

# Quantum error correction in solid state processing

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(PhysOrg.com) -- "Liquid state Nuclear Magnetic Resonance (NMR) has been successful for quantum information processing," Osama Moussa tells *PhysOrg.com*. "However, there are some questions about scalability and other issues. There are thoughts that maybe solid state NMR could overcome some of these problems."

In order for solid state quantum [information processing](#) to work, though, the ability to perform [error correction](#) would be required. Moussa, a scientist at Waterloo University in Ontario, Canada, worked with Jonathan Baugh, Colm A. Ryan and Raymond Laflamme to test a method of quantum error correction in a solid state information processing system. The results of their work can be found in [Physical Review Letters](#): "Demonstration of Sufficient Control for Two Rounds of Quantum Error Correction in a Solid State Ensemble Quantum Information Processor."

"People have looked at some ideas for controlling liquid state in quantum information processing, and proposed similar ways to control a solid state system," Moussa says. "We took the idea of emulating a [liquid state](#) processor by having an ensemble of molecules. Each has a string of nuclei acting as qubits."

Moussa explains that, unlike a liquid state system, there isn't the same amount of motion in a solid state system. "With a solid state system, you don't have motion so you can put molecules farther away from each other, and have a buffer," he says.

The team at Waterloo University used a single crystal malonic acid for their system. “Molecules with three carbon-13 nuclei provide the magnetic states that you can control,” Moussa says. “We call them the processors. We also include buffers of the same compound, but with carbon-12 instead of carbon-13. That way there is no interaction between the processors.”

“It’s similar to a liquid state [NMR](#),” Moussa continues, “but it works better for quantum processing. It has bigger couplings, and hence faster times for gates. Additionally, the solid state system has potential for higher polarization, and offers longer coherence times, which is important in quantum information processing.”

After preparing the solid state system, Moussa and his colleagues next needed to test the ability to perform error correction. Specifically, the group wanted to be able to accomplish two rounds of error correction. “The problem is that you need more definite states,” he says. “We have shown that, in principle, our system can reach highly definite states, but for the time being our system can’t reach very high definite states.”

One round of quantum error correction was possible, but the Waterloo team wanted to be able to do another round. “Instead, we came up with a way to measure as if we were doing it twice – but without having a definite state on the second round – and we showed that we have good enough control to perform two rounds,” Moussa explains. “This result offers evidence that this is a viable system in which you can implement quantum information processing with encoded states that are protected from natural noise.”

There is potential for hybrid [quantum information](#) systems, thanks to this result. “We’ve shown that there is the control possible to perform error correction in solid state systems where the information is encoded on nuclear spins,” Moussa points out. “One could envisage a variety of

hybrid systems with nuclear spins as the primary information carrier. As we get better at manipulating the states, and as we develop protocols for systems like these, [quantum information processing](#) as a field will benefit.”

**More information:** Osama Moussa, Jonathan Baugh, Colm A. Ryan, and Raymond Laflamme, “Demonstration of Sufficient Control for Two Rounds of Quantum Error Correction in a Solid State Ensemble Quantum Information Processor,” *Physical Review Letters* (2011). Available online: [link.aps.org/doi/10.1103/PhysRevLett.107.160501](http://link.aps.org/doi/10.1103/PhysRevLett.107.160501)

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