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**Integrating photonics with superconducting electronics to create artificial intelligent systems**

*Optoelectronic integration at low temperatures using superconductors is easier than when working at room temperatures using semiconductors*

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As artificial intelligence has attracted broad interest, many researchers are focused on understanding how the brain accomplishes cognition so they can construct artificial systems with general intelligence comparable to humans. Many have approached this challenge by using conventional silicon microelectronics in conjunction with light but the fabrication of silicon chips that have both electronic and photonic circuit elements is difficult for many physical and practical reasons related to how neurons communicate.

In a paper in Applied Physics Letters by AIP Publishing, researchers at the National Institute of Standards and Technology propose a new approach to large-scale artificial intelligence by focusing on integrating photonic components with superconducting electronics rather than semiconducting electronics.

“We argue that operating at low temperature and by using superconducting electronic circuits, superconducting single-photon detectors and silicon light sources, we will open a path toward rich computational functionality and scalable fabrication,” said author Jeffrey Shainline.

The researchers propose that using light for communication in conjunction with complex electronic circuits for computation will enable artificial cognitive systems of scale and functionality beyond what can be achieved with either light or electronics alone.

“What surprised me most was that optoelectronic integration may be much easier when working at low temperatures and suing superconductors than when working at room temperatures and using semiconductors,” said Shainline.

Superconducting photon detectors enable detection of a single photo, while semiconducting photon detectors require about a thousand photons. So not only do silicon light sources work in a 4K temperature, but they can be 1000 times less bright than their room-temperature counterparts and still communicate effectively.

Some applications such as chips in cell phones require working at room temperature, but the findings are still wide-reaching for certain advanced computing system. Next the researchers will explore more complex integration with other superconducting electronic circuits as well as demonstrating all of the components that comprise artificial cognitive systems, including synapses and neurons.

Showing that the hardware can be manufactured in a scalable manner so that large systems can be realize at a reasonable cost will also be important. Superconducting optoelectronic integration could also help create scalable quantum technologies such as a quantum module based on superconducting or photonic qubits. Such quantum-neural hybrid systems may also lead to new ways of leveraging the strengths of quantum entanglement with spiking neurons.

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The article, "Optoelectronic Intelligence" is authored by Jeffrey Michael Shainline. The article will appear in Applied Physics Letters on Month Date, 2021 (DOI: 10. 1063/5.0040567). After that date, it can be accessed at LINK.

**ABOUT THE JOURNAL**

Applied Physics Letters features rapid reports on significant discoveries in applied physics. The journal covers new experimental and theoretical research on applications of physics phenomena related to all branches of science, engineering, and modern technology. See <https://aip.scitation.org/journal/apl>.

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