Entanglement and the Thermodynamic Arrow of Time

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(Submitted on 1 Feb 2010)

We discuss quantum entanglement in the context of the thermodynamic arrow of time. We review the role of correlations in entropy-decreasing events and prove that the occurrence of a transformation between two thermodynamic states constitutes a new type of entanglement witness, one not defined as a separating plane in state space between separable and entangled states, but as a physical process dependent on the local initial properties of the states. Extending work by Partovi, we consider a general entangled multipartite system that allows large reversals of the thermodynamic arrow of time. We describe a hierarchy of arrows that arises from the different correlations allowed in a quantum state and examine these features in the cont of Maxwell's Demon. We examine in detail the case of three qubits, and also propose some simple experimental demonstrations possible with small numbers of qubits.

Comments: 10 pages with 9 figures
Subjects: **Quantum Physics (quant-ph)**
Cite as: **arXiv:1002.0314v1 [quant-ph]**

Submission history

From: David Jennings [view email]
[v1] Mon, 1 Feb 2010 19:53:24 GMT (673kb)

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