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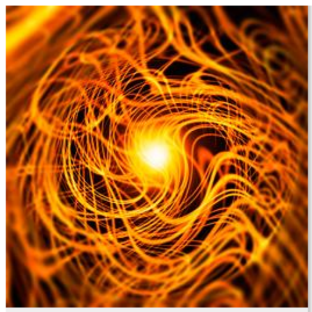
News

Gravity shows its helpful side

Theoretical study shows that the force can ease quantum calculations.

Geoff Brumfiel



Gravity is usually an obstacle to a theory of everything

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Gravity is unruly. It can throw theorists' equations into chaos, and has proved a stumbling block to the creation of a single 'theory of everything'. But an analysis now shows that gravity may at least make some fundamental calculations more manageable.

David Toms, a theoretical physicist at Newcastle University, UK, has found that gravity seems to calm the electromagnetic force at high energies. The finding could make some calculations easier, and is a rare case in which gravity seems to work in harmony with quantum mechanics, the theory of small particles. His paper is published today in *Nature*[1].

But don't get too excited: that elusive theory of everything is not just around the corner. Not everyone thinks that the calculations will stand up to scrutiny. Given physicists' "dicey" understanding of the relationship between gravity and other forces, it is too early to draw any deep conclusions, says Stanley Deser, a theoretical physicist at Brandeis University in Waltham, Massachusetts. Follow-up studies are needed to put Toms's calculations on solid ground.

Fundamental confusion

For decades, theoretical physicists have been able to explain the Universe in terms of four fundamental forces: the electromagnetic force, which causes electricity and magnetism; the weak nuclear force, which moderates some nuclear decays; the strong nuclear force, which binds quarks together inside atomic nuclei; and gravity. All except gravity have been incorporated into a 'standard model' of particle physics.

There are signs that an even more fundamental theory may be out there. At high energies, electromagnetism and the weak force merge into a single 'electroweak' force; and, at even higher energies, some as yet untested theories known as supersymmetry combine the electroweak and strong nuclear force. Theorists hope that the world's most powerful particle accelerator, the Large Hadron Collider near Geneva, Switzerland, will provide evidence for this combined strong and electroweak force.

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But gravity remains a stubborn holdout against efforts to create a theory of everything. The force is too weak at low energies to fit with the others, and it becomes too strong at high energies to be included in a single theory. Moreover, theories which attempt to describe gravity in quantum mechanical terms lead to nonsensical infinities in the equations. "That is a very serious problem," says Toms.

But Toms's equations have now shown that gravity can sometimes help, rather than hinder. He included a quantum formulation of gravity in a calculation of quantum electrodynamics (QED), a theory that describes how electrons interact with light particles, known as photons. The theory normally breaks down at high energies, because these interactions seem to grow far too strong to be calculated using conventional methods.

In Toms's work, gravity soothes the interaction, making the force between the electron and photon nearly zero at high energies (10^{15}–10^{19} GeV). This weakening of the force means that theorists can calculate the behaviour of high-energy electrons and photons after all. "What gravity seems to do is make things better for you," says Toms.

The future of the theory

There is still a lot of work to do, Toms warns. His calculations provide no basic insights into why gravity would weaken other forces. What's more, gravity itself is still likely to become uncontrollably strong at very high energies.

And many theorists are sceptical about whether Toms's calculations will bear close examination. "His mathematics could well be right, but I don't think his interpretation is," says John Donoghue, a theoretical physicist at the University of Massachusetts Amherst. Donoghue is concerned that when the method is applied to other interactions, involving different particles, it might yield a different answer. "The effects are not universal," he says. That would be a big problem for theorists, who want their methods to apply to everything equally.

Toms concedes that he "can't say for certain" whether his method will be universal. He now plans to take a second look at what happens to the strength of gravity at high energies, using the new approach. If gravity weakens like the other forces, theorists really might be closer to a theory of everything. Toms says that the calculations will be harder to do. But, he adds, "I think I know how to do it". ■

References

1. Toms, D. J. *Nature* **468,** 56-59 (2010). | Article | OpenURL