Enhanced Heat-Bath Algorithmic Cooling

N.A Rodríguez-Briones[a], E. Martín-Martínez[a,c], and R. Laflamme[a,b,c]

[a]Institute for Quantum Computing, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada
[b]Institute for Quantum Computing, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada
[c]Perimeter Institute for Theoretical Physics, 31 Caroline Street North, Waterloo, N2L 2Y5, Canada

The field of quantum information has inspired new methods for cooling physical systems at the quantum scale, such as heat-bath algorithmic cooling. These methods not only provide fundamental insight into quantum thermodynamics, but they also give a practical means for improving the purity of quantum states. This purification is required for initializing qubits in most algorithms, and for providing a reliable low-noise supply of ancilla qubits that satisfy the fault-tolerance threshold for quantum error correction. In this talk, I will first review the basic ideas of algorithmic cooling and give analytical results for the achievable cooling limits in the conventional heat-bath version of the algorithm[1]. Then, I will show how the limits can be circumvented by using correlations. Specifically, in one algorithm we take advantage of correlations that can be created during the rethermalization step with the heat-bath[2] and in another we use correlations present in the initial state induced by the internal interactions of the system[3]. These two algorithms show how correlations can be used to improve cooling.

[1]Rodríguez-Briones and Laflamme, **PRL** 116 (17), 170501 (2016). (arXiv:1412.6637)
[2]Rodríguez-Briones et al., **NJP** 19 (11), 113047 (2017). (arXiv:1703.02999)
[3]Rodríguez-Briones et al., **PRL** 119 (5), 050502 (2017). (arXiv:1703.03816)