



Tracking electron dynamics in graphene and transition metal dichalcogenides

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Novel quantum materials such as graphene and transition metal dichalcogenides are attracting vast interest particularly for their application in spintronic and optoelectronic devices. Their properties are intrinsically governed by the large momentum electrons (at the Brillouin zone K point). In order to eject such electrons in vacuum and observe their dynamics, a high energy (> 20 eV) photon source is required, as well as an ultrashort pulse duration. An high harmonic generation source [1] combined to an Angle-Resolved PhotoEmission Spectroscopy (ARPES) end-station is a powerful tool to observe such electron dynamics. After an introduction on ARPES and experimental concepts, I will present an overview of few recent time-resolved ARPES studies performed at the Artemis facility.

A quasi-free-standing monolayer of graphene was optically excited in a direct interband regime. The measurement of the electronic temperature reveals the role of the supercollisions during the cooling process of the electrons [2]. Over ~ 100 fs, a population inversion across the Dirac point is observed [3], supporting the potential of graphene for THz amplification applications.

Single layers of MoS₂ [4,5] and WS₂ [6], and bulk WSe₂ [7] were resonantly pumped across the band gap at the K point. Measurements of the valence and conduction bands populations give access to the direct quasiparticle band gap [4]. Depending on the screening effects, a strong band gap renormalization can be induced [5] by optically excited free charge carriers. Control of spin- and valley-quantum numbers in valence and conduction bands is achieved [6,7] by using circularly polarized optical excitation.

REFERENCES

1. F. Frassetto *et al.*, Optics Express **19**, 19169 (2011)
2. J. Johannsen *et al.*, Phys. Rev. Lett. **111**, 027403 (2013)
3. I. Gierz *et al.*, Nat. Mater. **12**, 1119 (2013)
4. A. Grubišić Čabo *et al.*, Nano Lett. **15**, 5883 (2015)
5. S. Ulstrup *et al.*, ACS Nano **10**, 6315 (2016)
6. S. Ulstrup *et al.*, arXiv:1608.06023 (2016)
7. R. Bertoni *et al.*, arXiv:1606.03218 (2016)