Physicists devise means for observing single atom interference over coherence length

September 11 2012, by Bob Yirka

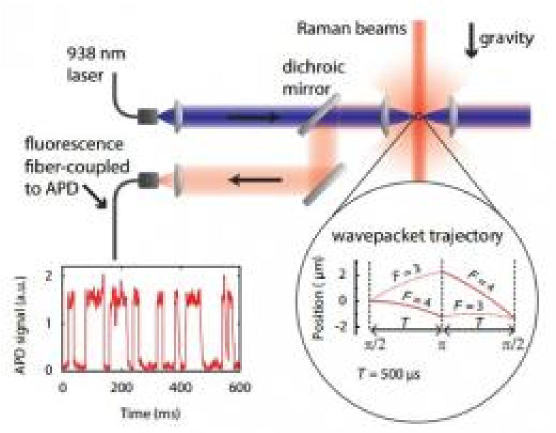

Diagram depicting the apparatus for observing a single-atom interferometer. A single atom is trapped in an optical tweezer. The florescence from the atom is coupled to an avalanche photodiode (APD) for detection, showing (bottom left) the two discrete levels of photon counts that are characteristic of collisionally blockaded loading of single atoms into an optical tweezer. A wavepacket trajectory is shown for an atom in free-fall under the influence of gravity and a light pulse atom interferometer sequence. Credit: arXiv:1208.4868v1 [physics.atom-ph]

(Phys.org)—Researchers at Sandia National Laboratories in Albuquerque, New Mexico have succeeded in observing the interference of a single atom over a distance far greater than its coherence length using lasers and sequences of light pulses. As they describe in their paper they've uploaded to the preprint server *arXiv*, it's the first ever such direct observance and opens the door to offering evidence of the existence of non-Newtonian gravity at the micron scale.

The research is based on previous work that has shown that a single atom can exist in a state of superposition (where the state of the atom is not known but is believed to exist in more than one at the same time) of two or more routes until a measurement is taken. Because of this it's possible to record an atom falling taking two different paths due to forces that cause a deviation.

To make this come about, the researchers caused a single caesium atom to become isolated after cooling using lasers and magnets. Then they directed the atom to where they wanted it to go using optical tweezers and finally shot it with another laser to cause it to exist in a predefined quantum state. Then, they let gravity take over by turning off the tweezers. As the atom fell, the researches directed pulses of light at it causing it to change its rate of descent; bumping it up or down slightly, creating an environment where two paths could be created. Another laser pulse caused the two paths to overlap at which point the optical tweezers were turned back on allowing for the atom's quantum state to be measured.

To measure the phase shift between the two paths that were created, the whole procedure was repeated several hundred times resulting in a measurement of gravitational forces at work on the atom. By adjusting the lasers the team was able to see a clear pattern of interference emerge, which as it turned out, was 200 times more than the atom's coherence length.

The researchers suggest that because the procedure involves just a single atom, it might be possible to use it to gain further insight into forces that exist between atoms and surfaces that are conductive. They add that with further refinement, i.e. greater precision, it might be possible to show that there exists non-Newtonian gravity at the micron level.

More information: Observation of Free-Space Single-Atom Matterwave Interference, arXiv:1208.4868v1 [physics.atom-ph] arxiv.org/abs/1208.4868v1

We observe matterwave interference of a single cesium atom in free fall. The interferometer is an absolute sensor of acceleration and we show that this technique is sensitive to forces at the level of $3.2times10^{-27}$ N with a spatial resolution at the micron scale. We observe the build up of the interference pattern one atom at a time in an interferometer where the mean path separation extends far beyond the coherence length of the atom. Using the coherence length of the atom wavepacket as a metric, we directly probe the velocity distribution and measure the temperature of a single atom in free fall.

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