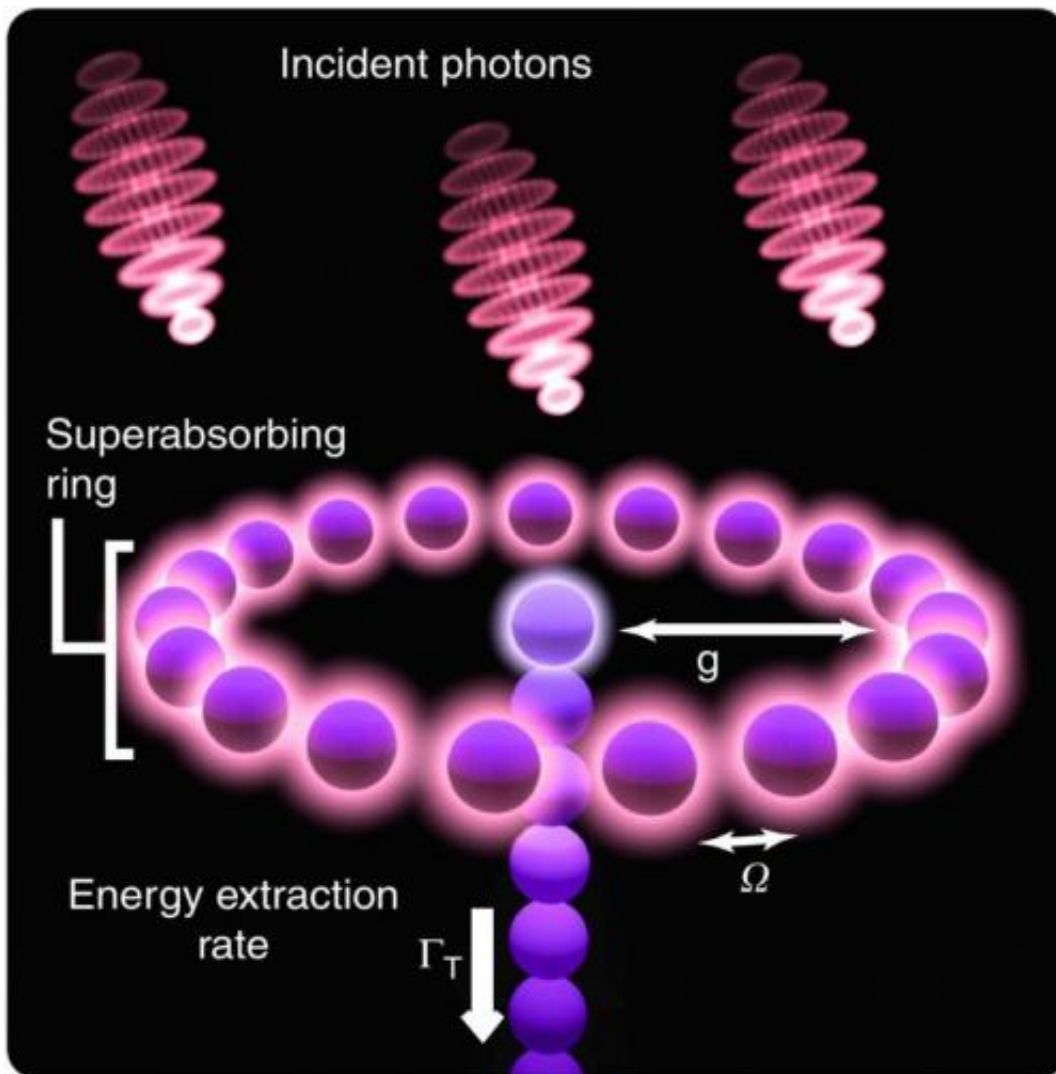


Physicists propose superabsorption of light beyond the limits of classical physics

August 28 2014, by Lisa Zyga



In one potential method to realize superabsorption, a superabsorbing ring absorbs incident photons, giving rise to excitons. Credit: Higgins, et al.

(Phys.org) —In a well-known quantum effect called superradiance, atoms can emit light at an enhanced rate compared to what is possible in classical situations. This high emission rate arises from the way that the atoms interact with the surrounding electromagnetic field. Logically, structures that superradiate must also absorb light at a higher rate than normal, but so far the superabsorption of light has not been observed.

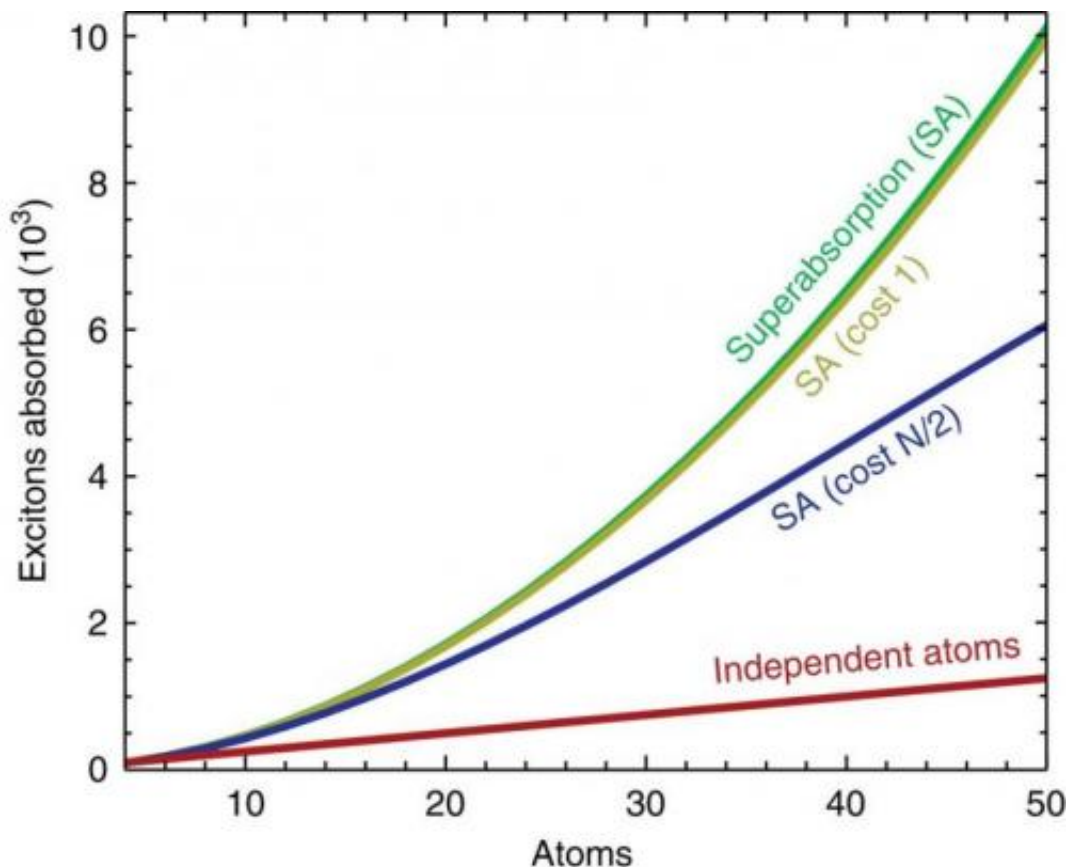
Now in a new paper published in *Nature Communications*, physicists Kieran Higgins, et al., have theoretically shown that superabsorption can be demonstrated using quantum engineering techniques. Structures capable of superabsorption could have applications including solar energy harvesting, novel quantum camera pixels, and wireless light-based power transmission.

"If you had a ring comprising 40 [atoms](#), this would absorb light 10x faster than any classical approach," Higgins, at Oxford University, told *Phys.org*. "The key thing in this work is that it's a fundamentally different way of absorbing light. So if you want to design the most efficient possible absorber and you have a certain number of atoms, this is a new and better way to do it using quantum physics. The atoms behave as if there's more of them than there actually are, which is the really cool thing."

As the physicists explain, superabsorption is the reciprocal of superradiance. Superradiance was first introduced 60 years ago by the physicist Robert Dicke, and since then has found a variety of applications, including a new class of laser. Physically, superradiance occurs when a system of excited atoms decays and moves down a ladder of states called the "Dicke" or "bright" states. As a result, light can be emitted at an enhanced rate that is proportional to the square of the number of atoms.

In natural systems, light emission dominates over light absorption, which

is why superabsorption has not yet been observed. But in the new paper, the scientists have shown that atoms in close proximity and with a suitable geometrical arrangement can interact with each other in such a way as to exhibit superabsorption.



A comparison of absorption: Independent atoms (red line) absorb excitons linearly, while a proposed superabsorption scheme (green line) could absorb excitons superlinearly (ideally, N^2). The yellow and blue lines represent superabsorption when accounting for costs in different ways. Credit: Higgins, et al.

The key to achieving superabsorption is to use quantum engineering techniques to ensure that most state transitions take place within a

specific frequency (which the scientists call the "good" frequency, in contrast with the "bad" frequencies that should be avoided). Photons can then be trapped so they are not emitted back out. Although the system would likely deviate from the "good" frequency over time, there are a few reinitialization schemes that would periodically monitor and correct the system's frequency.

The ability to absorb light beyond the limits of classical physics could lead to a new class of quantum nanotechnology. One potential application is optical light or microwave sensors that could be used in future cameras or for scientific instruments. Light-harvesting technologies could also benefit by absorbing an increased number of excitons compared to conventional systems. Superabsorption could be particularly useful for wireless power transfer using light for situations where wired electrical power is impractical, such as for remote sensors or biologically implanted devices.

"Eventually, harvesting sunlight in a highly efficient way might one day be possible using superabsorbing systems based on our design, but a more immediate application would be building an extremely sensitive light sensor that could form the basis of new camera technology," said coauthor Simon Benjamin, Professor at Oxford University. "A camera sensor harnessing the power of our superabsorbing rings would have very high time and spatial resolution. And it could pave the way for camera technology that would exceed the human eye's ability to see clearly both in dark conditions and in bright sunlight."

The physicists say that superabsorption could be experimentally demonstrated in the future in a few different ways, with possibilities including an array of quantum dots or a Bose-Einstein condensate. In the future, they plan to investigate new methods for achieving extreme light absorption.

"We are working on an alternative scheme for quantum enhanced [light absorption](#), which uses what's called a 'dark state' as an efficient means of extracting energy from light, and is similar to what happens in photosynthesis, which is in contrast to superabsorption, which is very different to how natural [light](#) harvesters work," Higgins said.

"We also have plans to extend the present work by adding another effect from quantum optics, which we hope will make the proposal much easier to implement experimentally and thus realize the potential technological applications more quickly."

More information: K.D.B. Higgins, et al. "Superabsorption of light via quantum engineering." *Nature Communications*. DOI: [10.1038/ncomms5705](https://doi.org/10.1038/ncomms5705)

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