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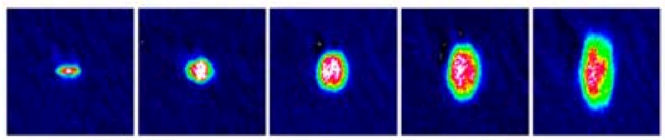
Photo finish in race for strontium condensate

Nov 18, 2009 1 comment



"An expanding field"

An Austrian group has beaten its US counterpart by a matter of days in a race to create a Bose-Einstein condensate (BEC) of strontium atoms.

Researchers at the Institute of Quantum Optics and Information (IQOQI) at the Austrian Academy of Sciences submitted their paper on a strontium BEC – a mass of ultracold atoms all in the same quantum state – just 10 days before those at Rice University in Houston, Texas. The breakthrough makes way for more precise quantum timekeeping and new studies of the quantum nature of matter.

"We have been in a race to get this done, and once some big unknowns were figured out a couple of years ago it was no mystery how to get here," says Rice University's Tom Killian, who adds that the IQOQI is "a great lab".

Rudi Grimm of the IQOQI says he and his colleagues learnt a lot from the Rice University group, but "were just quicker" with the final cooling stage.

A single state

Bose-Einstein condensation occurs when atoms of integer spin are cooled below a critical temperature. The atoms settle in the same quantum state and move coherently as though they are a single entity.

The first BECs were made in 1995 from alkali metal atoms, such as rubidium, which have one electron in their outer shell. Over the past few years BECs have also come made from atoms that have two outer electrons – ytterbium and more recently calcium. The real prize, however, is strontium – another atom with two outer electrons that has already proved very useful in extremely accurate optical clocks.

Two electron atoms are interesting because they have no magnetic moment in their ground state. This means that a BEC of strontium would not have to be shielded from stray magnetic fields – making it easier to use in applications such as an atom interferometer that could be used to detect tiny changes in the local gravitational field.

Breaking with convention

However, the conventional way of cooling atoms to create a BEC involves trapping them with a magnetic field, and then lowering the field's potential so the hottest atoms tend to collide with others and are ejected from the trap – a process called "evaporative cooling". Some researchers had found that lasers could perform both the trapping and evaporative cooling of non-magnetic atoms, but this has proven problematic.

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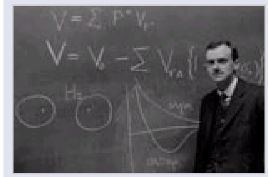

The trouble is related to the scattering length, which effectively marks the distance at which atoms collide. The most abundant isotope of strontium, Sr-88, has a very small scattering length, so the collision rate is too low and evaporative cooling fails. On the other hand, the next most abundant isotope, Sr-86, has a very big scattering length, so collisions occur among too many atoms.

The breakthrough of the two groups was to opt for a much rarer isotope, Sr-84, which has a scattering length somewhere between Sr-88 and Sr-86 – making it just right. The IQOQI group used it to create a BEC of about 1.5×10^5 atoms, while the Rice University group used it to create a larger BEC of 3×10^5 atoms.

“I think it is impressive how the field has matured and that we can now condense atoms which have small natural abundance, and which cannot be magnetically trapped in the ground state,” says Wolfgang Ketterle of the Massachusetts Institute of Technology, who won the Nobel Prize for Physics in 2001 for being one of the first to create a BEC. “The strontium experiment [has] demonstrated an amazing combination of advanced techniques.”

Robust and well defined

Strontium is advantageous because it forms fairly robust condensates that can last longer and be made larger. This makes it easier for studies of quantum degeneracy, in which atomic interactions are tuned, for example, to create novel quantum fluids. Another advantage is that it has several well defined electronic-transition frequencies, which makes it attractive as an atomic clock for more precise metrology studies.

Tilman Pfau, a physicist at the University of Stuttgart who used similar techniques to condense chromium five years ago, called the new work an “interesting” addition to the BECs of ytterbium and calcium. “What is maybe also interesting is that people talked about condensing strontium for years, and now within days two groups have achieved this goal almost simultaneously,” he adds. “Science is a nonlinear process.”

The strontium BECs comes hot on the heels of the first calcium condensate, which was reported in September by Sebastian Kraft and colleagues at Germany’s PTB metrology lab in Braunschweig. Kraft told *physicsworld.com* long term goal of the PTB team is to create an optical lattice of calcium atoms – in which each lattice site holds precisely one atom. Such a “Mott insulator” could in principle be used as part of an atomic clock that is extremely precise because individual atoms are isolated from each other.

The research is reported in three papers in *Physical Review Letters* (see restricted links).

About the author

Jon Cartwright is a freelance journalist based in Bristol, UK

1 comment

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1 **crnalas**
Nov 20, 2009 2:04 PM
Colne, United Kingdom

Zurich Airport, Chocolates, and an Atomic Clock

This takes me down memory lane. As a child I used to fly to and from Kenya for school holidays on the British Airway's 'Lollipop Express Flight'. The plane would often stop at Zurich Airport, which was probably intended as a treat for all the kids. We would marvel at all the mouth-watering chocolates on display in the departure lounge. One display that cought my attention was dedicated to time-keeping. All sorts of clocks, watches even sundials were on display, but the most fascinating object for me was a huge contraption, namely a fully working Atomic Clock....WOW!...Young minds are easilly impressed. Perhaps Zurich Airport may one day install a 'strontium condensate' Atomic Clock?..who knows?

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