Abstract Submitted
for the MAR15 Meeting of
The American Physical Society

Power law violation of the area law in quantum spin chains RAMIS MOVASSAGH, Northeastern Univ. / MIT, PETER SHOR, MIT, Mathematics —

The sub-volume scaling of the entanglement entropy with the system's size, n, has been a subject of vigorous study in the last decade. The area law provably holds for gapped one dimensional systems and it was believed to be violated by at most a factor of log(n) in physically reasonable models such as critical systems. We first describe and then generalize our earlier spin-1 model [PRL 109, 207202 (2012)] to all integer spin-s chains, whereby we introduce a class of exactly solvable models that are physical yet violate the area law by a power law [arXiv:1408.1657 quant-ph]. The proposed Hamiltonian is local and translationally invariant in the bulk. We prove that it is frustration free and has a unique ground state. Moreover, we prove that the energy gap scales as n^{-c}, where using the theory of Brownian excursions, we prove $c \geq 2$. This rules out the possibility of these models being described by a conformal field theory. We analytically show that the Schmidt rank grows exponentially with n and that the half-chain entanglement entropy to the leading order scales as $\sqrt{n}$. Lastly, we introduce an external field which allows us to remove the boundary terms yet retain the desired properties of the model.

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Date submitted: 13 Nov 2014 Electronic form version 1.4