# Qubit Noise Matters More Than Expected

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“What we have noticed,” J.H. Eberly tells *PhysOrg.com*, “is that noise is more important than it appears anyone expected. Widely understood, long-known features of the effect of noise on quantum systems fail to be true as soon as you take into account that a system has two distinguishable parts.”

Eberly, a physicist at the Rochester Theory Center for Optical Science and Engineering at the University of Rochester, continues: “We’ve been able to introduce to theoretical studies of noise an ‘entanglement lens’ that focuses very sensitively on features that arise only when a second part is identified within a system.” The results of these studies are canvassed in a Letter written by Eberly and his colleague Ting Yu. Titled “Quantum Open System Theory: Bipartite Aspects,” the Letter appears in *Physical Review Letters*.

Noise, Eberly explains, is generally of little interest in studies of quantum open systems because its effects are well understood. He says that open systems are, by definition, “open to influences from the world around,” as opposed to tightly controlled in experimental settings. “When open systems are weakly influenced by a whole bunch of uncontrollable and random forces,” Eberly says, “this is noise.” He continues to explain that noise “is usually innocuous, extremely weak, but always present.”

In a quantum open system with only one part, the effects of noise are under good control theoretically, and in agreement with experimental tests. Noise universally causes smooth degradation of coherence over time. But Eberly and Yu began considering something different with regards to quantum open systems. They decided to consider coherence degradation in quantum open systems made of two parts and focus on the two-part aspect. “It seems that physicists never thought to look at this before,” says Eberly. “Noise is so weak, so universal, you wouldn’t think it would matter.” But what Eberly and Yu found is that noise has unexpectedly different consequences when a two-part, or bipartite, quantum open system is considered. They found that while degradation is certainly still present when viewed through the “entanglement lens,” its surprising effect is termination of coherence abruptly rather than smoothly.

Their startling result comes from looking at a bipartite open system in terms of quantum entanglement. As Eberly explains, “When you look at a two party system through the ‘entanglement lens,’ you see new consequences of noise that are not present in standard open quantum system theory. It’s surprising and counter-intuitive, that by recognizing two parts, rather than one, noise has this unexpected effect.”

And, while nobody would be surprised by the fact that a two-part quantum system differs from a one-part system, studying its noise consequences by focusing on entanglement is not something that would normally be done. “Infinitesimal noise, usually completely ignorable, has effects no one would have predicted.”

Eberly and Yu’s Letter establishes their findings by making an example of the simplest of quantum systems, the qubit. Their proof concentrates on two qubits mutually entangled. They show how their work can lead to new open system effects, due to the fact that bipartite aspects of quantum information are different from, and not even found in, what is present in a single system — or even in a pair of classical systems.

Eberly poses this question rhetorically: “How much does this matter?” The answer: “We don’t really know yet. We’ve pointed out that it occurs, but how much it matters depends on the applications you use it for. And that's the stuff of future papers." Eberly invites discussion about his work, though. "It will be important to get reaction from the community in order to find out in which directions people can see the consequences more clearly," he says. "The open discussion on this topic has barely started."

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