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Making custom qubits by pushing together two individual atoms

By **Leah Crane**

IT'S a tight squeeze. For the first time, researchers have made a molecule simply by pressing two atoms together and making them bond on command. Molecules built this way could be used to process information in quantum computers.

"We're building a new molecule by putting together individual atoms like blocks of Lego, rather than traditional chemistry where we just throw a lot of things together and hope for a reaction," says Lee Liu at Harvard University.

He and his colleagues pointed two laser beams, each controlling an ultracold atom of sodium or caesium, at the same spot. They then added a third laser, which bound the two atoms together.

The result was a single molecule of sodium and caesium, NaCs, which is highly asymmetrical because caesium is much bigger than sodium (*Science*, doi.org/cnb2). That lets the molecule rotate, making it potentially useful for quantum computing.

In quantum computers, information is stored in quantum bits, or qubits. A good qubit has two key qualities: it doesn't change its quantum state due to environmental noise, such as slight changes in temperature, and it can interact with other qubits. Those qualities are often in direct conflict.

Not so in this case, Liu says. If these custom molecules are made to rotate quickly, it is tough for environmental noise to change that rate of rotation. And their asymmetrical magnetic field makes them behave like tiny bar magnets, so they don't have to touch to exchange rotational energy.

"Put two molecules together that are rotating at similar speeds, and then they'll be able to affect each other's quantum states, and that's how you do the computing," Liu says. The molecules they have made aren't bound together strongly enough to be useful qubits yet. Liu says they hope to tighten the bonds by reducing vibrations in the system.

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