PHOTOCURRENTS IN GRAPHENE AND CARBON NANOTUBES

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In my talk, I review experimental and theoretical investigations of photogalvanic effects induced in graphene and carbon nanotubes. The following items are planned to be discussed:

1. Photon drag effect induced in single-layer graphene under oblique incidence of the laser light, in the terahertz and infrared frequency regions [1, 2]. For the terahertz radiation the photon drag effect can be considered as a dynamic Hall effect. The special attention is paid to the circular drag photocurrent dependent on the radiation helicity and inverting its polarity under reversal of the circular polarization.
2. Terahertz radiation driven chiral edge currents in graphene induced in single layer graphene samples by illumination of the graphene edges with circularly polarized terahertz radiation at normal incidence [3].
3. Pure valley currents induced under the homogeneous normal-incidence photoexcitation of graphene [4]. The intravalley current appears because of the reduced symmetry D_{3h} of the valleys K and K', while the net electric current is forbidden by the overall D_{6h} point-group symmetry of graphene.
4. Photogalvanic properties of graphene superlattices (SLs) formed by periodic strain [5]. Asymmetric graphene SLs act as quantum ratchets and allow helicity-dependent photocurrents under normal incidence.
5. Effects inherent for chiral carbon nanotubes: circular photogalvanic effect (PGE), magneto- induced linear PGE, natural circular dichroism, magneto-spatial dispersion of light absorption, magneto-chiral *dc* electric current quadratic in the bias voltage applied to a chiral nanotube [6, 7].

[1] J. Karch, P. Olbrich, M. Schmalzbauer, C. Zoth, C. Brinsteiner, M. Fehrenbacher, U. Wurstbauer, M.M. Glazov, S.A. Tarasenko, E.L. Ivchenko, D. Weiss, J. Eroms, R. Yakimova, S. Lara-Avila, S. Kubatkin, S.D. Ganichev, Phys. Rev. Lett. **105**, 227402 (2010).
[2] Chongyun Jiang, V.A. Shalygin, V.Yu. Panevin, S.N. Danilov, M.M. Glazov, R. Yakimova, S. Lara-Avila, S. Kubatkin, S.D. Ganichev, Phys. Rev. B **84**, 125429 (2011).
[3] J. Karch, C. Drexler, P. Olbrich, M. Fehrenbacher, M. Hirmer, M.M. Glazov, S.A. Tarasenko, E.L. Ivchenko, B. Birkner, J. Eroms, D. Weiss, R. Yakimova, S. Lara-Avila, S. Kubatkin, M. Ostler, T. Seyller, S.D. Ganichev, Phys. Rev. Lett. **107**, 276601 (2011).
[4] L.E. Golub, S.A. Tarasenko, M.V. Entin, L.I. Magarill, Phys. Rev. B **84**, 195408 (2011).
[5] L.E. Golub, Yu.Yu. Kiselev, Phys. Rev B **84**, 235440 (2011).
[6] E.L. Ivchenko, B. Spivak, Phys. Rev. B **66**, 155404 (2002).
[7] E.L. Ivchenko, B. Spivak, Physica E **17**, 366 (2003).