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Dynamics of Entanglement in Large Quantum Systems: Our main effort has been directed to useful predictions of time evolution of non-separable entanglement in situations where many qubits or large Hilbert spaces are involved.

Three examples have yielded results already. They are complementary, all dealing with quantum information in very large systems. In the order we opened our examinations, they are

- (1) bi-photon entanglement in down conversion, where the Hilbert space is continuously infinite-dimensional (PRL with C.K. Law and Ian Walmsley);
- (1) qubit-qubit dynamics on a lattice of N qubits, in the large- N limit, using exact results from the Heisenberg spin chain field theory model (PRB with student Jeff Pratt);
- (3) photon-atom entanglement and quantum memory binding, where the ease of detection of the atom and the ease of transmission of the photon make an attractive "cross-platform" example (PRL with C.K. Law and student Cliff Chan).

Highlights of results:

- (3) Potentially the most interesting, and an immediate focus for further exploration. The discovery that entanglement (more specifically, quantum memory) has an interpretation as a physical "binding force" must be extended. The "exchange force" of the Pauli Principle is a special case of this more general effect existing between any pair of particles or even whole quantum systems.
- (2) The decoherence over time arising from nearest neighbor cross-talk in quantum qubit arrays is not exponentially rapid.
- (1) The number of "information eigenmodes" can be counted (and is often a very small integer) even for a continuous Hilbert space, giving a reliable measure of information capacity.

Dr. Jin Wang, a new CQI postdoc, has joined the effort to exploit better understanding of the role of dimensionality in raising or lowering decoherence rates. One goal is to obtain a working theoretical model that will clearly distinguish global decoherence decay from local relaxation, an open issue of importance to all proposed large-scale qubit arrays. She is just beginning to extend the random-environment approach of Albrecht in order to incorporate realistic environmental temperature and to determine the effect of increased dimension on decoherence-free subspaces.