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# HHG-laser-based time- and angle-resolved photoemission spectroscopy of quantum materials


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Time- and angle-resolved photoemission spectroscopy (TARPES) has played an important role in revealing the non-equilibrium electronic structures of solid-state materials. Moreover, the implementation of high harmonic generation (HHG) to obtain a higher photon energy also allows us to investigate the wide Brillouin zone on a time scale below 100 fs. In this presentation, I will talk about our recent studies on quantum materials using HHG-laser-based TARPES [1]. I will first highlight iron-based superconductors, namely $BaFe_2As_2$ [2] and FeSe [3]. We found significant time-dependent oscillations of photoemission intensities, which result from generations of coherent phonons. I will discuss the relation of this observation to lattice modulations and the possibility of photo-induced superconductivities. Then, I will move on to the ultrafast carrier dynamics of a quasi-crystalline 30° twisted bilayer graphene [4]. We found unbalanced electron distributions between the upper-layer and lower-layer Dirac cones in the ultrafast time scale. I will show the calculation results by solving rate equations to explain the observed dynamics, and discuss the possible mechanisms. Lastly, I will talk about $Ta_2NiSe_5$, which is regarded as a unique candidate for an excitonic insulator. We successfully revealed the dynamical behavior characteristic of an excitonic insulator, and the unexpected emergence of the photo-induced semimetallic state [5]. Furthermore, we investigated the underpinned mechanisms of this photo-induced insulator-to-metal transition by developing a novel analysis method, which we call frequency-domain ARPES (FDARPES) [6]. I will also talk about our very recent and ongoing research as well.



[1] T. Suzuki, et al., J. Electron Spectrosc. Relat. Phenom. **251**, 147105 (2021).
[2] K. Okazaki, et al., Phys. Rev. B **97**, 121107 (R) (2018).
[3] T. Suzuki, et al., Commun. Phys. **2**, 115 (2019).
[4] T. Suzuki, et al., ACS Nano **13**, 11981 (2019).
[5] K. Okazaki, et al., Nat. Commun. **9**, 4322 (2018).
[6] T. Suzuki, et al., Phys. Rev. B **103**, L121105 (2021).


Für diese Zeit steht eine Kinderbetreuung nach vorheriger Anmeldung zur Verfügung.


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