Solving one of nature's great puzzles: What drives the accelerating expansion of the universe?

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Credit: NASA

UBC physicists may have solved one of nature's great puzzles: what causes the accelerating expansion of our universe?

PhD student Qingdi Wang has tackled this question in a new study that tries to resolve a major incompatibility issue between two of the most successful theories that explain how our universe works: quantum mechanics and Einstein's theory of general relativity.

The study suggests that if we zoomed in-way in-on the universe, we would realize it's made up of constantly fluctuating space and time.

"Space-time is not as static as it appears, it's constantly moving," said Wang.

"This is a new idea in a field where there hasn't been a lot of new ideas that try to address this issue," said Bill Unruh, a physics and astronomy professor who supervised Wang's work.

In 1998, astronomers found that our universe is expanding at an ever-increasing rate, implying that space is not empty and is instead filled with dark energy that pushes matter away.

The most natural candidate for dark energy is vacuum energy. When physicists apply the theory of quantum mechanics to vacuum energy, it predicts that there would be an incredibly large density of vacuum energy, far more than the total energy of all the particles in the universe. If this is true, Einstein's theory of general relativity suggests that the energy would have a strong gravitational effect and most physicists think this would cause the universe to explode.

Fortunately, this doesn't happen and the universe expands very slowly. But it is a problem that must be resolved for fundamental physics to progress.

Unlike other scientists who have tried to modify the theories of quantum mechanics or general relativity to resolve the issue, Wang and his colleagues Unruh and Zhen Zhu, also a UBC PhD student, suggest a different approach. They take the large density of vacuum energy predicted by quantum mechanics seriously and find that there is important information about vacuum energy that was missing in previous calculations.

Their calculations provide a completely different physical picture of the universe. In this new picture, the space we live in is fluctuating wildly. At each point, it oscillates between expansion and contraction. As it swings back and forth, the two almost cancel each other but a very small net effect drives the universe to expand slowly at an accelerating rate.

But if space and time are fluctuating, why can't we feel it?

"This happens at very tiny scales, billions and billions times smaller even than an electron," said Wang.

"It's similar to the waves we see on the ocean," said Unruh. "They are not affected by the intense dance of the individual atoms that make up the water on which those waves ride."

Their paper was published last week in *Physical Review D*: https://journals.aps.org/prd/abstract/10.1103/PhysRevD.95.103504.

More information: Qingdi Wang et al, How the huge energy of quantum vacuum gravitates to drive the slow accelerating expansion of the Universe, *Physical Review D* (2017). DOI: 10.1103/PhysRevD.95.103504

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