TECHNISCHE UNIVERSITÄT WIEN

INSTITUT FÜR FESTKÖRPERPHYSIK
Institute of Solid State Physics

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EINLADUNG zum IFP-SEMINAR

Light-matter interaction in the quantum flatland: fundamentals and applications

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Host: Alexey Shuvaev

Termin: Mittwoch, 15. Juni 2022, 16:00 Uhr CEST

Ort: Institut für Festkörperphysik, TU Wien
Wiedner Hauptstraße 8-10, 1040 Wien
Seminarraum DC rot 07 (roter Bereich, 7. OG)

Abstract:

Understanding the physical properties of novel low-dimensional quantum materials has recently emerged as a critical challenge necessary to furthering condensed matter physics, material science, and quantum technology. In this talk, we will discuss that in quantum materials, a peculiar interplay between strong interactions, band geometry and topology, and reduced dimensionality in a unique way determines the response of such systems to external fields thereby offering a powerful setting by which to probe novel light-matter interaction effects and develop practical optoelectronic devices.

In the first (fundamental) part of my presentation, I will present our recent measurements of the quasi-relativistic Fizeau drag effect [1]. Predicted by Fresnel in the XIX century and demonstrated by Fizeau, the dragging of light by the flow of water was among the cornerstones of Einstein's special relativity. Our experiments on graphene materialized the electronic version of this fundamental effect in which the flow of electrons on par with the moving medium was found to alter the light dispersion (Fig. 1). Unlike the Fizeau effect for light, the SPP drag by electrical currents defies explanation by simple kinematics and is linked to the nonlinear electrodynamics of Dirac electrons in graphene. The observed plasmonic Fizeau drag enables the breaking of time-reversal symmetry and reciprocity at infrared frequencies without resorting to magnetic fields or chiral optical pumping. The Fizeau drag also provides a tool with which to study interactions and nonequilibrium effects in electron liquids.

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In the second (applied) part of my talk, I will show that with proper processing, atomically thin high-temperature cuprate superconductors can be used in single-photon detection technology. We will discuss how to fabricate superconducting nanowires out of thin flakes of Bi2Sr2CaCu2O8+δ (BSCCO) and La1.55Sr0.45CuO4/La2CuO4 (LSCO-LCO) bilayer films and, then, look into their response to visible and infrared light. I will show, that both materials feature single-photon operation above liquid helium temperature as revealed through the linear scaling of the photon count rate on the radiation power. For the BSCCO detectors, we observed single-photon sensitivity at the technologically important 1.5 μm telecommunications wavelength up to 25 K.

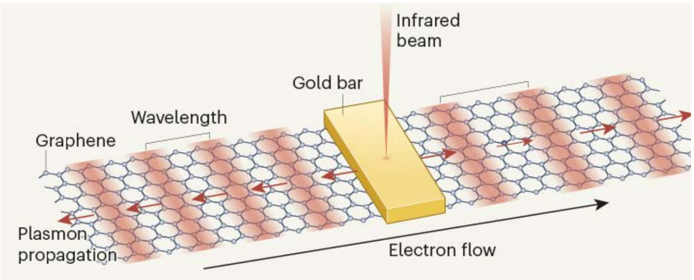

Fig. 1. Plasmons in graphene are dragged by drifting electrons. Image credit: Nature 594, 498-499 (2021), News and Views.

[1] Y. Dong, L. Xiong, I. Y. Phinney, Z. Sun, R. Jing, A. S. McLeod, S. Zhang, S. Liu, F. L. Ruta, H. Gao, Z. Dong, R. Pan, J. H. Edgar, P. Jarillo-Herrero, L. S. Levitov, A. J. Millis, M. M. Fogler, D. A. Bandurin & D. N. Basov, Fizeau drag in graphene plasmonics. Nature 594, 513–516 (2021).
[2] I.A. Charaev, D. A. Bandurin, et al. Single-photon detection using high-temperature superconductors, to appear on arxiv soon (2022).