Scalable Integrated Photonic Computing

Z Xue[1], Z Xu[1], W Wu[1], Y Jiang[1], and L Fang[1]

[1] *Department of Electronic Engineering, Tsinghua University, 100084, Beijing, China. Contact Phone: +86 15335801253*
Contact Email: xuezw21@mails.tsinghua.edu.cn

Scalable photonic intelligence is fundamentally limited by two coupled challenges: insufficient computational completeness of individual photonic units and error accumulation of photonic neural networks. This talk presents a unified approach that addresses both constraints to enable large-scale integrated photonics. At the device level, a complete photonic integrated neuron (PIN) [1] is introduced, which combines linear weighting, high-order spatiotemporal convolution, and nonlinear activation within a single silicon-nitride chip via Kerr nonlinearity, achieving sub-nanosecond optical computation with full neuron functionality. At the system level, an error-tolerant deep photonic learning framework (SLiM) [2] mitigates propagation redundancy through on-chip perturbations that decorrelate computational pathways, enabling stable operation across more than 100 effective layers. Together, these advances establish a scalable pathway toward photonic intelligence by jointly enhancing single-unit expressivity and depth-resilient network scaling. Together, these advances establish a scalable foundation for photonic intelligence, opening a pathway toward next-generation intelligent computing systems that combine unprecedented speed, energy efficiency, and scalability.

References

[1] T Yan, Y Guo, T Zhou, *et al.*, Nat. Comput. Sci. **5**, 1202 (2025)

[2] T Zhou, Y Jiang, Z Xu, Z Xue and L Fang, Nat. Commun. **16**, 10382 (2025)