Artificial Intelligence Laboratory

Massachusetts Institute of Technology

Physics of Computation Seminar

Date: Wednesday, February 19, 1997
Time: Refreshments at 3:45pm
Talk at **4:00pm**
Place: NE43-518

Nuclear Magnetic Resonance Spectroscopy: an experimentally accessible paradigm for quantum computing

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We introduce a new physical mechanism that is capable of computation, namely Nuclear Magnetic Resonance Spectroscopy, or NMR. It is based on the fact that the spin 1/2 nuclei of each molecule in a liquid sample are largely isolated from the spins in all other molecules. This makes it possible to describe the state of the spins by a reduced density matrix of size 2^n, where n is the number of spins in one molecule, rather than 2^N where $N \approx 10^{23}$ is the total number of spins in the sample. It also effectively makes each molecule into an independent quantum computer, with a decoherence time of order seconds. Finally, by identifying a manifold of statistical spin states that transform like true pure states, we show that one can utilize quantum parallelism in weakly polarized macroscopic liquids. We call a computer based on these principles an Ensemble Quantum Computer, or EQC.

In this talk we present experimental results that show how this approach enables us to easily implement the usual controlled-NOT or quantum XOR gate on single states as well as on "coherent superpositions." We also describe an NMR pulse sequence that directly implements the universal Toffoli gate. Scaling these experiments to molecules with as many as ten inequivalent spins is straightforward. A variety of experimental difficulties, in particular the limited signal-to-noise of NMR experiments, make scaling much past ten spins challenging. Nevertheless, the availability of this experimentally accessible paradigm for quantum computing should be of considerable utility in further developing the theory and methods that will be needed to solve significant problems by either quantum computing, or by ensemble quantum computing.

This is joint work with David Cory, Amr Fahmy and Mark Price.

Host: Norm Margolus

This talk is part of a seminar series on adapting computers and computations to the constraints of, and opportunities afforded by, microphysics; and on the development and application of the physical theory of computation and information. If you would like to receive electronic notice of these seminars, send email to "poc@mit.edu."