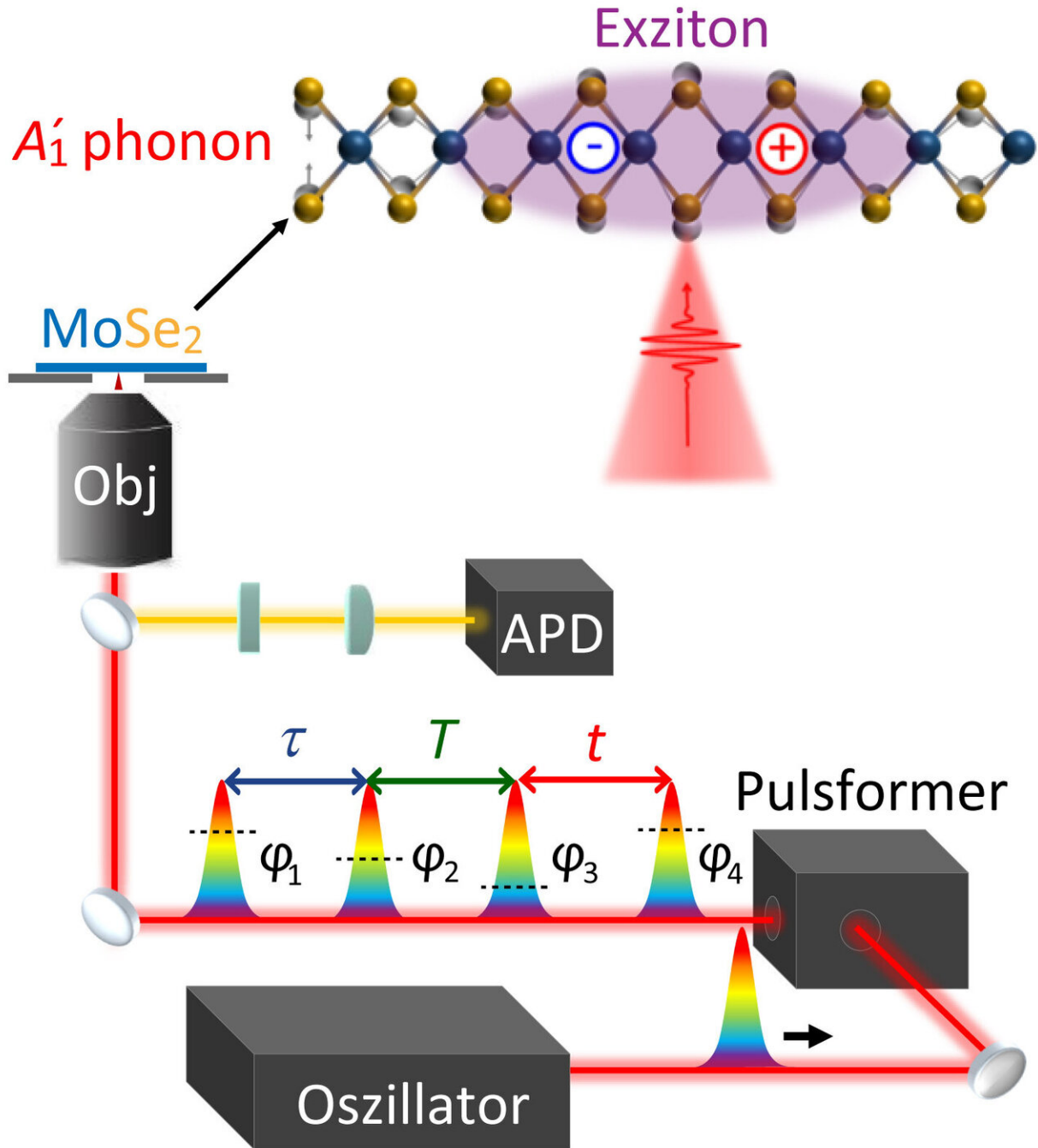


Vibrating 2-D materials

February 11 2021



From bottom to top: Laser (oscillator), pulse shaper with generated four-pulse sequence, avalanche photodiode (APD) for detection, microscope objective (Obj), 2D material (MoSe₂) with exciton (+/-) and oscillation (A₁' phonon).
Credit: Donghai Li / University of Würzburg

Current electronic components in computers, mobile phones and many other devices are based on microstructured silicon carriers. However, this technology has almost reached its physical limits and the smallest possible structure sizes.

Two-dimensional (2-D) materials are therefore being intensively researched. One can imagine these materials as extremely thin films consisting of only one layer of atoms. The best known is graphene, an atomically thin layer of graphite. For its discovery, Andre Geim and Konstantin Novoselov received the Nobel Prize in Physics in 2010.

While graphene consists purely of carbon, there are numerous other 2-D compounds that are characterized by special optical and electronic properties. Countless potential applications of these compounds are currently being researched, for example for use in [solar cells](#), in micro- and optoelectronics, in [composite materials](#), catalysis, in various types of sensors and light detectors, in biomedical imaging or in the transport of drugs in the organism.

Light energy can make 2-D materials vibrate

For the function of these 2-D compounds, one exploits their special properties. "It is important to know how they react to excitation with light," says Professor Tobias Brixner, head of the Chair of Physical

Chemistry I at Julius-Maximilians-Universität (JMU) Würzburg in Bavaria, Germany.

In principle, 2-D materials are electronically excited just like ordinary silicon solar cells when sufficient [light energy](#) hits them. However, the energy can cause the atomically thin layer to vibrate at the same time. This in turn influences the optoelectronic properties.

Strength of exciton-phonon coupling is difficult to determine

Until now, it was unknown how strongly light excites such oscillations in a 2-D material at room temperature. Now, in an [international collaboration](#), a team led by Tobias Brixner has succeeded for the first time in determining the strength of the oscillation excitation upon [light](#) absorption in a 2-D material—namely in a "transition metal dichalcogenide"—at room temperature.

"This quantity, known in technical jargon as exciton-phonon coupling strength, is difficult to determine because at [room temperature](#) the [absorption spectrum](#) is very much 'smeared out' and no individual spectral lines can be separated," says the JMU physicist and physical chemist.

Postdoc developed coherent 2-D microscopy

Now, however, postdoctoral researcher Dr. Donghai Li in Würzburg has developed the method of "coherent 2-D microscopy." It combines the spatial resolution of a microscope with the femtosecond time resolution of ultra-short laser pulses and with the multi-dimensional frequency resolution. This allowed Li to quantify the influence of the oscillations.

Brixner explains: "Surprisingly, it turned out that the exciton-phonon coupling strength in the investigated material is much greater than in conventional semiconductors. This finding is helpful in the further development of 2-D materials for specific applications."

More information: Donghai Li et al. Exciton–phonon coupling strength in single-layer MoSe₂ at room temperature, *Nature Communications* (2021). [DOI: 10.1038/s41467-021-20895-0](https://doi.org/10.1038/s41467-021-20895-0)

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