# Bypassing Shannon's Bound

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Cooling schemes for NMR and NMR quantum computing, based on unitary operations, have been devised, in the past, in order to increase spectral sensitivity of nuclear spins. Cooling the spins has many applications, for example it enables us to perform scalable of NMR quantum computing, as was shown by Schulman and Vazirani. However, their scheme and also an older scheme devised by Sørensen, are both bounded by Shannon's bound on entropy compression in a closed system. Meaning that in order to cool even a single spin to be close to a pure state, with reasonable error, one would need each molecule to have an enourmously impractical number of spins to begin with.

Algorithmic cooling is a method devised by Boykin, Mor Rowchodhury, Vatan and Vrijen (PNAS Mar'02) for initializing NMR systems in general and NMR quantum computers in particular. The algorithm recursively employs two steps. The first is an adiabatic entropy compression of the *computation qubits* of the system, this step is essentially similar to the methods devised by the above. The second step is an isothermal heat transfer from the system to the environment through a set of *reset qubits* that reach thermal relaxation rapidly. In this step the system is no longer closed, hence it is no longer bounded by Shannon's bound. An improved algorithm was suggested by Fernandes, Lloyd, Mor, and Roychowdhury.

To allow experimental algorithmic cooling, the thermalization time of the reset qubits must be much shorter than the thermalization time of the computation qubits. We added the paramagnetic salt Chromium Acetylacetonate to increase this ratio of thermalization times. An experimental demonstrating of non adiabatic cooling by thermalization and magnetic ion is currently performed by our group based on these results.