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Caught in a Trap of Light

Physicists have engineered a highly stable laser beam that can trap tiny clouds of atoms for up to 100 times longer than any laser so far could. Reported in the 24 May issue of *Physical Review Letters*, the new technique may be used to probe the properties of very cold, weakly interacting atoms.

For several years now, physicists have used both lasers and magnetic fields to slow rapidly moving atoms or molecules in their tracks so that they can cool down and stay close together. Magnetic traps have proved more stable; they can hold their quarry for minutes at a time, while atoms typically escape from laser traps after a few seconds. But magnetic traps only work for magnetic atoms, such as sodium and cesium, but not helium. Also, they catch just those atoms whose internal magnetic field is oriented in a specific direction. A highly focused laser beam, which traps atoms in an "energy well" created by its electric field, doesn't have those constraints. So physicist John Thomas of Duke University in Durham, North Carolina, and his colleagues are looking for ways to make laser traps last as long as magnetic ones.

Two years ago, the team concluded from mathematical models that "noise" in the laser equipment played a more important role in destroying the trap than previously suspected. Slight movements of the laser beam and fluctuations in its intensity jiggle atoms around and heat them up. In an attempt to minimize these problems, Thomas's group took a carbon dioxide laser--one of the most inherently stable ones around--and customized it to further reduce noise. When they applied the laser as a trap, they successfully held about 20,000 lithium atoms at a temperature just 0.0004 of a degree above absolute zero for 5 minutes.

"This is the most stable optical trap that has been demonstrated so far," says Wolfgang Ketterle, a physicist at the Massachusetts Institute of Technology. Ketterle says the trap may be useful for what many consider to be one of the most ambitious experiments in physics: to test the prediction that atoms such as lithium tend to pair up at very low temperatures, like electrons in a superconductor. Lithium atoms are very hard to bring close together, because they are fermions--the term for particles that can't occupy the same quantum state. But lithium atoms whose internal magnetic fields point in opposite directions may be easier to bring together, as their quantum states won't be identical. The use of laser traps seems a promising strategy to do this, Ketterle says.

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