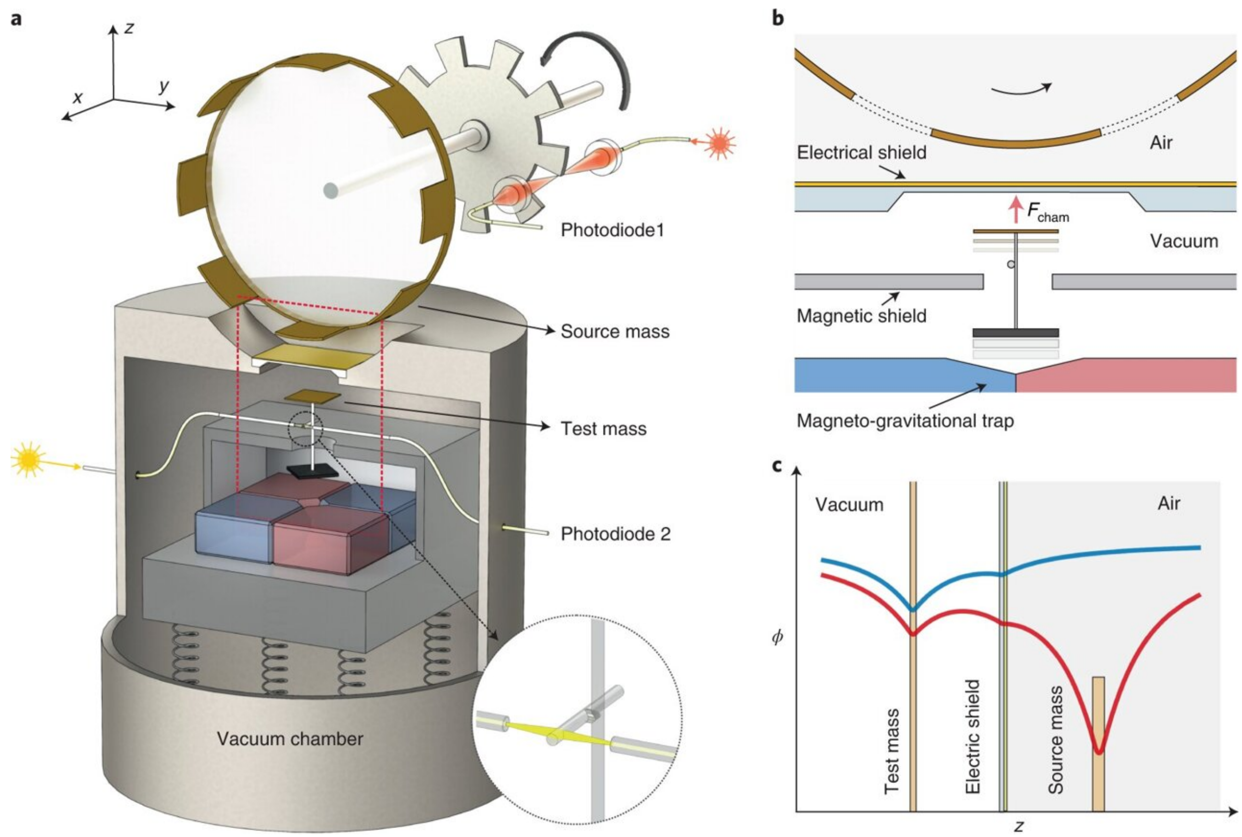
PHYS.ORG

Extended tests with levitated force sensor fail to find evidence of fifth force

August 26 2022, by Bob Yirka



Schematic of experiment. a, The 'fifth force' of the chameleon field is generated by eight thin films (source masses) of polyimide with thickness of 75 µm, spaced equally on a rotating plate. The force sensor consists of a piece of pyrolytic graphite, diamagnetically levitated in a magneto-gravitational trap and a 12.5-µm-thick film (test mass) of the same material as the source masses at the top supported by a glass rod. The magneto-gravitational trap is placed in a vacuum chamber with seismic noise isolation. The distance between the test mass and the source masses is 390 µm. The rotation of the source masses and the motion of the force sensor are monitored by optical systems, with the optical signals being detected by photodiode 1 and photodiode 2, respectively. The inset shows a schematic of the detection of the displacement of the force sensor. b, The rotating source masses generate a periodic 'fifth force' Fcham acting on the test mass. A thin electrical shielding window with thickness of 0.5 μm and a magnetic shield are used to screen the background electrostatic and magnetic forces. c, The field ϕ along the central z axis at two different rotation phases. The red and blue curves indicate the cases with and without a film of source mass above the test mass, respectively. The schematic is not to scale but for visibility. Credit: *Nature Physics* (2022). DOI: 10.1038/s41567-022-01706-9

A team of researchers from Nanjing University, working with two colleagues from the University of Science and Technology of China, has conducted new tests of the chameleon theory and report a failure to find any evidence of a fifth force. They have published their paper in the journal *Nature Physics*.

Prior research has suggested that there is a mysterious force acting on the universe—dubbed by theoretical physicists as dark energy, it was theorized as a way to explain why the universe is expanding at an accelerating rate. Despite much effort, no one has been able to prove that dark energy exists. One theory called the chameleon theory suggests that objects affected by gravity can behave in ways that fluctuate based on factors in their environment. The theory includes the idea of a chameleon field as a fifth force. The theory has been hotly debated because it directly contradicts the theory of general relativity, which states that gravitational forces are expected to be constant.

In this new effort, the researchers sought either to prove or disprove the theory using a levitated force sensor—a wheel-shaped device with plastic fins attached to it that spins past a thin film sitting atop a magnetically levitated piece of graphite. The base below the graphite is held up with springs. The goal is to test the idea that gravity exerts differing amounts of force depending on the density of objects in its vicinity. In a large context, the chameleon field would exert less force in a dense environment such as on an individual planet than it would over a large, less dense swath of space. If a fifth force exists, then the spinning films should exert a periodic force on the levitating film.

After running the experiment multiple times, the researchers failed to find any evidence of the spinning fins impacting the levitated film, which, they contend, rules out the chameleon theory as an explanatory candidate for dark energy. They also suggest their methodology highlights the need for robust, lab-based testing as a means of verifying or discrediting theoretical research. They suggest their methodology could also be used in other endeavors.

More information: Peiran Yin et al, Experiments with levitated force sensor challenge theories of dark energy, *Nature Physics* (2022). DOI: 10.1038/s41567-022-01706-9