O 72: Mini-Symposium: Coherent band structure engineering with light II

Time: Wednesday 13:30–15:30 Location: R2

Invited Talk O 72.1 Wed 13:30 R2

On the survival of Floquet-Bloch states in the presence of scattering — •Isabella Gierz — University of Regensburg, Institute for Experimental an Applied Physics

Floquet theory has spawned many exciting possibilities for electronic structure control. The experimental realization in solids, however, still largely remains pending. Despite the enormous potential for future applications, the influence of scattering on the formation of Floquet-Bloch states remains poorly understood. Here we combine time- and angle-resolved photoemission spectroscopy (tr-ARPES) with time-dependent density functional theory (TDDFT) and a simple two-level system with dissipation to investigate the survival of Floquet-Bloch states in the presence of scattering. We find that Floquet-Bloch states will be destroyed if scattering — activated by electronic excitations — prevents the Bloch electrons from following the driving field coherently. The two-level system also shows that Floquet-Bloch states reappear at high field intensities where energy exchange with the driving field dominates over energy dissipation to the bath. Our results clearly indicate the importance of long scattering times combined with strong driving fields for the successful realization of various Floquet phenomena.

O 72.2 Wed 14:00 R2

Ultrafast spin-dependent band structure renormalization of a molecular/2D semiconductor heterostructure by the formation of interlayer excitons — •Benito Arnoldi[1], Sebastian Hedwig[1], Sara Zachritz[2], Oliver L.A. Monti[2,3], Martin Aeschlimann[1], and Benjamin Stadtmüller[1] — [1]Department of Physics, University of Kaiserslautern, Erwin-Schroedinger-Strasse 46, Kaiserslautern 67663, Germany — [2]Department of Chemistry and Biochemistry, University of Arizona, Tucson, Arizona 85721, United States — [3]Department of Physics, University of Arizona, Tucson, Arizona 85721, United States

Engineering the spin-dependent band structure of atomically thin materials with ultra-short light pulses offers the intriguing possibility to control spin and charge carrier functionalities on smallest length and fastest time-scales. Here, we explore the transient band structure dynamics of a heterostructure between C_{60} and WSe_2 after optical excitation with fs light pulses. The ultrafast charge carrier dynamics of the interface is investigated by time-, spin- and angle-resolved photoemission spectroscopy. Resonant optical excitation of the molecular layer instantaneously results in the formation of excitons within the C_{60} layer. These excitons transform within 200 fs into interlayer excitons, which are trapped at the heterostructure interface for 14 ps. Most interestingly, the formation of the interlayer excitons coincides with a transient spin-dependent renormalization of the valence band structure of WSe_2. This transient spin texture modification is attributed to the charge transfer character to the interlayer excitons at the interface.

O 72.3 Wed 14:15 R2

Ultrafast Dynamical Lifshitz Transition — •Samuel Beaulieu[1,2], Shuo Dong[1], Nicolas Tancogne-Dejean[3], Maciej Dendzik[1,4], Tommaso Pincelli[1], Julian Maklar[1], R. Patrick Xian[1], Michael Sentef[3], Martin Wolf[1], Angel Rubio[3,5], Laurenz Rettig[1], and Ralph Ernstorfer[1] — [1]Fritz Haber Institute of the Max Planck Society, Faradayweg 4-6, 14195 Berlin, Germany — [2]Université de Bordeaux - CNRS - CEA, CELIA, UMR5107, F33405 Talence, France — [3]Max Planck Institute for the Structure and Dynamics of Matter, Luruper Chaussee 149, 22761 Hamburg, Germany — [4]Department of Applied Physics, KTH Royal Institute of Technology, Electrum 229, SE-16440, Stockholm, Kista, Sweden — [5]Center for Computational Quantum Physics (CCQ), The Flatiron Institute, 162 Fifth Avenue, New York NY 10010

Fermi surface is at the heart of our understanding of metals and strongly correlated many-body systems. An abrupt change in the Fermi surface topology, also called Lifshitz transition, can lead to the emergence of fascinating phenomena like colossal magnetoresistance and superconductivity. Combining time-resolved multidimensional photoemission spectroscopy with state-of-the-art TDDFT+U simulations, we introduce a novel scheme for driving an ultrafast Lifshitz transition in the correlated type-II Weyl semimetal T_d-$MoTe_2$. We demonstrate that this non-equilibrium topological electronic transition finds its microscopic origin in the dynamical modification of the effective electronic correlations.

Invited Talk O 72.4 Wed 14:30 R2

Light-induced anomalous Hall effect in graphene — •James McIver — Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany

Optical driving has been proposed as a means of engineering topological properties in topologically trivial systems. One proposal for such a "Floquet topological insulator" is based on breaking time-reversal symmetry in graphene through a coherent interaction with circularly polarized light [1]. This was predicted to lift the degeneracy of the Dirac point, opening a topological band gap in the resulting photon-dressed band structure accompanied by the formation of dressed chiral edge states [2]. In this talk, I will report on our recent observation of a light-induced anomalous Hall effect in monolayer graphene driven by an intense femtosecond pulse of circularly polarized light [3]. We probed electrical transport using an ultrafast device architecture based on photoconductive switches. The dependence of the anomalous Hall effect on a gate potential used to tune the equilibrium Fermi level revealed multiple features that reflect a Floquet-engineered topological band structure. This included an approximately 60 meV wide conductance plateau centered at the Dirac point, where a gap of equal magnitude was predicted to open. We found that when the Fermi level was tuned within this plateau, the estimated anomalous Hall conductance saturated around 1.8 +/- 0.4 e^2/h. [1] T. Oka & H. Aoki. Phys. Rev. B 79, 081406 (2009) [2] T. Kitagawa et al. Phys. Rev. B 84, 235108 (2011) [3] J.W. McIver et al. Nature Physics 16, 38 (2020)

O 72.5 Wed 15:00 R2

Observing Light-Induced Floquet Band Gaps in the Longitudinal Conductivity of Graphene — •Lukas Broers[1,2] and Ludwig Mathey[1,2,3] — [1]Center for Optical Quantum Technologies, University of Hamburg, 22761 Hamburg, Germany — [2]Institute for Laser Physics, University of Hamburg, 22761 Hamburg, Germany — [3]The Hamburg Center for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany

We propose optical longitudinal conductivity as a realistic observable to detect light-induced Floquet band gaps in graphene. These gaps manifest as resonant features in the conductivity, when resolved with respect to the probing frequency and the driving field strength. We demonstrate these features via a dissipative master equation approach which gives access to a frequency- and momentum-resolved electron distribution. This distribution follows the light-induced Floquet-Bloch bands, resulting in a natural interpretation as occupations of these bands. Furthermore, we show that there are population inversions of the Floquet-Bloch bands at the band gaps for sufficiently strong driving field strengths. This strongly reduces the conductivity at the corresponding frequencies. Therefore our proposal puts forth not only an unambiguous demonstration of light-induced Floquet-Bloch bands, which advances the field of Floquet engineering in solids, but also points out the control of transport properties via light, that derives from the electron distribution on these bands.

Open discussion