Lab-based dark energy experiment narrows search options for elusive force

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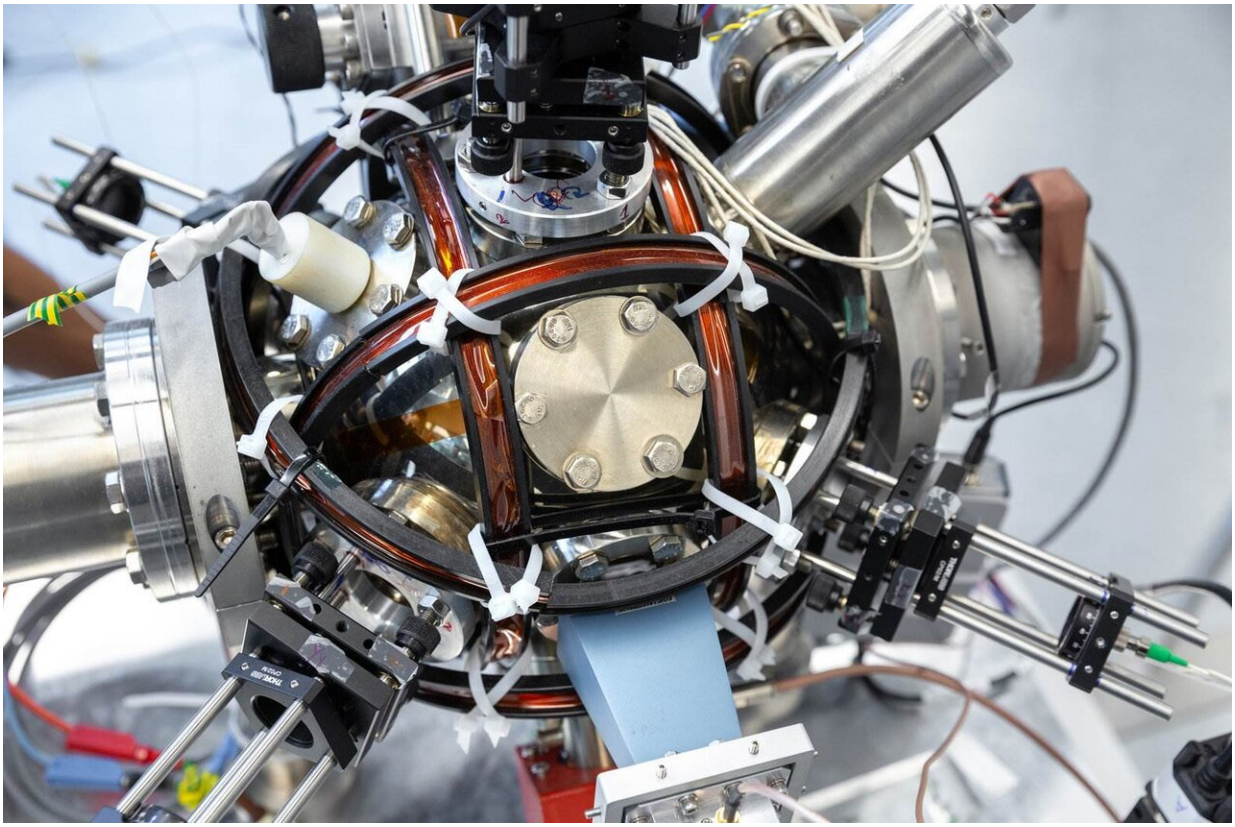

The atom interferometer. Credit: Imperial College London

An experiment to test a popular theory of dark energy has found no evidence of new forces, placing strong constraints on related theories.

Dark energy is the name given to an unknown force that is causing the universe to expand at an accelerating rate.

Some physicists propose dark energy is a 'fifth' force that acts on matter, beyond the four already known—gravitational, electromagnetic, and the strong and weak nuclear forces.

However, researchers think this fifth force may be 'screened' or 'hidden' for large objects like planets or weights on Earth, making it difficult to detect.

Now, researchers at Imperial College London and the University of Nottingham have tested the possibility that this fifth force is acting on single atoms, and found no evidence for it in their most recent experiment.

This could rule out popular theories of dark energy that modify the theory of gravity, and leaves fewer places to search for the elusive fifth force.

The experiment, performed at Imperial College London and analyzed by theorists at the University of Nottingham, is reported today in *Physical Review Letters*.

Professor Ed Copeland, from the Centre for Astronomy & Particle Physics at the University of Nottingham, said: "This experiment, connecting atomic physics and cosmology, has allowed us to rule out a wide class of models that have been proposed to explain the nature of dark energy, and will enable us to constrain many more dark energy models."'

The experiment tested theories of dark energy that propose the fifth force is comparatively weaker when there is more matter around—the

opposite of how gravity behaves.

This would mean it is strong in a vacuum like space, but is weak when there is lots of matter around. Therefore, experiments using two large weights would mean the force becomes too weak to measure.

The researchers instead tested a larger weight with an incredibly small weight—a single atom—where the force should have been observed if it exists.

The team used an atom interferometer to test whether there were any extra forces that could be the fifth force acting on an atom. A marble-sized sphere of metal was placed in a vacuum chamber and atoms were allowed to free-fall inside the chamber.

The theory is, if there is a fifth force acting between the sphere and atom, the atom's path will deviate slightly as it passes by the sphere, causing a change in the path of the falling atom. However, no such force was found.

Professor Ed Hinds, from the Department of Physics at Imperial, said: "It is very exciting to be able to discover something about the evolution of the universe using a table-top experiment in a London basement."

More information: D. O. Sabulsky et al. Experiment to Detect Dark Energy Forces Using Atom Interferometry, *Physical Review Letters* (2019). DOI: 10.1103/PhysRevLett.123.061102

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