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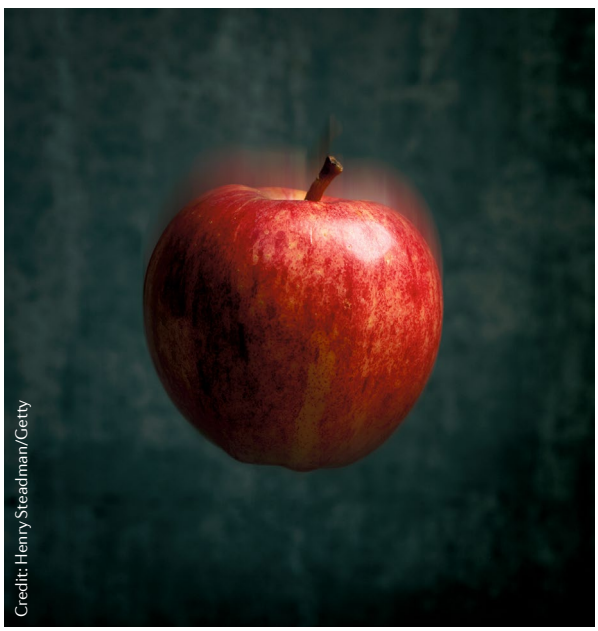
GRAVITY

Even at short range, Newton's law still rules

The $1/r^2$ distance dependence of gravitational attraction was formulated by Isaac Newton and is familiar to anyone who has taken an elementary physics class. However, new physics phenomena may modify the inverse square law — for example, string theory requires extra 'rolled up' gravitational space dimensions that would cause the inverse square law to break down at short distances. Measuring the distance dependence of gravity for objects with small separations would thus potentially reveal new physics, but is hard to do, because gravitational forces are weak and easily drowned out by noise. Writing in *Physical Review Letters*, Eric Adelberger and colleagues report the separation dependence of gravity between 52 μm and 3 mm, finding results consistent with Newton's law of gravitation and tightening the upper limit on the radius of hypothesized extra dimensions to 30 μm.



Credit: Henry Steadman/Getty

The principle behind the measurements is that a disc studded with holes suspended above a rotating disc, also studded with holes, will experience a torque that depends on the separation between the discs. The torque is tiny — of the order of a femtonewton-metre for discs separated by hundreds of microns — and experimental challenges include the accurate fabrication of the discs, minimizing electrostatic and magnetostatic effects, reducing noise from seismic vibrations and keeping dust out of the set-up.

Positioning the holes on each disc in patterns with both 18-fold and 120-fold azimuthal symmetry results in torque signals that vary at 18 and 120 times the rotational frequency of the lower disc. The torques decay exponentially with disc separation, with length scales set by both the range of the force that modifies Newtonian gravity and the symmetry numbers of the hole patterns. Thus, using patterns with two distinct symmetries effectively tests the inverse square law at two length scales simultaneously. Data fitting shows that in fact no modification is needed to Newtonian gravity for the separations tested, thereby constraining the possible strength and range of a modified gravitational interaction. These constraints in turn dictate parameters such as the size of extra dimensions arising in string theory.

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ORIGINAL ARTICLE Lee, J. G. et al. New test of the gravitational $1/r^2$ law at separations down to 52 μm. *Phys. Rev. Lett.* **124**, 101101 (2020)