**First-principles investigations of nonequilibrium states of periodically driven black phosphorous**

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Recent advances in ultrafast spectroscopy open a route toward engineering new phase of solids with optical pumping. The nonequilibrium electronic states of solids driven by the electromagnetic field manifest novel topological states which don't exist at equilibrium conditions. Using first-principles calculations and Floquet theorem, we studied the dressed states of black phosphorous and graphene under periodic driving by laser. Intriguing photo-dressed electronic states including Floquet Dirac semimetals, Floquet topological insulators *etc* can be engineered in black phosphorous by changing the direction, intensity and frequency of incident laser [1]. The coexistence of type-I and type-II Floquet Dirac fermion (FDF) in graphene can be realized simultaneously, which can be monitored by simulating the pump-probe time and angular-resolved photoelectron spectroscopy. In the transition boundary between type-I and -II FDF, we found one critical type-III FDF, which could be utilized to achieve the highest Hawking temperature *T*H hitherto reported [2]. Our works demonstrate examples of the nonequilibrium topological states of two-dimensional materials by first-principles calculations, and open an avenue towards the Floquet engineering of quantum materials.

1. H. Liu *et al*., Phys. Rev. Lett. **120**, 237403 (2018).
2. H. Liu *et al*., arXiv: 1809.00479