Quantum world without queues could lead to better solar cells

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In a recent study from Lund University in Sweden, researchers have used new technology to study extremely fast processes in solar cells. The research results form a concrete step towards more efficient solar cells.

The upper limit for the efficiency of normal solar cells is around 33 per cent. However, researchers now see a possibility to raise that limit to over 40 per cent, thereby significantly improving the potential of this energy source.

The experiments in the present study involved 'juggling' on quantum level with photons, i.e. light particles, and electrons. Quantum level refers to the microcosm of the world formed by individual atoms and their building blocks. In juggling the particles, the researchers took advantage of the fact that the laws of nature work slightly differently on quantum level than what we are used to in our world.

"We were actually a bit surprised that it worked", said Tönu Pullerits, Professor of Chemical Physics at Lund University.

In the study, Tönu Pullerits and his colleagues studied solar cells containing nanometre-sized balls of material known as quantum dots. These quantum dots can be likened to individual artificial atoms of semiconductor materials. When sunlight hits the quantum dots, two electrons can be extracted from one photon, which can increase the efficiency of the solar cells.

"This would mean a radical improvement to solar cells", said Professor Pullerits.

The explanation for this effect lies in the laws of quantum mechanics that control particles on the quantum scale. The phenomenon is called quantum coherence and can lead to a type of energy transfer that produces an almost perfect flow of energy without any obstacles.

Coherence opens up a possibility that the flow of energy can find the shortest route by taking all the possible routes at the same time and then selecting the best. To stretch a metaphor, you could compare it to avoiding choosing a queue in the supermarket – instead you can stand in all the queues and see which moves the fastest. Although in reality, the process is extremely fast: it takes a matter of billionths of a second in the quantum world. There are ongoing discussions between researchers on whether the phenomenon might be used by certain photosynthetic organisms to capture sunlight.

Over recent years, Tönu Pullerits and his colleagues have conducted research to try to understand and control the coherence phenomenon in order to make use of it in more efficient solar cells, but the results can also be used in other contexts where the transport and interaction of electrons and photons is decisive, such as in future high-speed quantum electronics.

The present study is a collaboration between researchers at Lund University and in Oregon, USA. The study has been published in the scientific journal *Nature Communications*.

More information: "Coherent two-dimensional photocurrent spectroscopy in a PbS quantum dot photocell," Khadga J. Karki, Julia R. Widom, Joachim Seibt, Ian Moody, Mark C. Lonergan, Tõnu Pullerits & Andrew H. Marcus, *Nature Communications*, DOI:

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