

## **Excitons pave the way to higher-performance electronics**

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Credit: Mediacom

After developing a method to control exciton flows at room temperature, EPFL scientists have discovered new properties of these quasiparticles that can lead to more energy-efficient electronic devices.

They were the first to control <u>exciton</u> flows at <u>room temperature</u>. And now, the team of scientists from EPFL's Laboratory of Nanoscale



Electronics and Structures (LANES) has taken their technology one step further. They have found a way to control some of the properties of excitons and change the polarization of the light they generate. This can lead to a new generation of electronic devices with transistors that undergo less energy loss and heat dissipation. The scientists' discovery forms part of a new field of research called valleytronics and has just been published in *Nature Photonics*.

Excitons are created when an electron absorbs light and moves into a higher energy level, or "energy band" as they are called in solid quantum physics. This excited electron leaves behind an "electron hole" in its previous <u>energy</u> band. And because the electron has a <u>negative charge</u> and the hole a positive charge, the two are bound together by an electrostatic force called a Coulomb force. It's this electron-electron hole pair that is referred to as an exciton.

## **Unprecedented quantum properties**

Excitons exist only in semiconducting and insulating materials. Their extraordinary properties can be easily accessed in 2-D materials, which are materials whose basic structure is just a few atoms thick. The most common examples of such materials are carbon and molybdenite.

When such 2-D materials are combined, they often exhibit quantum properties that neither material possesses on its own. The EPFL scientists thus combined tungsten diselenide (WSe<sub>2</sub>) with molybdenum diselenide (MoSe<sub>2</sub>) to reveal new properties with an array of possible high-tech applications. By using a laser to generate light beams with circular polarization, and slightly shifting the positions of the two 2-D materials so as to create a moiré pattern, they were able to use excitons to change and regulate the polarization, wavelength and intensity of light.



## From one valley to the next

The scientists achieved this by manipulating one of the excitons' properties: their "valley," which is related to the extremes of energies of the electron and the hole . These valleys – which are where the name valleytronics comes from – can be leveraged to code and process information at a nanoscopic level.

"Linking several devices that incorporate this technology would give us a new way to process data," says Andras Kis, who heads LANES. "By changing the polarization of <u>light</u> in a given device, we can then select a specific valley in a second device that's connected to it. That's similar to switching from 0 to 1 or 1 to 0, which is the fundamental binary logic used in computing."

**More information:** Alberto Ciarrocchi et al. Polarization switching and electrical control of interlayer excitons in two-dimensional van der Waals heterostructures, *Nature Photonics* (2018). DOI: 10.1038/s41566-018-0325-y

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