Researcher accurately determines energy difference between two quantum states

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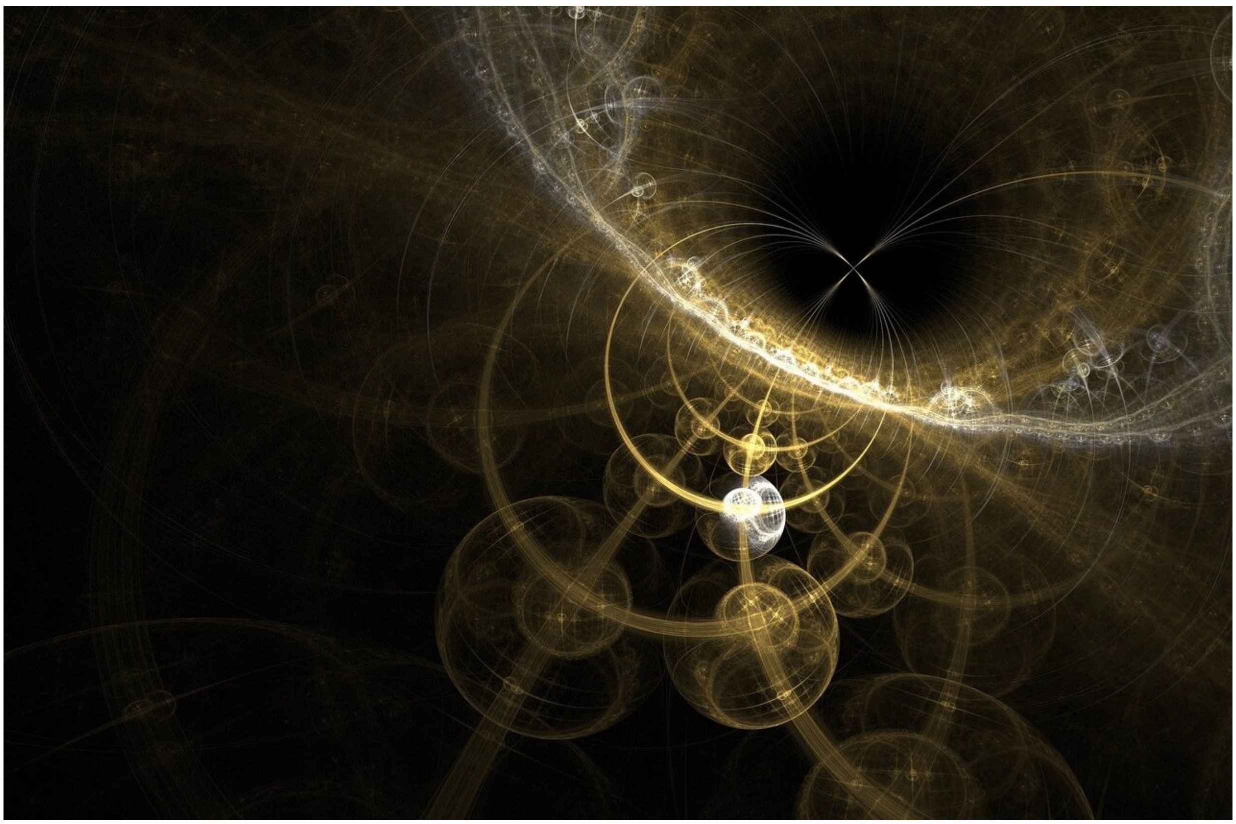

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A kiwi physicist has discovered the energy difference between two quantum states in the helium atom with unprecedented accuracy, a ground-breaking discovery that contributes to our understanding of the universe and space-time and rivals the work of the world's most expensive physics project, the Large Hadron Collider.

Our understanding of the universe and the forces that govern it relies on the Standard Model of particle physics. This model helps us understand space-time and the fundamental forces that hold everything in the universe in place. It is the most accurate scientific theory known to humankind.

But the Standard Model does not fully explain everything, for example it doesn't explain gravity, dark matter, dark energy, or the fact that there is way more matter than antimatter in the universe.

So scientists are continually testing the model by manipulating and controlling matter at the atomic level, looking for effects that cannot be explained directly. The research team's experiment involved the helium atom, the second-simplest atom after hydrogen.

The latest experiment, carried out by Dr. Maarten Hoogerland from the University of Auckland and the Dodd-Walls Centre for Photonic and Quantum Technologies and Dr. Wim Vassen from Vrije University in the Netherlands, was to test the helium atom's transition between two states of energy. This is sometimes referred to as a quantum jump, or leap.

This significant change in energy in the helium atom was precisely measured to estimate the diameter of the nucleus. This is done in an experiment that could fit on a table top with ultra-cold gas using an ultra-stable laser, accurate to a million times a million or, if you were using this level of measurement to measure the distance from Earth to the moon, it would be accurate to within a fraction of a millimetre.

"The fact the transition occurred is rare, and a milestone for quantum physics research. It advances our knowledge of the way atoms are put together and hence contributes to our understanding of space-time," Dr. Hoogerland says

"This new result is a great test for our understanding of the Model and also allows us to determine the size of the helium nucleus and of the helium atom. This has been the subject of intensive research for decades so for our experiment to have succeeded is an incredibly exciting result."

The Large Hadron Collider is the largest machine ever built and a major international project involving hundreds of scientists looking for effects that cannot be explained by the Standard Model directly and for new particles at very high energy that do not fit the model.

The research is published today in *Nature Physics*.

More information: R. J. Rengelink et al. Precision spectroscopy of helium in a magic wavelength optical dipole trap, *Nature Physics* (2018). DOI: 10.1038/s41567-018-0242-5

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