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UCSB Physicists Detect and Control Quantum States in Diamond with Light

Physicists at UC Santa Barbara have succeeded in combining laser light with trapped electrons to detect and control the electrons' fragile quantum state without erasing it. This is an important step toward using quantum physics to expand computing power and to communicate over long distances without the possibility of eavesdropping. The work appears online today at Science Express.

The research, led by David Awschalom, professor of physics, electrical and computer engineering, and director of UCSB's Center for Spintronics and Quantum Computation, and graduate student Bob Buckley, exploits an unusual property of the microscopic quantum world: the ability to combine things that are very different.

Using electrons trapped in a single atom-sized defect within a thin crystal of diamond, combined with laser light of precisely the right color, the scientists showed that it was possible to briefly form a mixture of light and matter. After forming this light-matter mixture, they were able to use measurements of the light to determine the state of the electrons.

Likewise, by separately examining the electrons, they showed that the electron configuration was not destroyed by the light. Instead, it was modified –– a dramatic demonstration of control over quantum states using light. "Manipulating the quantum state of a single electron in a semiconductor without destroying the information represents an extremely exciting scientific development with potential technological impact," said Awschalom.

Preserving quantum states is a major obstacle in the nascent field of quantum computing. One benefit of quantum information is that it can never be copied, unlike information transferred between today's computers, providing a measure of security that is safeguarded by fundamental laws of nature. The ability to measure a quantum state without destroying it is an important step in the development of technologies that harness the advantages of the quantum world.

Buckley, putting this research in perspective, said: "Diamond may someday become for a quantum computer what silicon is for digital computers today –– the building blocks of logic, memory, and communication. Our experiment provides a new tool to make that happen. "

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