A New Kind of Quantum Pump

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“We hope to apply quantum pumping to quantum computing architecture,” Ari Mizel, a professor at Penn State tells *PhysOrg.com*. In a world where scientists are striving to build quantum computing mechanisms and processes, various blueprints are on the table. And one of the integral parts of any quantum computing scheme is entanglement.

Along with his student Sungjun Kim at Penn State and his postdoctoral researcher Kunal Das, now an assistant professor at Fordham University, Mizel proposes a quantum pumping method of delivering entangled electron pairs for use in quantum computing. A method that provides electron pairs and eliminates the background noise associated with single electron transport. Their findings are published in a Letter titled “Controlled Flow of Spin-Entangled Electrons via Adiabatic Quantum Pumping,” in *Physical Review Letters*.

“Quantum pumping,” explains Mizel, “is a lot like swallowing. Electrons are in a channel, and as the walls deform periodically, it pushes stuff down.” Quantum pumping itself is not brand new, although the idea is a relatively recent development. Different experimental groups have been working with quantum pumping and use it to push charge or individual electrons with spin. What is different about the model of Kim, Das, and Mizel is that it would work by gathering paired electrons only, rather than “grabbing” single electrons and pumping them as well. Mizel’s team proposes a quantum pumping method that eliminates the transport of these single electrons that can provide background noise and increase decoherence.

“We worked out a way to grab a couple of carriers at a time by changing interactions between the carriers,” says Mizel. The channels that hold the electrons are contorted, and the oscillations force the electron pairs through, carrying entanglement. Mizel explains, “The energy of individual electrons is not changed by the contortions. There is a counterbalance, so the individual electrons don’t feel the change. The electron pairs, though, feel it and get mushed closer together. Then the oscillations force them down and through.”

This method would make it easier to eliminate non-entangled electrons. Right now, the background noise they create either has to be accounted for, or scientists attempt to catch and remove individual electrons. With this method devised by Mizel, Kim and Das, there would be no need to try to remove individual electrons; the carriers would just leave them behind, creating better entanglement. “There would be a stream of pairs, an individual electron will only feel contortion if it’s in proximity to a second electron. Then the carriers would be pushed down in groups.”

Mizel admits that right now, this idea is in the theoretical stage. “We try to talk to people at conferences, and we’re familiar with who’s been doing quantum pumping in the past. Hopefully we can get some interest in this.” And it shouldn’t be that difficult. While Mizel concedes that this method of quantum pumping would be challenging to instigate, he also points out that it is not far beyond current scientific capabilities. “This doesn’t require any bold, brand new technology,” he insists. “It’s not far outside the possibilities. It would be interesting to see what could be achieved by this method.”

Citation: Kunal K. Das, *et al.*, Controlled Flow of Spin-Entangled Electrons via Adiabatic Quantum Pumping, *Physical Review Letters*, 97, 096602 (2006)