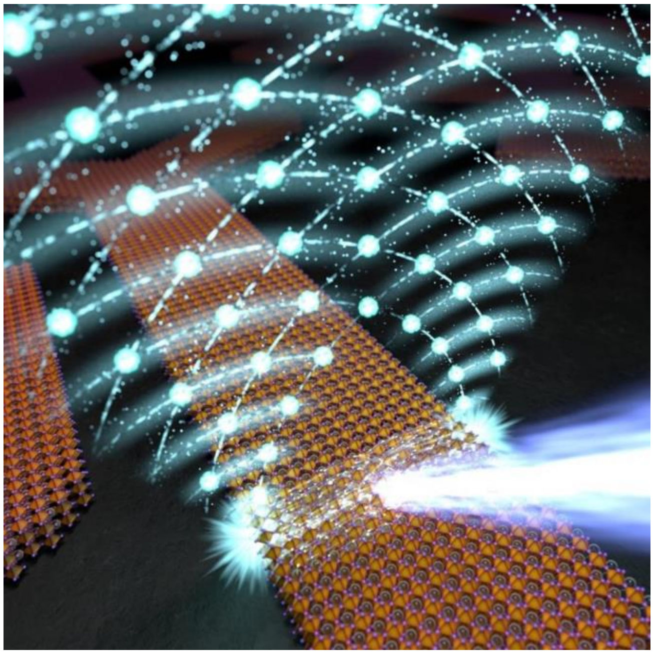
Integrated perovskite-polariton circuits for spin logic

Particles in the quantum world possess a fundamental quantized property known as “spin” which, like charge of an electron, could revolutionize information processing technologies. Spin-dependent interactions between quantum particles and their transport in condensed matter are essential for solid-state spintronic devices, where the electron spin offers faster, denser, and more reliable data storage and processing. However, controlling electron spin is challenging due to short lifetimes and low mobility under normal conditions. By combining photonic and electronic properties through strong light-matter coupling, the emerging field of spinoptronics addresses these challenges. Semiconductor microcavities host exciton-polaritons, hybrid particles with spinor properties that exhibit ultrafast response, long lifetimes, superfluid transport, and strong optical nonlinearities. These features make polaritons ideal for integrated photonic circuits capable of efficient spin-based signal processing.

Current polariton spin switches and logic components are bulky, operate at low temperatures, and lack scalability. Advancing polariton-based spinoptronics requires room-temperature operation in compact, interconnected circuits controlled by both electrical and optical inputs. Achieving this would revolutionize spin-based optical computing for digital, analog, and neuromorphic applications while enabling quantum technologies like entangled photon sources.

This project, led by the University of Warsaw, aims to create room-temperature polariton circuits using lead-halide perovskites and liquid crystal technologies. High-quality perovskite microwires with strong spin interactions will be combined with electric-field-tunable liquid crystals for precise control. Theoretical work will guide the design of spin-switches, logic gates, and transistors, with experimental validation providing proof-of-concept for integrated polariton circuits. Success will pave the way for on-chip optical computing with high speed, energy efficiency, and photonic parallelism.



Schematic perovskite microwire illuminated by an incident optical beam and emitting coherent light that interferes