Bouncing atoms may be the key to the future of gravimetry

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(PhysOrg.com) -- When studying cold atoms, scientists often use magnetic or optical traps to keep the atoms in place. However, in some cases experimentalists want to study free atoms, avoiding the effects of a trap. "One way to study free atoms," Cass Sackett tells *PhysOrg.com*, "is by bouncing them off a surface... most of the time, the atoms are free." He says that scientists have been interested in bouncing atoms for a long time, but that before now only about five bounces have been achieved. "Using magnets and certain lasers, it is possible to bounce atoms. However, they are lost relatively quickly."

Sackett, a scientist at the University of Virginia in Charlottesville, and his colleagues, Hughes and Burke, have managed to construct a scheme in which they were able to get 100 bounces out of atoms. “We succeeded with finely tuned laser pulses,” Sackett explains. The Virginia team’s work can be seen in Physical Review Letters: “Suspension of Atoms Using Optical Pulses, and Application to Gravimetry.”

“There are a number of experiments done with falling atoms,” Sacket says. “We focus on the use of our bouncing scheme for measuring gravity, though.” Gravity can be measured very accurately using falling atoms, but it requires large equipment. “If you want to probe these atoms for precision measurements, you have let them fall a long way. The apparatus starts to get bigger and becomes awkward to handle. What are you going to do? You start talking about machines that are 10 meters tall so that you can drop atoms a longer way.”

Instead of building large measuring devices, Sackett and his peers propose using a more compact system using bouncing atoms. “You get similar effects, with the number of bounces involved, so you don’t need something that allows the atoms to fall a long way,” he says. “We rely on the fact that we can control lasers so well to set up a situation that might be able to replace falling atoms in experiments.”

While the team at the University of Virginia focused mainly on gravimetry applications, Sackett believes that this breakthrough could also be applied in other fields. “It might be used to improve atomic clocks and test for fundamental values of certain constants - constants like Planck’s constant.”

Sackett also sees potential for experiments that so far need to be done in space. “Since you can suspend atoms in a way, it’s sort of similar to the conditions in space, where nothing falls. For instance, in gravity, you can only get atoms so cold before our cooling techniques stop working. I think with bouncing, we could get much colder, to well below one nano-Kelvin. And it would be a lot less expensive than sending an experiment into space on a rocket.”

He is careful to underscore the fact that there is still a lot of work ahead to make the experiment work with the kind of precision they are hoping for. “Nothing new has to be developed,” Sackett says, “but we are working with different approaches to fine tune the process. There’s still quite a bit of work, but it looks promising, and we’ve taken the first steps.”

More information: Hughes, Burke and Sackett, “Suspension of Atoms Using Optical Pulses, and Application to Gravimetry.” *Physical Review Letters* (2009). Available online: link.aps.org/doi/10.1103/PhysRevLett.102.150403 .