Photonic non-von Neumann computing

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Conventional computers are organized around a centralized processing architecture (that is, with a central processor and separated memory), which is suited to running sequential, digital, procedure-based programs. Such an architecture is inefficient for computational models that are distributed, massively parallel and adaptive, most notably those used for neural networks in artificial intelligence. In these application domains demand for high throughput, low latency and low energy consumption is driving the development of not only new architectures, but also new platforms for information processing.

Light is established as the communication medium of telecoms and datacentres, but it has not yet found widespread use in information processing and computing [1]. The same properties that allow optoelectronic components to excel at communication are at odds with the requirements of digital gates. However, non-digital computing models, such as neural networks, could be more conducive to being implemented in photonics. The goal of such non-von Neumann photonic processors should not be to replace conventional computers, but to enable applications that are unreachable at present by conventional computing technology.

Photonic integrated circuits meet these requirements and allow for realizing the underlying computing architectures, which process optical signals in analogy to electronic integrated circuits. Therein electrical connections are replaced with photonic waveguides which guide light to desired locations on chip. Through heterogeneous integration, photonic circuits, which are normally passive in their response, are able to display active functionality and thus provide the means to build neuromorphic systems capable of learning and adaptation [2]. In this talk, I will give an overview of emerging photonic platforms for developing optical non-von Neumann computing devices. In reconfigurable photonic architectures in-memory computing allows for overcoming separation between memory and central processing unit as a route towards artificial neural networks, which operate entirely in the optical domain.

[1] B.J. Shastri, A.N. Tait, T. Ferreira de Lima, W.H.P. Pernice, H. Bhaskaran, C.D. Wright and Paul R. Prucnal, *Nature Photonics* **15**, 102 (2021).

[2] J. Feldmann, N. Youngblood, C.D. Wright, H. Bhaskaran, and W.H.P. Pernice, *Nature* **8**, 1256 (2019).