Physicists present a non-destructive technique for measuring at the atomic scale

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Improving our understanding of the human brain, gathering insights into the origin of our universe through the detection of gravitational waves, or optimizing the precision of GPS systems- all are difficult challenges to master because they require the ability to visualize highly fragile elements, which can be terminally damaged by any attempt to observe them. Now, quantum physics has provided a solution. In an article published in *Nature Photonics*, researchers at the Institute of Photonic Sciences (ICFO) report the observation of a highly fragile and volatile body through a new quantum-mechanical measurement technique.

Researchers from the group led by Morgan Mitchell applied the so-called "quantum non-demolition measurement" to a tiny cloud of atoms. They were able to observe the spinning of the electrons in the atoms, and more importantly, the atom cloud was not disturbed in the process. It is the first time quantum non-demolition measurement has been demonstrated with any material object. The same method could be extended to permit the observation of individual atoms.

In the experiment, scientists prepared light pulses with photons in complementary states, and then sent them through the cloud of atoms, measuring their polarization on the way out. "A first measurement gives us information reflecting the action of the first light pulse. A second measurement, taken with photons in a complementary state from the first, cancels the influence of the preliminary pulse, allowing us to observe the original characteristics of the object," explains Dr. Robert Sewell, researcher at ICFO. This process has enabled the team to gather precise information on the magnetic field of the atom's surroundings.

The information obtained exceeds the so-called "standard quantum limit ", which quantifies the maximum amount of information obtainable with any traditional probing. Two achievements made this possible. On one hand, researchers were able to structure the observation so that the noise resulting from the visualization was shifted away from the object being measured and into a different variable. In addition, they introduced quantum statistical correlations among the atoms so that they were able to gather in one measurement what previously they needed a collection of measurements to observe. "This experiment provides rigorous proof of the effectiveness of quantum physics for measuring delicate objects" concludes Sewell.

More information: Certified quantum non-demolition measurement of a macroscopic material system, DOI: 10.1038/nphoton.2013.100

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