Ultrafast materials design with tailored light pulses

Isabella Gierz

Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany

The electronic properties of solids are mainly determined by the orbital overlap between neighbouring atoms. Therefore, electronic properties are commonly controlled via the chemical composition that determines the relevant structural parameters such as bond angles and lengths.

My group follows a different approach where control of the effective orbital overlap is achieved by periodic modulation of the solid with strong laser fields in the (mid-)infrared spectral range. We investigate the resulting band structure changes with time- and angle-resolved photoemission spectroscopy (tr-ARPES).

The stable crystal structure and therefore the band structure of a solid is determined by the deepest minimum on the potential energy surface. We follow three different approaches to modify the shape of the potential energy surface with light and thereby control the electronic properties of different low-dimensional materials:

I will present results on the light-induced insulator-to-metal phase transition in one-dimensional indium wires where strong electronic excitation quenches the minimum on the potential energy surface associated with the insulating ground state [1,2].

Next I will show how resonant driving of an infrared-active lattice vibration in bilayer graphene results in a transient enhancement of the electron-phonon coupling constant [3,4].

Recently, coherent modulation of the Bloch electron's momentum with strong light fields has emerged as a new route for dynamical band structure engieneering. There are predictions for various light-induced phase transitions including the formation of Floquet topological insulators [5] and Mott insulating states [6]. I will present our recent results concerning the observation of photon-dressed states in graphene and bulk WSe_2 and end with an outlook on future projects.

References

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