Buffer gas cooling could open up the field of ultracold physics

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(PhysOrg.com) -- "Scientists have been making Bose-Einstein Condensates [BECs] for nearly 15 years," Charlie Doret tells PhysOrg.com. "Essentially all BEC research to date, however, begins with laser cooling. Unfortunately, laser cooling is impractical for some atoms, and it is especially difficult with molecules, limiting the scope of new research."

In order to create a more general method for producing ultracold atoms and molecules, Doret, a graduate student at Harvard University, worked with a team to develop a method of buffer-gas cooling that would work for many different atoms and even for many molecules. “Our process is more general than laser cooling,” he explains. Along with Colin Connolly and John Doyle at Harvard and Wolfgang Ketterle at MIT, Doret believes that their more widely applicable technique will enable creation of BECs with new atoms and molecules. Their work can be found in *Physical Review Letters:* “Buffer-Gas Cooled Bose-Einstein Condensate.”

To make BECs with ultracold atoms and molecules, an initial cooling and trapping stage is needed. The atoms or molecules in question are cooled to a point where they are moving slowly enough to be trapped. Once they are trapped they can be cooled further, leading to Bose-Einstein condensation. BECs are useful in a number of experiments, and have potential practical applications due to their similarities to laser light. “Unfortunately,” Doret points out, “laser cooling just doesn’t work well for some stuff.”

In laser cooling, photons are sent to bombard the atom in such a way that it eventually slows down, via a scattering process. Doret explains that this technique is similar to using golf balls to slow down a bowling ball. “It works eventually, but it takes a lot of photon scattering events to slow an atom, just as you would expect to use a great many golf balls to effectively slow a bowling ball.”

Instead of using lasers to slow down an atom, Doret and his peers opted for using a buffer gas. “We have a cold gas that we can bounce off of hot atoms. Collisions with this buffer gas cools the atoms, making them easier to magnetically trap, after which they can be further cooled until they Bose-condense."

For the current experiment, the Harvard and MIT team used cooled helium gas as a buffer to cool metastable helium atoms. “We have demonstrated the process from start to finish with atoms, but we haven’t done it with molecules. But the principle should be the same, and our next attempt will probably be to attempt to use buffer-gas cooling - with a few little tweaks - to create a BEC of the NH molecule.”

A general path to BEC with molecules would be a huge step forward for ultracold physics, Doret insists. “One big effect it could have is for the possibility of building a quantum computer. One way that has been suggested is to take polar molecules and trap them in an optical lattice, using the cold molecules as qubits. Due to the difficulty of laser cooling molecules, getting polar molecules into a lattice is a challenging but important step. Buffer-gas cooling could work, though.”

In the end, Doret believes that buffer-gas cooling could provide the means to experiment further with BECs and other subjects of interest. “Buffer-gas cooling allows us to use atoms and molecules not accessible in the past. There are new applications to pursue, and more tools that can be brought into play. This could open up the entire field of ultracold physics.”

More information: Doret, et. al. “Buffer-Gas Cooled Bose-Einstein Condensate,” Physical Review Letters (2009). Available online: http://link.aps.org/doi/10.1103/PhysRevLett.103.103005.

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