Random sparse Hamiltonians and quantum advantage

Joel Tropp
Caltech, USA
jtropp@caltech.edu

This talk introduces a simple and elegant random matrix ensemble, called a sparse random Hamiltonian. This model contains very little randomness, yet the spectrum is close to the semicircular distribution. A quantum computer can reliably produce a low-energy state of this type of random Hamiltonian, while it is unlikely that the same task is tractable for a classical computer. As a consequence, this ensemble provides evidence of a potential "quantum advantage".

The proof of these claims involves new tools from nonasymptotic random matrix theory. In particular, a novel application of the Lindeberg principle yields a comparison between the sparse random Hamiltonian and a GUE matrix. The talk focuses on the probabilistic aspects and proof ideas, and no prior knowledge of quantum computation is assumed.

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