# Physicists clarify exotic force, but no 'Theory of Everything' yet

June 20 2005

The quest for a single theory that unites all of the universe's fundamental forces has thus far eluded physicists, but that has not stopped a team of them from clearing the way for nanotechnologists while they look for it. The group, which includes Purdue University's Ephraim Fischbach, has recently completed research that improves our understanding of how tiny objects placed very close together can influence each other. Their experiment, which involves the behavior of a minuscule gold ball as it moves over different substances, shows that gravity behaves exactly as Isaac Newton predicted, even at small scales.

Unfortunately for those in search of the so-called "Theory of Everything," the finding would seem to rule out the exceptions to his time-honored theories that physicists believe might occur when objects are tiny enough.

But in the process, the team has measured another, less familiar, force that does influence small objects, and at those scales is more influential than gravity itself. Their precise observations of this Casimir force could make life easier for nanotechnologists, whose tiny creations will be subject to its effects.

"We have measured the Casimir force with greater accuracy than has ever before been achieved," said Fischbach, who is a professor of physics in Purdue's College of Science. "Because this force can push small objects around, a clearer conception of its effects will be useful to the nanotech industry. Anyone creating a nanodevice will have to consider the Casimir force, just as a car manufacturer has to consider tire friction and air resistance."

Just as car designers want to minimize the effects of friction on their vehicles, the research team wanted to minimize the effects of the Casimir force, which is expressed as a powerful attraction between tiny objects that are separated by a few hundred nanometers, or billionths of a meter. Members of the team have published other papers on related research; for more details on how the Casimir force works, see the previous story online.

Their new paper, which appears in today's (Monday, June 20) issue of the scientific journal *Physical Review Letters*, represents a step forward not only in their measurement of the Casimir force, but also in their ability to see past it to the far fainter effects of gravity in the nanoworld, which team members believe could lead to far more profound knowledge about the universe.

"We're doing work that could have cosmological implications, but it rests on the behavior of objects too small to see with the naked eye," said Ricardo S. Decca, the assistant professor of physics at Indiana University — Purdue University Indianapolis (IUPUI) who designed the experiment. "Though measuring the Casimir force has practical value for today's nanoengineers, what we are trying to do is find out whether gravity behaves differently than we think it does if the scale is small enough. The trouble is that the Casimir force is so strong at that scale that it virtually drowns out gravity to the point where it is unobservable."

To solve the problem, the team placed a tiny sphere made of gold on the tip of a flexible cantilever, giving the impression of a ball on the end of a diving board. They mounted the cantilever on a mobile stand that could be moved from side to side. A few hundred nanometers beneath the sphere was a plate made of two different materials – gold on one side, germanium on the other – both of which were then covered in a very thin layer of gold.

Because the influence of the Casimir force is noticeable over distances of only a few hundred nanometers, its effect between the gold surfaces of the ball and the plate were equal regardless of which material lay beneath the gold layer. But because gravity can be observed over greater distances, the team was able to move the sphere back and forth over the plate, observing how far the cantilever bent over the two sections.

"Germanium has different mass than gold, so we knew the cantilever would bend further on one side than the other if gravity behaved as expected," Fischbach said. "The question was whether it would bend differently than Newton predicted because of some undiscovered exception to gravity's behavior on the quantum scale."

Such a variation, if seen, would have been a revolutionary discovery because it might have allowed physicists to perceive the relationship between large-scale gravity and the tiny quantum world of elementary charged particles, which has proven elusive.

"To this day, we still have to describe the behavior of the universe in terms of multiple forces – gravity, electromagnetism, and the strong and weak nuclear forces," Fischbach said. "Gravity often seems to be the odd force out because the others are primarily visible on the quantum scale. Connecting it with the quantum world is the holy grail of physics, and we hoped this experiment would give us a clue of how to do it."

No deviations from the expected behavior of gravity showed up in the experiment, but the team has plans to improve its methods to make even finer observations next time around.

"We are trying to improve our experiment so it will be a million times more sensitive than it is now, which is already far more sensitive over this distance scale than anything done before," Decca said. "We think that is feasible with our technique. If we do find deviations then, it will give us a lead into what direction to look for the Theory of Everything."

Until then, Fischbach said, the improved understanding of the Casimir force was an accomplishment that could assist both his group and more business-oriented researchers.

"Without compensating for the Casimir force, nanoparticles might clump together, nanogears might jam and adjacent nanowires might short out due to its attraction effects," he said. "This study will hopefully bring a useful piece of information to design labs all over the still-nascent nanotechnology industry. And since our team is working with such small tools, it will likely help us the next time we redesign our experiment."

In addition to Decca and Fischbach, the team consists of Daniel Lopez of Lucent Technologies, Dennis Krause of Wabash College and Chris Jamell of IUPUI. Their work was funded in part by the U.S. Department of Energy.

---

**ABSTRACT**

## Constraining New Forces in the Casimir Regime Using the Isoelectronic Technique

*R. S. Decca, D. Lopez, H. B. Chan, E. Fischbach, D. E. Krause, and C. R. Jamell*

We report the first isoelectronic differential force measurements between a Au-coated probe and two Au-coated films, made out of Au and Ge. These measurements, performed at submicron separations using

soft microelectromechanical torsional oscillators, eliminate the need for a detailed understanding of the probe-film Casimir interaction. The observed differential signal is directly converted into limits on the parameters alpha and lambda which characterize Yukawa-like deviations from Newtonian gravity. We find alpha is less than or equal to10^12 for lambda of approximately 200 nm, an improvement of approximately 10 over previous limits.

---

Source: [Purdue University](https://www.purdue.edu/) (by Chad Boutin)

Citation: Physicists clarify exotic force, but no 'Theory of Everything' yet (2005, June 20) retrieved 25 April 2024 from https://phys.org/news/2005-06-physicists-exotic-theory.html