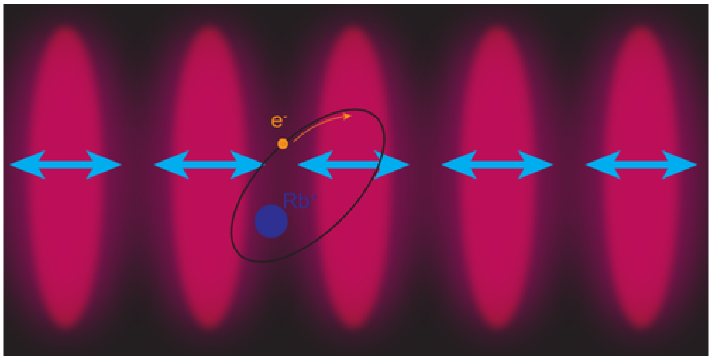
Shaken Atoms Change Quantum States

Oscillating an optical lattice of Rydberg atoms at the right frequency causes the atoms to make electronic transitions, which can be useful for quantum processing techniques.

By **David Ehrenstein**

Rydberg atoms—those that have a highly excited electron—could be useful for quantum computing and for quantum simulations because of favorable properties, such as long lifetimes. For these applications, researchers would like to trap the atoms in a one-dimensional (1D) lattice and manipulate each atom's quantum state with lasers. But laser-based methods for driving such quantum-state transitions have difficulty accommodating so-called odd-parity transitions, which are necessary for some types of quantum information processing. Now researchers have developed a way to induce both odd- and even-parity Rydberg transitions for atoms trapped in a 1D lattice [1], making the system more useful for quantum information processing.

For their demonstration, Ryan Cardman and Georg Raithel of the University of Michigan, Ann Arbor, trapped Rydberg atoms in a 1D optical lattice, which they created with two counterpropagating laser beams. They added a third beam whose phase they varied in order to slide the lattice back and forth along the direction of the lasers. They measured the quantum states of excited Rydberg atoms in the lattice as they varied the oscillation frequency.



Credit: R. Cardman/University of Michigan

Cardman and Raithel showed that when the transition frequency of the excited atoms was an integer multiple of the oscillation frequency, the atoms in the lattice could switch between Rydberg quantum states. The duo confirmed that the oscillating lattice was the source of the excitation by blocking one of the lattice lasers and showing that the spectral line attributed to the state switching disappeared. The resulting measured spectral line also matched the duo's simulations and expectations based on an alternative microwave irradiation approach.

David Ehrenstein is a Senior Editor for ***Physics Magazine***.

REFERENCES

1. R. Cardman and G. Raithel, "Driving alkali Rydberg transitions with a phase-modulated optical lattice," **Phys. Rev. Lett. 131, 023201 (2023).**