A Quantum Information Processing Initiative

The field of quantum information processing has created a great deal of interest all over the world because it has within it the potential to solve two outstanding problems that plague present information technology: (i) it can provide unconditional security for e-commerce and information exchange; (ii) it promises solution of optimization problems that cannot be solved using classical computers. Quantum computing promises to be the basis of the next advance in information processing and quantum computing theory is more powerful than classical computing theory. Recognizing its importance, quantum information processing was listed as one of the research areas in the recent IT initiative funded by the NSF.

LSU has current expertise in quantum algorithms and in theoretical quantum mechanical studies that are basic to the study of structures that will make quantum computing possible. These studies on quantum interference and superposition and quantum entanglement are also of great interest for quantum or phase control of various processes. Although this area may not lead to applications in the short term, it is an important area of research that has the potential to make major impact on the direction of information technology research.

The study of arrangements of computing elements that provide enormous speedup over classical computing schemes is one important topic in this field. Preliminary research has led to the proof of the concept. The door has been opened to entirely new way of looking at distributed computing at the most elementary level in terms of nanostructures.

It is normally understood that in classical systems if the error rate is smaller than a certain value, the error-correction system will correct it. In the quantum error-correction systems, this important criterion is violated. Only certain specific errors are corrected, others even if smaller, are not. Since the proposed models are based on a local error model while real errors are nonlocal, these codes are not capable of completely correcting small errors that cause new entangled component states to be created.

Nonlocality, related both to the evolution of the quantum information system and errors, defines a context in which error-correction based on syndrome decoding will not work. How should error-correction be defined then? It appears that a new approach through a system akin to associative learning in spin glasses must be considered.

Another area lies in already-extant research at LSU in the domain of atomic and optical physics. Intense and short-pulse (ultrabroad bandwidth) lasers and entangled states of Rydberg atoms are widely regarded as possible components of the hardware of quantum computing. The huge number of states in such atoms that can be entangled for purposes of computing or control makes these systems interesting and are cureently under active investigation here.

We envisage research at LSU in the fields of quantum computing algorithms, quantum communications and cryptography, Rydberg atoms and their coupling to short-pulse lasers or other nanostructures that can support quantum computing.

This initiative will be best managed as an interdepartmental effort. A faculty cluster of four would be required. For physical experiments, a quantum information processing lab will have to be funded.