Physicists find a way to study coldest objects in the universe

November 27 2013

They are the coldest objects in the Universe and are so fragile that even a single photon can heat and destroy them.

Known as Bose-Einstein condensates (BECs) and consisting of just a cluster of atoms, it has up until now been impossible to measure and control these remarkable forms of matter simultaneously.

In a new study published today, 28 November, in the Institute of Physics and German Physical Society's *New Journal of Physics*, a group of researchers from the UK and Australia have come up with a new way of measuring BECs by using a filter to cancel out the damage caused by the streams of light that are typically used to measure them.

Not only can the filter create a best estimate of the state of BECs by removing "noise" from the measurements, it can also use these measurements to actively feedback to the BECs and remove some of the heating based on what has already been observed.

It is hoped that once this theory is realised experimentally, researchers will be able to gather much more information about BECs and extend their use in fundamental science, such as in atom lasers to precisely measure gravity and as models to study the emission of Hawking radiation from black holes.

In the future, they may also be used by the military to detect submarines, underground bunkers and threats, and to also see through stealth technology.

Lead author of the study Michael Hush, from the University of Nottingham, said: "It's like trying to check if your refrigerator is still working but not wanting to let cold air out by opening the door.

"The smallest amount of heat can destroy a BEC and many of even the most up-to-date imaging devices end up destroying the BEC after a single image. Experimentalists have demonstrated that a BEC can be imaged non-destructively for a limited amount of time, but our work will allow them to be imaged for much, much longer – potentially indefinitely."

BECs are a cluster of atoms that are cooled until they are only 100 nano-Kelvin above absolute zero. At this temperature, the atoms lose their individual identity and behave as one macroscopic entity, almost like a superatom.

Because BECs are extremely cold, they have very little "noise" associated with them, so they are ideal for investigating physics that involves atoms – such as probing atomic structure – because they will exhibit very little interference.

The best way of measuring a BEC is to use off-resonant light, which tends to bounce off the atoms instead of being absorbed and thrown back out – this happens when resonant light is used. Off-resonant light has a very different wavelength to the one that would naturally be absorbed and emitted by the atoms, so it doesn't disturb the BEC as much as resonant light and makes it much easier to measure.

Off-resonant light can cause some spontaneous-emission, however, which induces heating and can destroy a BEC, so the researchers developed a filter and feedback to control this heating effect, resulting in a net cooling of the BEC.

Hush continued: "We've essentially created a window to look into the world's coldest fridge. By peering through this window, we hope that scientists can potentially view previously inaccessible phenomena related to BECs and begin to realise their potential applications."

More information: 'Controlling spontaneous-emission noise in measurement-based feedback cooling of a Bose-Einstein condensate' M R Hush et al 2013. *New J. Phys*, 15 113060. iopscience.iop.org/1367-2630/15/11/113060/article

Provided by Institute of Physics

Citation: Physicists find a way to study coldest objects in the universe (2013, November 27) retrieved 24 April 2024 from https://phys.org/news/2013-11-physicists-coldest-universe.html