant, G. Giudici, E. Gonzalez Lazo, M. Dalmonte, A. Scardicchio, J. Zakrzewski, in preparation

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