Physicists lay the groundwork for cooler, faster computing

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University of Toronto quantum optics researchers Sajeev John and Xun Ma have discovered new behaviours of light within photonic crystals that could lead to faster optical information processing and compact computers that don't overheat.

"We discovered that by sculpting a unique artificial vacuum inside a photonic crystal, we can completely control the electronic state of artificial atoms within the vacuum," says Ma, a PhD student under John's supervision and lead author of a study published in a recent issue of Physical Review Letters. "This discovery can enable photonic computers that are more than a hundred times faster than their electronic counterparts, without heat dissipation issues and other bottlenecks currently faced by electronic computing."

"We designed a vacuum in which light passes through circuit paths that are one one-hundredth of the thickness of a human hair, and whose character changes drastically and abruptly with the wavelength of the light," says John. "A vacuum experienced by light is not completely empty, and can be made even emptier. It's not the traditional understanding of a vacuum."

"In this vacuum, the state of each atom - or quantum dot - can be manipulated with color-coded streams of laser pulses that sequentially excite and de-excite it in trillionths of a second. These quantum dots can in turn control other streams of optical pulses, enabling optical information processing and computing," says Ma.

The original aim of the investigation was to gain a deeper understanding of optical switching, part of an effort to develop an all-optical micro-transistor that could operate within a photonic chip. This led to the discovery of a new and unexpected dynamic switching mechanism, imposed by the artificial vacuum in a photonic crystal. The research also led to the discovery of corrections to one of the most fundamental equations of quantum optics known as the Bloch equation.

"This new mechanism enables micrometer scale integrated all-optical transistors to perform logic operations over multiple frequency channels in trillionths of a second at microwatt power levels, which are about one millionth of the power required by a household light bulb," says John. "That this mechanism allows for computing over many wavelengths as opposed to electronic circuits which use only one channel, would significantly surpass the performance of current day electronic transistors."

More information: The results appear in a paper titled "Ultrafast Population Switching of Quantum Dots in a Structured Vacuum", published online in the *Physical Review Letters* on December 3.

Source: University of Toronto (news : web)