# Scientists set record for light-matter interaction

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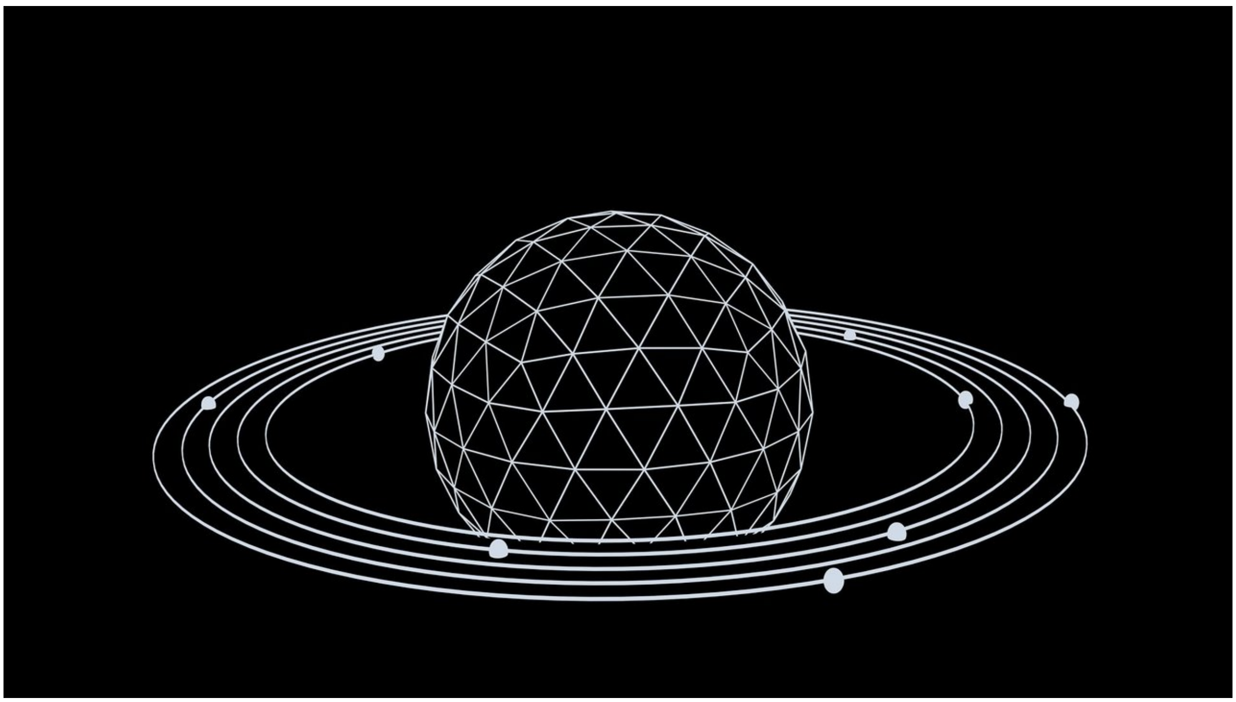

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An international team of physicists from the Mandelstam Institute for Theoretical Physics at Wits University and the Institut Néel in Grenoble, France, has created a tiny superconducting circuit that mimics the quantum mechanical process in which an atom absorbs or emits light.

Their work was recently published *Quantum Information*, and was highlighted in an editorial piece in the same journal. What makes their device unique is that they achieve an artificial light-matter interaction that is an order of magnitude larger than in the world at large.

The team was led by Nicholas Roch from the Institut Néel at the Centre National de la Researche Scientifique in France. The experiments were conducted by Ph.D. students Javier Martínez and Sébastien Léger.

"The advantage of artificial devices like ours is that they can easily be tweaked. In this way they can be made to mimic other known strongly interacting systems," says Dr. Izak Snyman, from Wits University, who played a prominent part in the theoretical modelling of the device and in analysing and interpretation of the experimental data.

"An exciting application is to use our device to simulate quantum phenomena that happen inside a lump of metal, where it is not possible to observe what is happening as closely as in our artificial system."

The team achieved their enhancement of the light matter interaction by embedding their artificial atom inside a carefully patterned array of identical tiny superconductors, each around 1000 nanometres in size (1000thof a millimetre). To the light emitted or absorbed by the artificial atom, this looks like a crystal, which drastically lowers the speed at which the light travels. As a result, there is more time for a light pulse to interact with the artificial atom, and a stronger interaction results.

To determine the strength of the light matter interaction, the team studied the rate at which their atom emits light. They compared this to the rate at which the "electron" in their artificial atom orbits. Where an electron in a normal hydrogen atom orbits around 10 million times before it decays and emits a packet of light, the researchers managed to get the artificial atom to decay and emit a packet of light after only 10 oscillations.

"This shows a surprisingly strong interaction between the light and the atom," says Snyman. "In previous devices where this feat was achieved, the environment through which light had to travel invariably behaved similarly to a tuning fork for light, by strongly favouring a single light frequency."

By not picking a particular frequency (or colour), the environment allows for much richer behaviour to emerge from the light-matter interaction than previous devices. Furthermore, whereas for a given natural atom, one is stuck with the interaction strength nature chooses, in the new device it can be adjusted by hand.

"This is similar to having an app that allows one to adjust the amount of electrical charge a proton or electron carries, rather than settling for the standard amount decreed by nature," says Snyman.

While there are not necessarily real-world applications for this new device, Snyman believes that it provides scientists with a new set of tools to explore strongly interacting quantum mechanical systems.

"Many unanswered fundamental questions in physics involve strong interactions. For instance, how do quarks bind to form protons and neutrons? Devices like ours may provide clues to these puzzles."

**More information:** Javier Puertas Martínez et al. A tunable Josephson platform to explore many-body quantum optics in circuit-QED, *npj Quantum Information* (2019). DOI: 10.1038/s41534-018-0104-0

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