A smallest computable entanglement monotone and the practical detection of entanglement

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Entanglement is the key feature of quantum mechanics that renders it different from a classical statistical theory. Given the central role entanglement plays in quantum information science and in quantum many-body physics, it is no surprise that over the years, many conceptual tools of quantifying it and methods of actually experimentally measuring it have been devised. In this talk, we will report progress along both lines of thought. In the first part, we will address a question from the theory of formal entanglement quantification as such. The Rains relative entropy of a bipartite quantum state is the tightest known upper bound on its distillable entanglement - which has a crisp physical interpretation of entanglement as a resource - and it is efficiently computable by convex programming. It has not been known to be a selective entanglement monotone in its own right. In this work, we strengthen the interpretation of the Rains relative entropy by showing that it is monotone under the action of selective operations that completely preserve the positivity of the partial transpose, reasonably quantifying entanglement. That is, we prove that Rains relative entropy of an ensemble generated by such an operation does not exceed the Rains relative entropy of the initial state in expectation, giving rise to the smallest, most conservative known computable selective entanglement monotone [1]. In the shorter second part, we will see how known quantum dynamics or quantum circuits - often of a random nature - and simple, feasible measurements allow for experimentally obtaining a wealth of meaningful entanglement signatures [2-4], a mindset that can be extended to the estimation of entanglement entropies in tensor networks using frames or one-designs [5].

[1] arXiv:2201.00835 (2022).
[2] Phys. Rev. Lett. 127, 090503 (2021).
[3] arXiv:2110.13178 (2021).
[4] Nature Rev. Phys. 2, 382-390 (2020).
[5] arXiv:2202.04089 (2022).