Quantum mechanics and gravity dancing to the beat of drums

Gravity and quantum mechanics seem reluctant to get along, so what better way to break the ice than using drums? In their recent paper, researchers from the Steele Lab at the Quantum Nanoscience department of the TU Delft, and University of Oxford, propose a new way to explore the interaction between these two pillars of Physics using mechanical resonators.

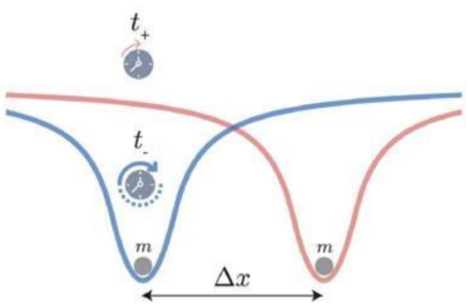
Why do quantum mechanics and general relativity seem incompatible? For general relativity time and space are connected. This gives rise to impressing phenomena, for example, it makes a clock tick slowly near a black hole, because the mass of the black hole is big enough to distort spacetime affecting not only the trajectories of objects, but also the flow of time. Therefore, we observe that **mass can influence time**. What about quantum mechanics? One of the most characteristic aspects of the quantum world is that particles can occupy several positions at the same time, something that we call **superposition**. For example, the electrons of the atom like to live at the points of a cloud, the atomic orbital, all at the same time. Combined with general relativity, that predicts a distortion of time in the presence of a mass, this superposition would yield an uncertainty in time: if a particle is living in two places at the same time, where does time slow down? This is a huge problem, because the formalism of quantum mechanics does not have the tools to describe uncertainties in time.

But… can we even measure this effect? According to Steele and Gely, we may be able to do so! For that they propose an experiment in which a quantum superposition in a heavy enough object could be created, using a mechanical resonator coupled to a superconducting qubit. This mechanical resonator, or drum, is 1mm in size and needs to be cooled down close to absolute zero. To push it, they propose using a superconducting qubit, the building block of the quantum computers of Google and IBM. This superconducting qubit could be driven into a superposition of *pushing the mechanical resonator up and down* at the same time, thus making the membrane live in two places at the same time. The idea is that the mechanical resonator is big enough for gravity to affect this superposition

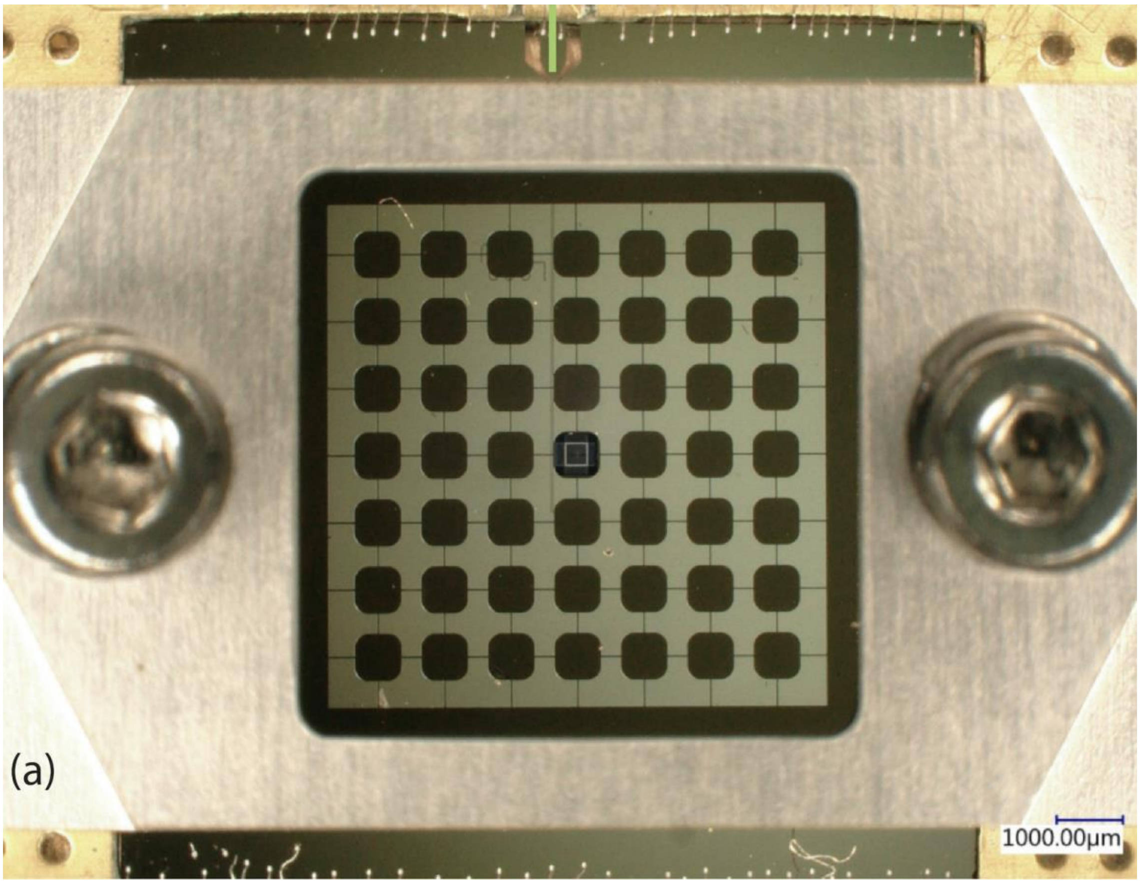
Steele and Gely hope that this proposal will inspire further experiments and perhaps shed some light on the interplay of these two beautiful theories. This type of experiments could also give new insights on how quantum effects appear at different scales, extending the limits of the quantum physics realm. You can read the original paper *Superconducting electro-mechanics to test Diósi–Penrose effects of general relativity in massive superpositions* from AVS Quantum Science:

https://doi.org/10.1116/5.0050988

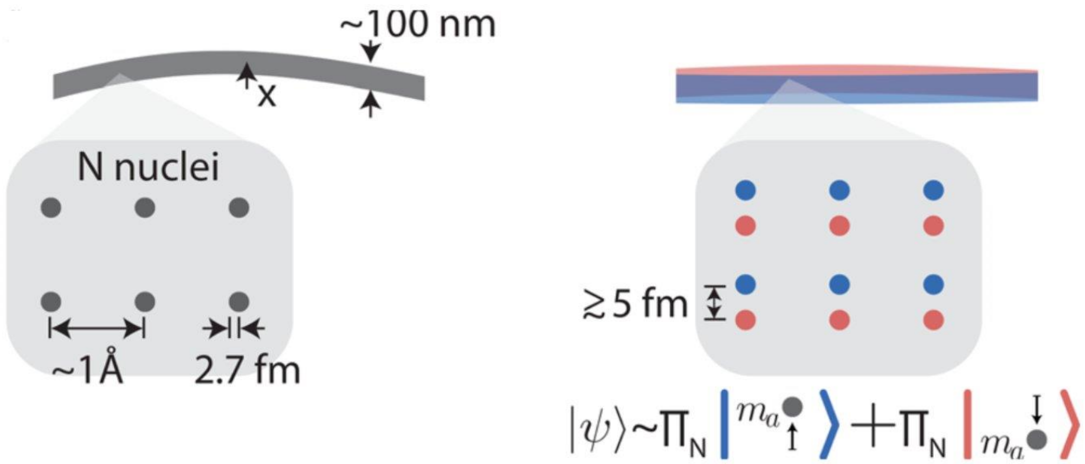
IMAGES:



Sketch of the effect of a superposition in time [1]



Mechanical resonator [2]



Sketch of superposition in a mechanical resonator [1].

[1] *Superconducting electro-mechanics to test Diósi–Penrose effects of general relativity in massive superpositions*, AVS Quantum Science, https://avs.scitation.org/doi/10.1116/5.0050988?via=site

[2] Courtesy of Prof. Gary Steele.