seminars

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Nanociencia y Nanotecnología: lo pequeño es diferente

Nanoscience and Nanotechnology: small is different

seminar

Thursday December 1st

c/Faraday, 9
Conference Hall
Imdea Nanociencia
Ciudad Universitaria de Cantoblanco

10:00h

Photoexcited two-dimensional materials

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This talk comprises my recent results on the photoexcited electrons in graphene and two-dimensional (2D) transition-metal dichalchogenides. In general, the interband optical absorption in the direct-gap semiconductors is strongly influenced by excitons. The physics of excitons, electron-hole pairs that are bound together by their mutual Coulomb attraction, can to great extent be understood in the framework of the quantum-mechanical hydrogen model. This model has recently been challenged by spectroscopic measurements on 2D transition-metal dichalchogenides that unveil strong deviations from a hydrogenic spectrum. We develop an analytically solvable model able to qualitatively explain such non-hydrogenic exciton spectra. Our exciton Hamiltonian explicitly includes additional angular momentum associated with the pseudospin degree of freedom unavoidable in 2D semiconducting materials with honeycomb structure. We claim that this is the key ingredient for understanding the nonhydrogenic exciton spectra that was missing so far.

Graphene can be seen as a gapless semiconductor, where optical absorption is governed by the direct interband transitions. The photocarrier evolution in graphene is, however, highly nontrivial since the linear dispersion for carriers opens a highly efficient electron-electron (e-e) scattering channel, where all momenta involved are parallel (collinear e-e scattering). We propose an explicitly solvable model for collinear scattering of photoexcited carriers in intrinsic graphene irradiated by monochromatic light. The result agrees with the recent numerical prediction [Nat. Commun. 7, 11617 (2016)], where calculations have been performed in full 2D momentum space with all collinear and noncollinear electron-electron scattering processes included. The agreement between the full two-dimensional model and our approximate one-dimensional approach suggests that collinear electron-electron collisions indeed dominate photocarrier thermalization as long as the optical phonon emission is suppressed. This paves the way towards correct assessment of the photocarrier thermalization dynamics in graphene-based optoelectronic devices.

Please refer to the following papers for details:

1. M. Trushin, M. O. Goerbig, W. Belzig, Optical Absorption by Dirac Excitons in Single-Layer Transition-Metal Dichalcogenides, Phys. Rev. B 94, 041301(R) (2016).

2. M. Trushin, Collinear scattering of photoexcited carriers in graphene, Phys. Rev. B 94, 205306 (2016).