Optical properties of monolayer bismuthene, new topological 2D material

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Optical spectroscopy significantly enhanced our understanding of fundamental excitations in low-dimensional semiconductor materials characterized by a trivial topology of the bands. This includes observation of neutral and charged exciton complexes in widely studied semiconductors belonging to the transition-metal dichalcogenides family, including WS_2, WSe_2, MoS_2, $MoSe_2$ and $MoTe_2$. However, in recent years a new type of atomically thin materials appears, exhibiting exciting bandgap properties. It is expected that also in these new materials, strongly reduced dimensionality will lead to enhanced Coulomb correlations between electrons and holes reflected in the observed optical spectrum of such material.

In 2017, a new, atomically-thin material belonging to the family of topological insulators was synthesized [1]. The bismuthene is composed of Bi atoms arranged in the honeycomb lattice stabilized by the underlying SiC(0001) substrate. The large atomic number of bismuth atoms is translated onto a giant spin-orbit coupling responsible for the significant (~0.5 eV) Rashba splitting in the valence band and the opening of a substantial topological bandgap of ~1 eV in the material, as predicted by the theory.

In this presentation, we show that bismuthene shows a clear optical response at the room-temperature reflecting strong excitonic properties of the material. The utilized high-spatially-resolved photo-modulation experiment reveals a strong absorption-like optical transition at ~1.19 eV, ascribed to the fundamental excitonic transition A in the K/K' valley of the Brillouin zone. In addition, a second photo-modulated resonance appears at ~1.63 eV, which is attributed to the B exciton transition between the spin-orbit-split valence band and the conduction band at the K/K' valley. The experimentally obtained transition energies for A and B excitons agree very well with the theoretical simulations. These results pave the way for optical studies on strongly Coulomb-correlated fundamental excitations in 2D topological materials.

[1] F. Reis, G. Li, L. Dudy, M. Bauernfeind, S. Glass, W. Hanke, R. Thomale, J. Schäfer, R. Claessen, *Science* 357, 287 (2017).