Quantum Physics

Ground State Entanglement in One Dimensional Translationally Invariant Quantum Systems

Sandy Irani

(Submitted on 8 Jan 2009)

We examine whether it is possible for one-dimensional translationally-invariant Hamiltonians to have ground states with a high degree of entanglement. We present a family of translationally invariant Hamiltonians {H_n} for the infinite chain. The spectral gap of H_n is Omega(1/poly(n)). Moreover, for any state in the ground space of H_n and any m, there are regions of size m with entanglement entropy Omega(min{m,n}). A similar construction yields translationally-invariant Hamiltonians for finite chains that have unique ground states exhibiting high entanglement. The area law proven by Hastings gives a constant upper bound on the entanglement entropy for 1D ground states that is independent of the size of the region but exponentially dependent on 1/Delta, where Delta is the spectral gap. This paper provides a lower bound, showing a family of Hamiltonians for which the entanglement entropy scales polynomially with 1/Delta. Previously, the best known such bound was logarithmic in 1/Delta.

Comments:	22 pages
Subjects:	**Quantum Physics (quant-ph)**
Cite as:	**arXiv:0901.1107v1 [quant-ph]**

Submission history

From: Sandy Irani [view email]
[v1] Thu, 8 Jan 2009 20:28:40 GMT (45kb)

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