Quantum complexity beyond entanglement: magic of many-body states

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Abstract: Remarkable quantum computing experiments have demonstrated first building blocks of error correction. This motivates a new viewpoint on complexity, based on the corresponding error-correction-related resource-magic. I will present our recent findings on many-body magic

Quantum resources have entered the many body stage over the last two decades. It is by now widely appreciated that entanglement plays a key role in characterizing physical phenomena, as diverse as topological order and critical behaviour. However, entanglement alone is not informative about state complexity, and in fact, it is only one side of the medal. In this talk, I will flip the coin and tackle quantum state complexity of many-body systems under the lense of non-stabilizerness - also known as magic. Magic quantifies the difficulty of realizing states in most error corrected codes, and is thus of fundamental practical importance. However, very little is known about its significance to many-body phenomena.

I will present method(s) to measure magic in tensor network simulations [1,2], and illustrate a series of applications to many body systems, including: (a) how state magic and long-range magic behave in conformal field theories - illustrating the limit of the former, and the capabilities of the latter [2]; (b) how magic characterizes phases of lattice gauge theories, both in the context of spin liquids/error correction (toric code), and in the context of theories describing coupling between matter and light (Schwinger model) [2,3]; and (c) how the corner of Hilbert space represented matrix product states is in fact chopped into different complexity blocks, once magic is properly taken into account [4,5].

Finally, I will discuss the broader impact of these findings on state complexity - indicating that realizing generic state quantum dynamics may require a very large amount of resources in error correcting quantum computers, but at the same time, providing interesting perspectives on new classes of variational states more powerful than tensor networks.

Example References

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