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Two-dimensional materials under tailored laser pulses

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Abstract

The successful synthesis of monolayer graphene has led to the proliferation in synthesising of other two-dimensional (2D) materials, such as hexagonal boron nitride and transition metal dichalcogenides. These 2D materials exhibit attractive transport and optoelectronic properties, which hold promise for upcoming technologies. In parallel, tremendous advancement has been made in laser technology. Light-matter interaction has played a pivotal role in understanding and probing several linear and nonlinear optical properties of these 2D materials.

In this talk, I will present few examples where 2D materials are exposed to various tailored laser pulses. As a first example, I will discuss how valley-selective excitation in graphene with zero bandgap can be achieved by an all-optical means [1, 2]. Ultrashort laser pulses are employed to obtain a desire control over valley polarisation. By tailoring the waveforms of the laser pulses to the symmetry of the graphene's sub-lattice, I will demonstrate that it is possible to induce and read valley polarization in graphene – a medium where light-driven valleytronics was thought to be impossible. Valleytronics in 2D materials have potential to encode, process, and store quantum information at room temperature – A holy grail for quantum computing. As a second example, I will show how high-harmonic spectroscopy probes coherent phonon excitations in graphene, particularly longitudinal and transverse optical phonon modes, on the electronic response [3, 4]. This work brings the key advantage of high-harmonic spectroscopy – the combination of subfemtosecond to tens of femtoseconds temporal resolution – to the problem of probing phonon-driven electronic response and its dependence on the dynamical symmetries in solids. Later, I will demonstrate how tailored laser pulses provide a platform to generate circularly polarised harmonics with identical helicity [5] – an essential ingredient for chiral-sensitive light-matter interaction phenomena, such as recognition of chiral molecules, circular dichroism in magnetic materials to name but a few.

References

[1] Optica **8** (2021) 422.
[2] J. Phys. B **54** (2021) 224001.
[3] Phys. Rev. B **106** (2022) 064303.
[4] Phys. Rev. A **106** (2022) 053116.
[5] Phys. Rev. Appl. **18** (2022) 064049.