New ERC Proof of Concept for Valleytronics

ICREA Prof. at ICFO Dr. Jens Biegert is awarded the ERC PoC to study optical computing solutions that use light to control states in materials, to offer a faster, more energy-efficient path for next-generation AI technologies.

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As artificial intelligence systems become more demanding, they are placing unprecedented strain on current computing infrastructures. Computer processing today faces growing challenges in scalability and energy efficiency, while their environmental impact continues to rise and poses a necessity to search for new, sustainable computing technologies. Although optical (light-wave) computing has long been seen as a solution, its transition to industry has been hindered by the lack of practical, adaptable platforms.

The new ERC-funded Proof of Concept, awarded to ICREA Prof. at ICFO, Dr. Jens Biegert and his team, including Dr. Igor Tyulnev and Dr. Alastair Cunningham, could help overcome these barriers. The project seeks to move light-based computing from theory to practical prototypes by embedding ultra-thin materials into photonic crystal fiber waveguides, thereby

enabling efficient light control and direct compatibility with electronic systems. The research builds on recent advances in controlling a quantum property known as **valley polarization**-a key concept in next-generation electronics.

By shaping light into a specially structured **i¿½trefoili¿½** field that matches a material's internal symmetry, researchers can selectively steer electrons into specific valleys and tune this effect simply by rotating the light. This approach, known as **valleytronics**, is designed to work across a wide range of materials, use widely available laser technology, and integrate ultra-fast optical processing with electronic readouts. The use of light instead of electricity to process information aims to significantly reduce energy losses and enable ultrafast (in the femtosecond range), scalable performance.

By leveraging a universal light-control approach within a fiber-based device, the team aims to pursue high-efficiency, high-speed computing technologies essential for the future. It bridges photonic and electronic technologies, in which information is carried not just by electric charge but also by the quantum state of electrons, enabling new types of logic gates and computing architectures. As such, it aims to accelerate the commercialization of optical computing while unlocking entirely new methods or techniques for information processing, paving the way for faster, more energy-efficient AI systems in the years to come.

As ICREA Prof. at ICFO Jens Biegert, concludes, i¿½this ERC Proof of Concept gives our gro p the opportunity to translate a discovery into a technological concept. After identifying a universal way to induce valley polarization with light, we can now concentrate on realizing a valleytronic device and demonstrating its potential."

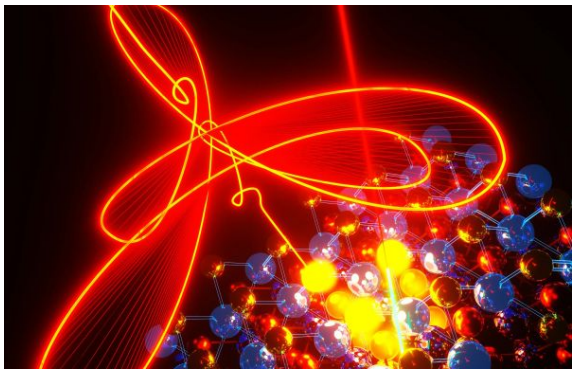

Illustration of the trefoil field