Test of wave function collapse suggests gravity is not the answer

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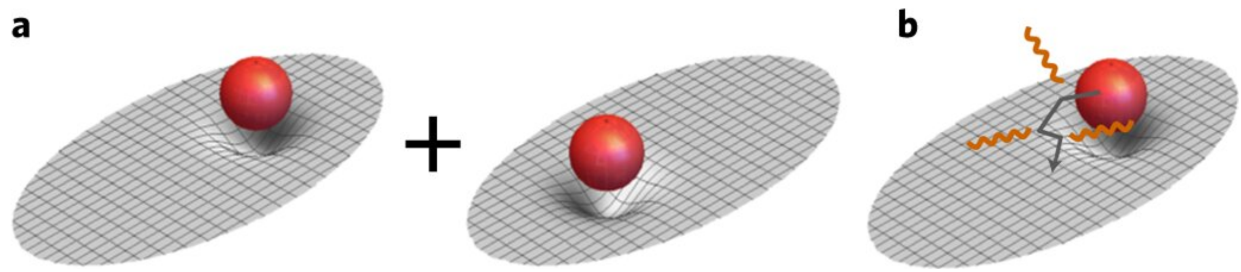

The Diósi–Penrose (DP) model of gravity-related wave function collapse. a, According to quantum gravity, a spatial quantum superposition of a system (red sphere) generates a superposition of different spacetime curvatures (grey sheets), corresponding to the possible different locations of the system. Penrose argues that a superposition of different spacetimes is unstable and decays in time, making the system's wave function also collapse. He provides an estimate for the time of collapse as given in equation (1), which is faster for a larger system, similar to that suggested earlier by Diósi. b, The master equation of the DP model (equation (3)) predicts not only the collapse of the wave function, but also an omnipresent Brownian-like diffusion (represented by the grey arrow) for each constituent of the system. When the constituents are charged (protons and electrons), the diffusion is accompanied by the emission of radiation (wavy orange lines), with a spectrum that depends on the configuration of the system. This is given by equation (4) in the range $\Delta E = (10–10^5)$ keV of photon energies. The predicted radiation emission is faint but potentially detectable by an experiment performed in a very low-noise environment. We performed such an experiment to rule out the original parameter-free version of the DP model. Credit: *Nature Physics* (2020). DOI: 10.1038/s41567-020-1008-4

A team of researchers from Germany, Italy and Hungary has tested a theory that suggests gravity is the force behind quantum collapse and has found no evidence to support it. In their paper published in the journal *Nature Physics*, the researchers describe underground experiments they conducted to test the impact of gravity on wave functions and what their work showed them. Myungshik Kim, with Imperial College London has published a News & Views piece in the same issue, outlining the work by the team and the implications of their results.

Quantum physics suggests that the state of an object depends on its properties and the way it is measured by an observer; the thought experiment involving Schrödinger's cat is perhaps the most famous example. But the theory is not universally accepted—physicists have wrangled for many years over the notion, with some arguing that it seems a bit too anthropocentric to be real. Behind the theory is the concept of waveform collapse, by which the observation of a particle, as an example, makes it collapse. To help make sense of the idea, some physicists have suggested that the force behind waveform collapse is not a person taking a look at a particle, but gravity. They suggest that gravitational fields exist outside of quantum theory and resist being forced into awkward combinations such as superpositions. A gravitational field forced to do so soon collapses, taking the particle with it. In this new effort, the researchers devised an experiment to test this theory in a physical sense.

The experiment consisted of building a small crystal detector made from germanium and using it to detect gamma and X-ray emissions from protons in the nuclei of the germanium. But before running the experiment, they wrapped the detector in lead and dropped it into a facility 1.4 kilometers below ground level at the Gran Sasso National Laboratory in Italy to prevent as much extraneous radiation from reaching the sensor as possible. After two months of testing, the team recorded far fewer photon hits than theory would suggest—indicating that the particles were not collapsing due to gravity, as theory had suggested.

More information: Sandro Donadi et al. Underground test of gravity-related wave function collapse, *Nature Physics* (2020). DOI: 10.1038/s41567-020-1008-4

M. S. Kim. A massive test, *Nature Physics* (2020). DOI: 10.1038/s41567-020-1026-2