A step closer to a practical atom laser

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"When doing precise measurements of any kind, it is important to be able to count something, such as photons coming by at any given time," Mattias Johnsson tells *PhysOrg.com*.

"But there is an uncertainty, since the number passing fluctuates. When the fluctuations are larger than the effect you are looking for, precise measurements are more difficult. For example, if the fluctuations in your signal due to underlying quantum uncertainty is 50 photons per second, and the effect you're looking for change the number you're measuring by 10 per second, you won't see the effect. What we have done is try to get rid of some of that uncertainty."

Johnsson, a scientist at The Australian National University in Canberra, and his coauthor, Simon Haine, believe that one way to reduce the uncertainty associated with measurements in atom lasers is to perform a technique known as "squeezing." However, creating a squeezing effect can be difficult. Johnsson and Haine have created models to show a way to get a squeezing effect though self-interaction of atoms using technology that exists now. Their findings can be found in "Generating Squeezing in an Atom Laser through Self-Interaction," which is published in *Physical Review Letters*.

"An atom laser makes use of atoms with special quantum properties rather the photons employed by a normal optical laser," Johnsson says. "This potentially allows for much more precise measurements, as well as measurements of effects that cannot be seen by an optical laser. Many of the things we do now with optical lasers, we hope to be able to do with atom lasers."

"Right now it is fair to say that an atom laser is more of a research tool," Johnsson concedes. "But in the 1960s, when optical lasers were first being used, the case was the same. But now there are all sorts of applications. We believe our work will lead to interesting applications for atom lasers."

And one of the steps toward that realization is discovering that squeezing can provide a steadier stream of atoms. "Squeezing allows you to shuffle uncertainty from one quality, such as velocity or motion, to another. You can't measure both as accurately as you want," Johnsson explains. "With squeezing, if you want to measure how many particles are passing at a given time, you can measure that more accurately at the expense of making something else — something you don't care about — less accurate."

Johnsson and Haine's idea was to find a simpler way to make the squeezing happen. Other scientists have tried to use squeezing with optical lasers, but it is very difficult. "The different properties of atoms actually makes it easier," Johnsson says. "Photons in a light beam don't interact with each other. Atoms are constantly bumping into each other. They naturally, through interaction, create the squeezing effect. We were surprised at how easy it works."

But that is where the difficulty begins. "Even though we don't have to do anything to facilitate the squeezing," Johnsson points out, "if you let it go on too long, the effect will break down. You have to be able to manipulate them in order to get the atoms in the beam to interact just enough." The next problem, he continues, will be actually measuring the squeezing effect. "We've come up with a scheme that allows us to create an atom laser for precise measurements, and the experiment should be easy to set up. But we need a detector."

Johnsson explains that detecting individual atoms is difficult, and that the biggest challenge will be counting them in order to verify the squeezing effect. He remains optimistic, though. “This is one of the major things the experimentalists in our group want to do in the next couple of years. We could be closer to a better atom laser.”