

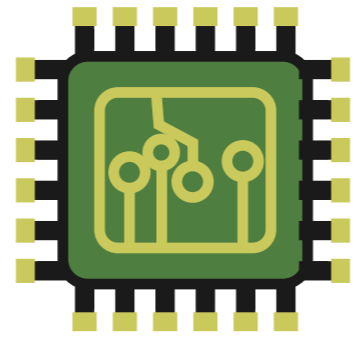
Space-Time Metasurfaces for Optical Computing

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IMPERIAL

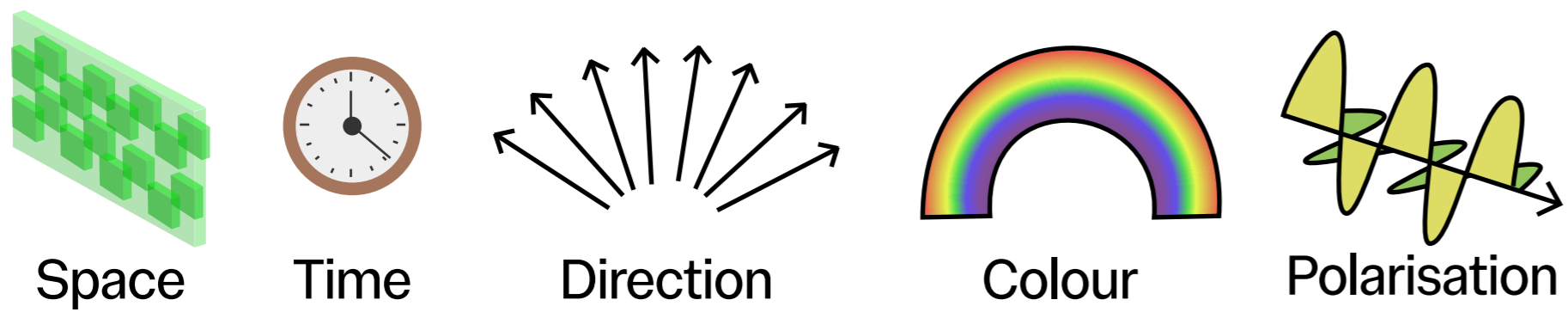
The Limits of Electronic Processors

- Heat dissipation limits scaling
- Limited bandwidth
- Energy cost of data movement



Computers that control

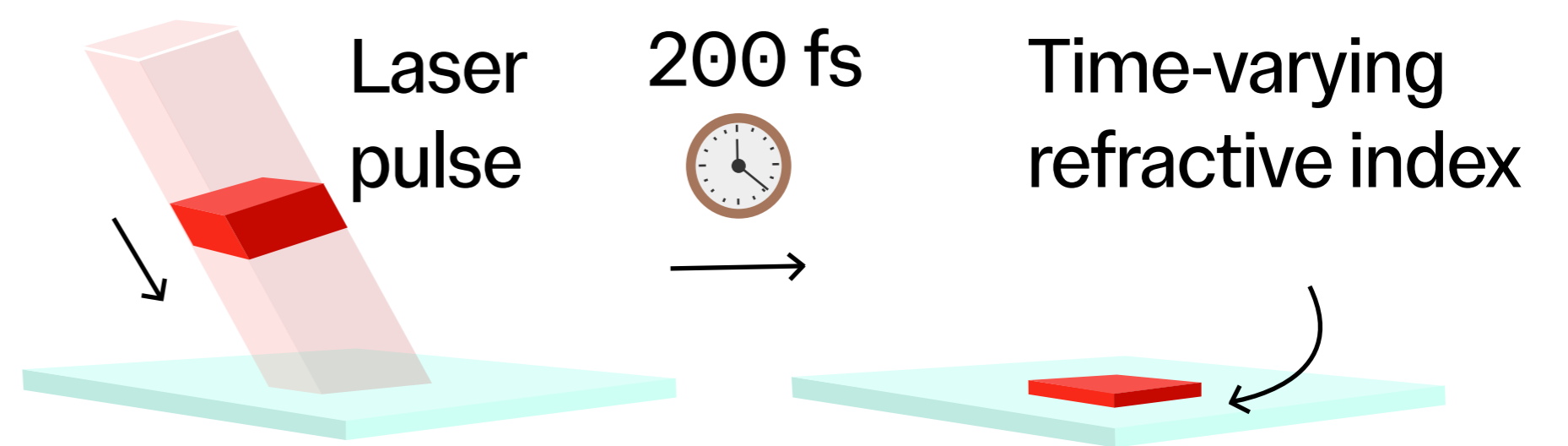
Light offers high bandwidth and parallelism ...



... but static devices cannot control all these dimensions

Space-Time Metasurfaces

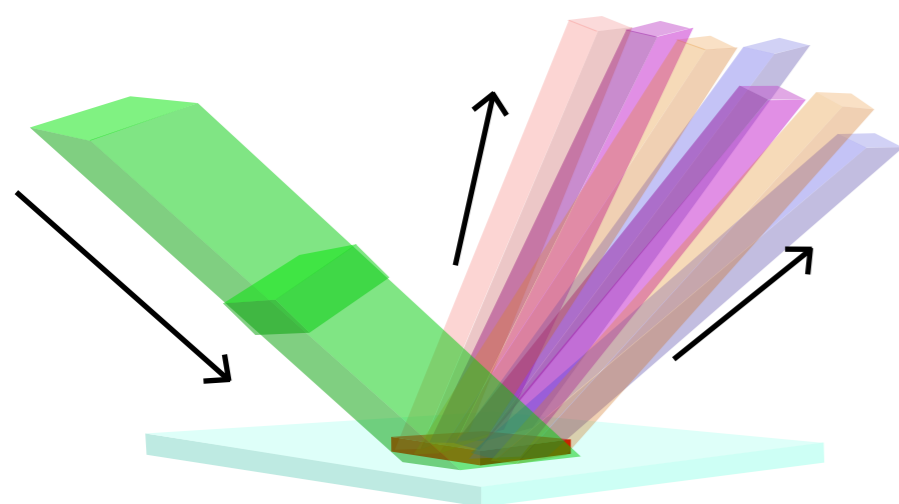
We have developed optically-programmable nanoscale devices for controlling optical signals



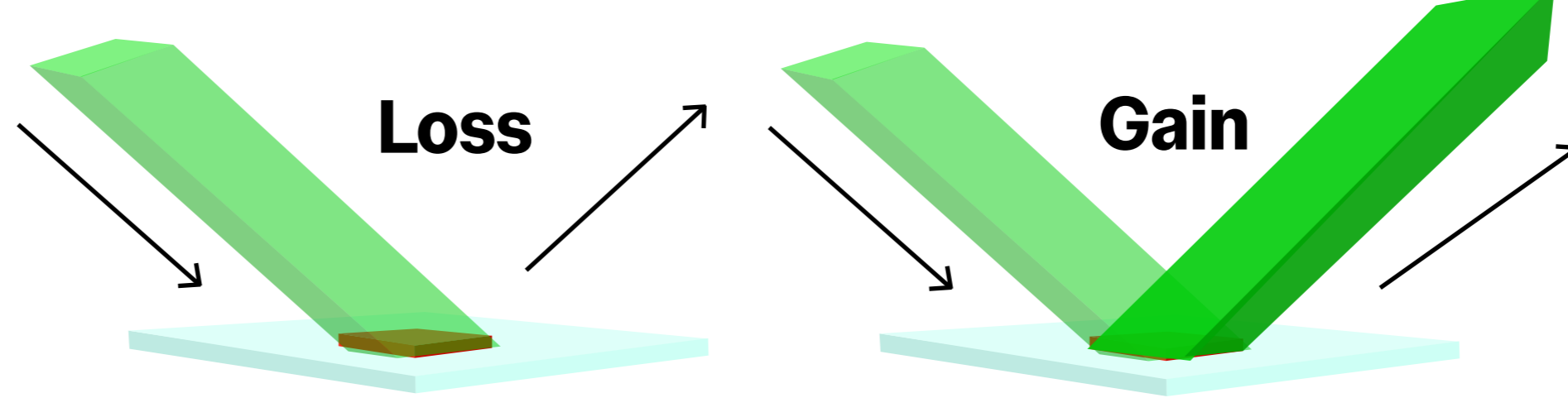
Time-variation breaks energy conservation, enabling nonlinear operations

Controlling Light with Space-Time Metasurfaces

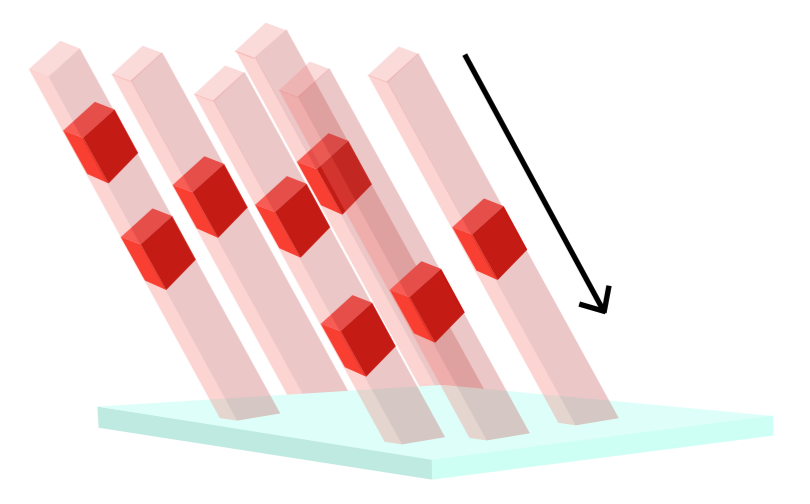
Control of frequency and direction [1]



Tuneable loss and gain [2]



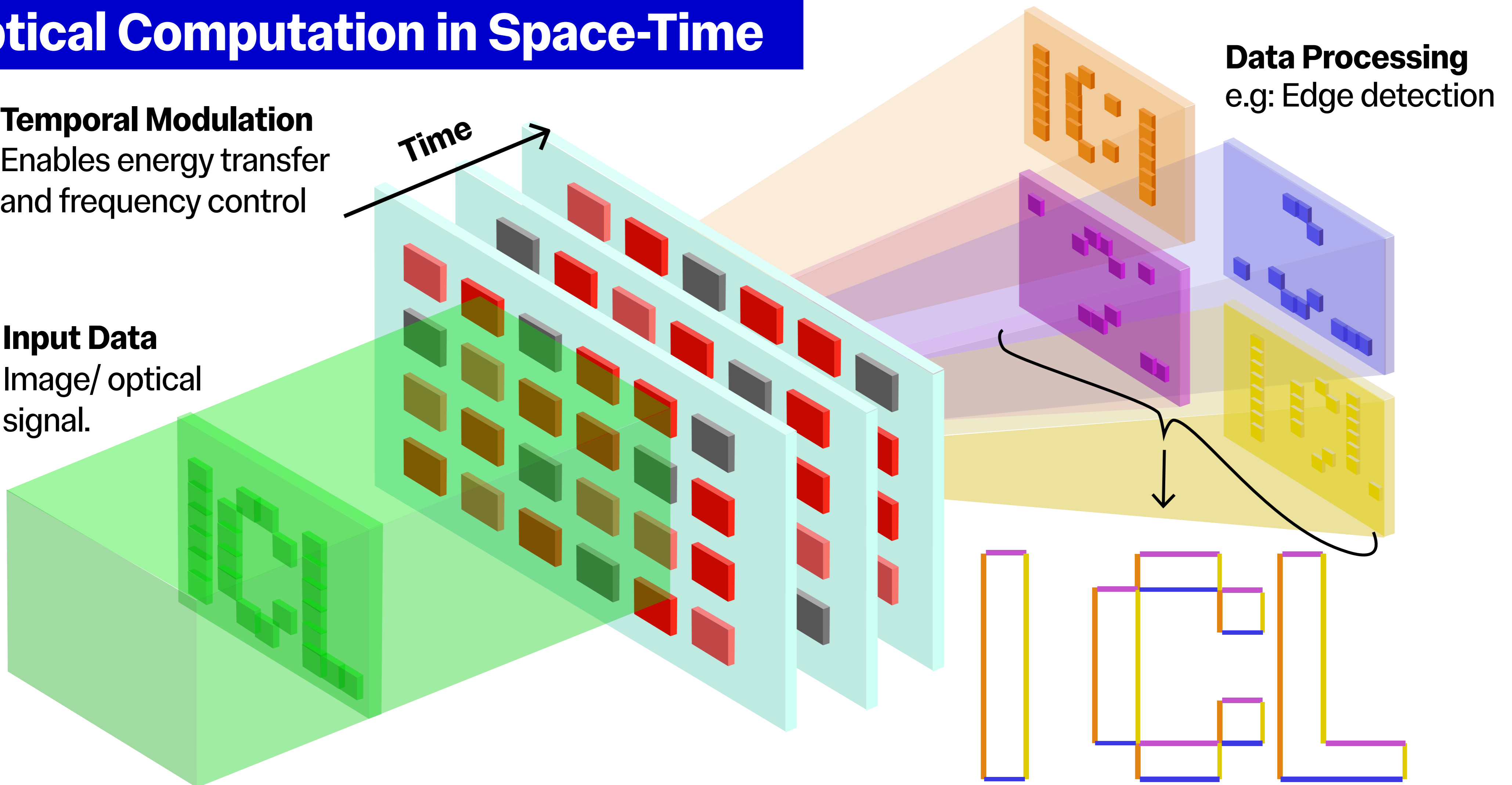
Space-time programmability [3]



Optical Computation in Space-Time

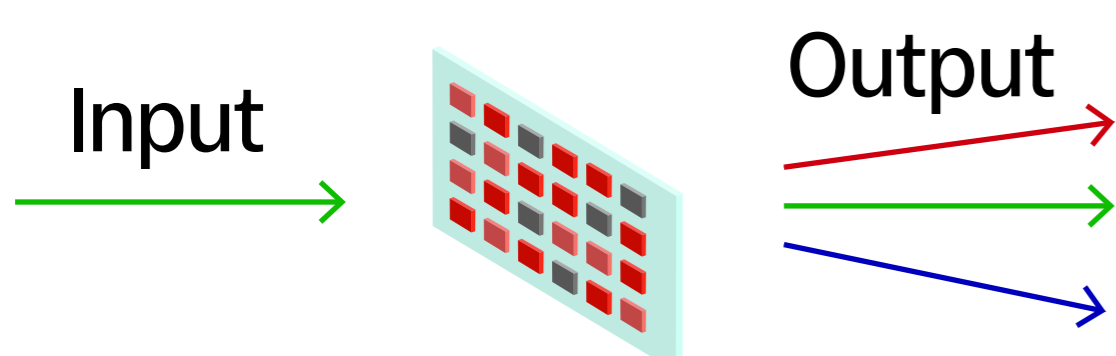
Temporal Modulation
Enables energy transfer and frequency control

Input Data
Image/ optical signal.



Applications

We have demonstrated a nonlinear, highly parallel, optical signal transformer, what next?



- Ultrafast optical signal processing
- Energy-efficient edge inference
- Analogue photonic computing

More Information



The research group



Physics with Tony

[1] = Harwood, A. C. et al. Nature Communications 16, 5147 (2025).

[2] = Galiffi*, E. Harwood*, A. C. et al. Nature Photonics 1-7 (2026)

[3] = Cielecki, D. Harwood, A. C. et al. In Submission (2026)