When mediated by superconductivity, light pushes matter million times more

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When a mirror reflects light, it experiences a slight push. This radiation pressure can be increased considerably with the help of a small superconducting island. This was revealed by the joint research done in the Aalto University and the Universities of Jyväskylä and Oulu. The finding paves a way for the studies of mechanical oscillations at the level of a single photon, the quantum of light. The results of the research were published in *Nature Communications* in April.

In our everyday lives, the effects of the radiation pressure of light can be neglected. Your furniture is not moved over even though the light, or more generally the electromagnetic radiation, emitted by your lamps bounces off from its surfaces thus creating a radiation pressure force. An ordinary 100 Watt light-bulb causes a radiation pressure that is only a trillionth of the normal atmospheric pressure. Nevertheless, in space the relevance of the phenomenon becomes apparent: because of the radiation pressure the tails of comets typically point away from the Sun. Radiation pressure has also been proposed as the propulsion for the solar sails.

In the recent years, the radiation pressure has been harnessed also in the field of laser physics. It can be used to couple the electromagnetic laser field to, for example, the movement of the small mechanical oscillators that can be found inside ordinary watches. Due to the weakness of the interaction, one typically needs substantially strong laser fields.

"Radiation pressure physics in these systems have become measurable only when the oscillator is hit by millions of photons," explains theorist Jani Tuorila from the University of Oulu.

In the work reported here, the researchers combine their knowledge on experimental and theoretical physics, and show how the strength of the radiation pressure coupling can be considerably increased. They placed a superconducting island in between the electromagnetic field and the oscillator to mediate the interaction.

"In the measurements, we exploited the Josephson coupling of the superconducting junctions, especially its nonlinear character," explains Juha Pirkkalainen from Aalto University, the post-doctoral researcher who conducted the measurements.

The researchers were able to alter the radiation pressure coupling significantly.

"With the superconducting island, the radiation pressure increased a millionfold the value we had previously achieved," reports the supervisor of the experimental group, professor Mika Sillanpää from Aalto University.

Because of the increased radiation pressure coupling, the oscillator observes the electromagnetic field with the precision of a single photon. Correspondingly, the oscillators reveal themselves to the field with the resolution of a single quantum of oscillations, a phonon.

"Such strong coupling allows, in principle, the measurement of quantum information from an oscillator nearly visible to the naked eye," explains professor Tero Heikkilä from the University of Jyväskylä who was in charge of the theoretical studies.

The research enables the observation of quantum phenomena in larger structures than before. Thus, it allows studying the validity of the quantum mechanical laws in large structures. – Some claim that the theory holds only with very small particles. Nevertheless, the existence of an upper limit for the validity region has not been found – yet.

More information: "Cavity optomechanics mediated by a quantum two-level system," *Nature Communications* 6, 27 April 2015., www.nature.com/ncomms/2015/150 … /abs/ncomms7981.html

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