Quantum computing, no cooling required

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It's a challenge that's long been one of the holy grails of quantum computing: How to create quantum bits, or qubits – the key building blocks of quantum computers - that exist in a solid-state system at room temperature. Most current systems, by comparison, rely on complex and expensive equipment designed to trap a single atom or electron in a vacuum then cool the entire system to close to absolute zero.

A group of Harvard scientists, led by Professor of Physics Mikhail Lukin and including graduate students Georg Kucsko and Peter Maurer, and post-doctoral researcher Christian Latta, say they've cracked the problem, and they did it by turning to one of the purest materials on Earth – diamonds.

Using a pair of impurities in ultra-pure, laboratory-grown diamonds, researchers were able to create quantum bits, and store information in them for nearly two seconds – an increase of nearly six orders of magnitude over the lifespan of earlier systems. The work, described in the June 8 issue of *Science*, is a critical first step in the eventual construction of a functional quantum computer, as well as a host of other potential applications.

"What we've been able to achieve in terms of control is quite unprecedented," Lukin said. "We have a qubit, at room temperature, that we can measure with very high efficiency and fidelity. We can encode data in it, and we can store it for a relatively long time. We believe this work is limited only by technical issues, so it looks feasible to increase the lifespan into the range of hours. At that point, a host of real-world applications become possible."

In addition to a practical quantum computer, Lukin envisions the system being used in applications that include "quantum cash" – a payment system for bank transactions and credit cards that relies on the coding of quantum bits to thwart counterfeiters – and quantum networks – a highly secure communications method which uses quantum bits to transmit data.

"This research is an important step forward in research toward one day building a practical quantum computer," said Kucsko, a graduate student working in Lukin's lab and one of two first authors of the paper. "For the first time, we have a system that has a reasonable time-scale for memory and simplicity, so this is now something we can pursue."

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