Researchers have created a new type of "ultracold" molecule, using lasers to cool atoms nearly to absolute zero and then gluing them together, a technology that might be applied to quantum computing, precise sensors and advanced simulations.

"It sounds counterintuitive, but you can use lasers to take away the kinetic energy, resulting in radical cooling," said Yong P. Chen, an associate professor of physics and electrical and computer engineering at Purdue University.

Other researchers have used the method to create cold molecules out of atoms of other alkali metals, which are relatively easy to turn into ultracold molecules. The Purdue researchers are the first to achieve the milestone with the alkali metals lithium and rubidium, in work led by Chen and Elliott.

If the molecules are heteronuclear there is a difference in electric charge between these two atoms and the molecule is said to be polar. This difference in charge is called a dipole moment, which enables interaction between molecules. The greater the dipole moment, the stronger the interaction.

The lithium-rubidium molecule is potentially ideal for various applications, including quantum computing, because it has a significant dipole moment, which can enable these molecules to be used as "quantum bits."

Quantum computers would take advantage of a phenomenon described by quantum theory called "entanglement." Instead of only the states of one and zero used in conventional computer processing, there are many possible "entangled quantum states" in between one and zero, dramatically increasing the capacity to process information.

"In quantum computing the larger the dipole moment the stronger the interaction would be between molecules, and you need that interaction," Elliott said. "They need to interact with each other in order to affect each other, the key to
Another potential advantage for the lithium-rubidium molecule is that it can be produced in large quantities.

"The rate of production is much greater for lithium-rubidium than for other bi-alkali-metal molecules," Chen said. "That was a pleasant surprise. It was already known that it has the third-largest dipole moment among bi-alkali-metal molecules, but nobody expected it would be made so efficiently."

Ultracold means temperatures less than about one thousandth of degree above absolute zero. Achieving such frigid extremes requires reducing the kinetic energy of molecules as well as their "internal excitation energies," which are stored in three ways: the rotation of the molecule itself, the vibrations of the atomic nuclei, and the movement of electrons in "shells" surrounding the nuclei. The combined energy of the trio is called rovibronic, a shortened version of rotational, vibrational and electronic.

"We are reporting a highly efficient production of ultracold lithium-rubidium molecules by photoassociation," Dutta said. "This provides the first step towards the production of such ultracold lithium-rubidium molecules in their ground, polar state."

Molecules in their "ground state" have the lowest possible rovibronic energy, which would make them more stable and easier to control.

A related research paper was also published by the team in January in the journal *Europhysics Letters*, a publication of the European Physical Society. That paper is available online at [http://iopscience.iop.org/0295-5075/104/6/63001/article](http://iopscience.iop.org/0295-5075/104/6/63001/article)

"Lithium rubidium is one of the last bi-alkali molecules to be made cold, and we are the first to do this," Chen said. "People knew virtually nothing about these molecules."

Ultimately, researchers are seeking more efficient methods for the production of ultracold molecules.
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