Researchers see exotic force for first time

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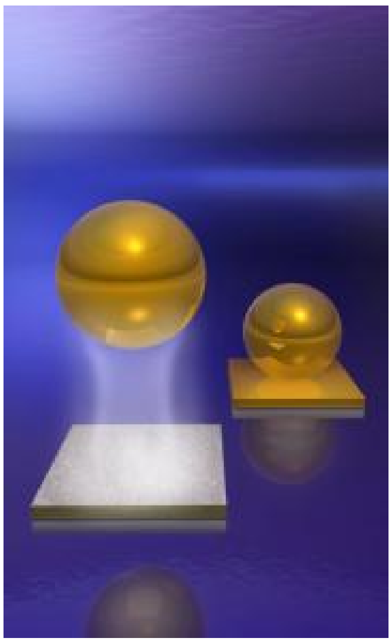

This is an artist's rendition of how the repulsive Casimir-Lifshitz force between suitable materials in a fluid can be used to quantum mechanically levitate a small object of density greater than the liquid. Figures are not drawn to scale. In the foreground a gold sphere, immersed in Bromobenzene, levitates above a silica plate. Background: when the plate is replaced by one of gold levitation is impossible because the Casimir-Lifshitz force is always attractive between identical materials. Courtesy of the lab of Federico Capasso, Harvard School of Engineering and Applied Sciences

(PhysOrg.com) -- For the first time, researchers have measured a long-theorized force that operates at distances so tiny they're measured in billionths of a meter, which may have important applications in nanotechnology as scientists and engineers seek new ways to create devices far too small for the eye to see.

The advance, by researchers by Harvard and National Institutes of Health (NIH) researchers, used a novel combination of materials to create a repulsive Casimir force, which pushes apart certain materials when separated by distances so tiny — between 20 nanometers and 100 nanometers — that they're nearly touching.

The force, which decreases in strength as the distance between the two materials increases, may provide a new means to build ultra-low friction and other nanoscale devices, such as new types of compasses, accelerometers, and gyroscopes.

"Repulsive Casimir forces are of great interest since they can be used in new ultra-sensitive force and torque sensors to levitate an object immersed in a fluid at nanometric distances above a surface," said Federico Capasso, Robert L. Wallace Professor of Applied Physics at Harvard's School of Engineering and Applied Sciences (SEAS), who led the study. "Further, these objects are free to rotate or translate relative to each other with minimal static friction because their surfaces never come into direct contact."

The results from Capasso's and his colleagues' work will be published in tomorrow's edition of the journal Nature. Capasso's co-authors are Jeremy Munday, formerly a graduate student in Harvard's Department of Physics and presently a postdoctoral researcher at the California Institute of Technology, and V. Adrian Parsegian, senior investigator at the NIH in Bethesda, Md.

The discovery builds on previous work related to the Casimir force, which was theorized by Hendrick Casimir in 1948 as both attractive and repulsive, pulling materials together under some circumstances and pushing them apart under others.

Until now, however, researchers have only been able to measure the attractive Casimir force, which, in some cases, has created headaches for nano-engineers because it can cause the components of tiny devices to stick together. Discovery of the repulsive version of the Casimir force can potentially help researchers overcome this problem.

“When two surfaces of the same material, such as gold, are separated by vacuum, air, or a fluid, the resulting force is always attractive,” explained Capasso.

Instead of using gold-coated materials, Capasso and colleagues swapped out one of the gold surfaces for one made of silica, then immersed them both in a liquid, bromobenzene. That combination did the trick, switching the attractive Casimir force to repulsive. The Harvard researchers have filed for a U.S. patent covering nanodevices based on quantum levitation.

Yale University Physics Professor Steve Lamoreaux, in an accompanying article in Nature, called the advance “pivotal for both fundamental physics and nanodevice engineering.” Though applications of the repulsive Casimir force in nanoscale devices have yet to be explored, Lamoreau said that “the prospects look exciting.”

Provided by Harvard University

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