# Measuring single qubits

June 20 2006

“In a quantum system,” explains Alexander Korotkov at the University of California, Riverside, “the result of a measurement can change the system so that it moves in the same direction as the result.” Testing this idea that “our observation changes the direction of the system evolution” is one of the key components of a Letter published May 24th in *Physical Review Letters*.

The Letter, titled “Signatures of Quantum Behavior in Single-Qubit Weak Measurements,” is authored by Korotkov and two colleagues at Penn State: Rusko Ruskov and Ari Mizel.

“The idea of this paper was to come up with something similar to Bell inequalities, but for solid-state systems,” Korotkov explains to *PhysOrg.com*. John Bell’s famous theorem, that predictions of quantum mechanics differ from what is intuited, and his famous paper, “On the Einstein Podolsky Rosen Paradox,” have formed the basis for deriving various inequalities regarding quantum mechanics. Many inequalities assume that projective measurements can be performed on the system. However, practically applying such measurements in a solid-state system is difficult. Korotkov and his colleagues suggest that rather than using projective measurements, Bell inequalities could be used to test quantum systems using weak continuous measurements.

Testing quantum systems is important when it comes to developing the next generations of computer technology: creating quantum computers. “Before attempting to construct a device for quantum computing, it is important to verify that a candidate system actually exhibits rudimentary quantum behavior," Korotkov and his coauthors explain.

This is where Korotkov and his peers come in. Their system would possibly be a more practical way of distinguishing between a system that exhibits classical behaviors and quantum behaviors. The test proposed by Korotkov and his colleagues is one that makes use of quantum back action, a concept that many in quantum mechanics choose to ignore. "Such an experiment would prove that you can't explain this principle in terms of classical physics." Plus, using such a test would detect a system that "is required to evolve in the direction of the result, giving you information gradually." And a system that does that, a system affected by observation, is an indicator of a quantum system.

While such an experiment detecting these signatures of quantum behavior is possibly three to five years down the road, another experiment, using the same underlying idea, has already been performed by an experimental group from UC Santa Barbara led by John Martinis, and in collaboration with Korotkov. Its results were published in the June 9th issue of the journal Science. "This experiment," says Korotkov, "shows that the system remains coherent in a process of quantum collapse. This contradicts—or better to say—complements the concept of decoherence due to measurement, accepted in the solid-state community."

He explains that decoherence is the norm for ensembles of quantum systems, but not for individual qubits. The recent experiment, though on a completely different system than proposed in the *PRL* paper, has the same basic idea: that even in a solid-state, "the state remains pure through the whole collapse process." Additionally, "If you start with a mixed state, it becomes better and better known, which means purification of the state."

The key, though, is continuous measurement instead of projective measurement. “There are already such experiments in optics, but this one uses a solid state system. It is completely new in that community,” says Korotkov. And it can lead to a practical way to test quantum systems and determine which would make good candidates for quantum computing. “Our *PRL* paper isn’t a breakthrough,” says Korotkov. “But it is a step in our correct understanding of quantum mechanics.”

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Citation: Measuring single qubits (2006, June 20) retrieved 19 April 2024 from
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