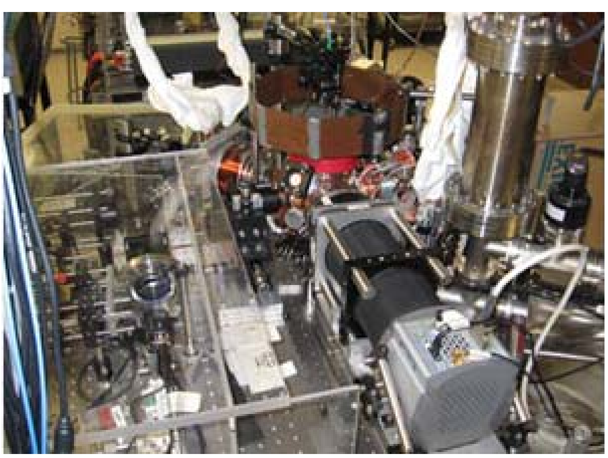
Excited Atoms Advance Quantum Computing

For decades, researchers have dreamed of harnessing the quirky power of quantum mechanics to solve impossibly difficult computation problems. Now a group of researchers, led by Mark Saffman at the University of Wisconsin-Madison, brings unprecedented computing power a step closer by showing that a single atom can control another atom. With this new technique, they hope to create working logic devices, similar to transistors in an electronic circuit, which could eventually be used in a quantum computer.

Atoms having electrons in highly excited states are known as Rydberg atoms. Theory has predicted that electrons in a Rydberg atom are so energized that they can interact with each other over a long distance, and this strong interaction would allow only one atom at a time to be in a Rydberg state—an effect called the Rydberg blockade. The research team demonstrated that one Rydberg atom can indeed block the excitation of a second Rydberg atom. Over a period of six years, the team learned to control and detect single atoms, built extremely stable lasers and optical systems, and got everything working together to test their concept.

This achievement provides the central element of a CNOT logic gate that would work with quantum bits of information, or "qubits." The researchers' next step will be to demonstrate an actual CNOT gate using the Rydberg blockade principle, and then scale up the system to work with a larger number of qubits. Their long-term goal is to create and study the properties of quantum mechanical entangled states of many qubits. The states may be used for simulating other quantum systems and for quantum computing tasks such as factoring and search.

End-on view of high numerical aperture custom lens system used to trap and image single atoms. Credit: Mark Saffman



Mark Saffman's laboratory, showing the vacuum chamber and camera used to detect single atoms. Credit: Mark Saffman

Urban, E., T. A. Johnson, T. Henage, L. Isenhower, D. D. Yavuz, T. G. Walker, and M. Saffman, "Observation of Rydberg blockade between two atoms" *Nature Physics* **5**, 110– 114 (2009), published online: 11 January 2009 | doi:10.1038/nphys1178

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