ТЕЗИСЫ ДОКЛАДОВ

МЕЖДУНАРОДНАЯ КОНФЕРЕНЦИЯ

**«Физическая мезомеханика.
Материалы с многоуровневой иерархически организованной структурой и интеллектуальные производственные технологии»,**

посвященная 90-летию со дня рождения
основателя и первого директора ИФПМ СО РАН
академика Виктора Евгеньевича Панина

в рамках
Международного междисциплинарного симпозиума
«Иерархические материалы: разработка и приложения для новых технологий и надежных конструкций»

5–9 октября 2020 года
Томск, Россия

Томск
Издательство ТГУ
2020

DOI: 10.17223/9785946219242/305

MAGNETO-OPTIC CONDUCTIVITY AND TRANSPORT PROPERTIES OF BILAYER GRAPHENES IN THE EXTERNAL FIELDS WITH BROKEN SYMMETRY OF THE GROUND STATE

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We present the results of the theoretical study of influence of the different representations of the ground state energy of bilayer graphene [1,2] with the energy gap, which depends on a choice of spin $s = \pm h/2$ and valley ξ variables in the Dirac K (ξ=1) and K' (ξ=-1) points in its quasiparticle energy spectrum on bilayer's longitudinal and Hall optic conductivities both AA, and AB-stacked graphene on a base of low-energy quantum electrodynamics approach in (2+1)-dimensional space-time.

Exact analytical expressions for the optical (circular) conductivities $\sigma_{\pm}$ in the external electric (with the gap of 50-250 meV) and magnetic fields (3-10 Tesla) are deduced with help of four-bandc помощью 4-зонного microscopic Dirac type Hamiltonian being linear in the covariant derivatives (with the magnetic field potential to be perpendicular to the graphene layers)

$$H = \xi \begin{pmatrix} \Delta_{\xi s} & \gamma_3 v_F \pi/\gamma_0 & \gamma_4 v_F \pi^+/\gamma_0 & v_F \pi^+ \\ \gamma_3 v_F \pi^+/\gamma_0 & -\Delta_{\xi s} & v_F \pi & \gamma_4 v_F \pi/\gamma_0 \\ \gamma_4 v_F \pi/\gamma_0 & v_F \pi^+ & -\Delta_{\xi s} & \gamma_1 \\ v_F \pi & \gamma_4 v_F \pi^+/\gamma_0 & \gamma_1 & \Delta_{\xi s} \end{pmatrix} \text{ for } \Delta_{\xi s} = U + \xi \Delta_T + s U_T + \xi s \Delta \qquad (1)$$

(different for AA and AB-stacking with account of trigonal spectrum distortion (γ_3). Obtained conductivities according to Kubo's formulas [4] specify Falkovsky results [3] for the case of general energy gap $\Delta_{\xi s}$ (1). They include dependences on temperature and chemical. The limiting case of the direct current and the relationships between $\sigma_{\pm}$ and Kerr and Faradey for the composite systems with the layers from AB (AA)-graphene are derived. The influence of the impurities on the conductivities behavior on the basis of the exact Green's function for two-band Hamiltonian of AB-graphene. The results predict a number of regimes for the ground states with broken global symmetry with respect to unitary U(4) group with the state's realizations under external fields control, for using in nano- and microelectronics on a base of graphene devices.

In the particular, we present the following kinds of the ground states within 4-band model, when choosing of the concrete form of the gap, [6,7]: *Quantum Valley Hall* (QVH) *State* for $\Delta_{\xi s} = U$; *Layer antiferromagnetic* (LAF) when $\Delta_{\xi s} = U_T$; *Quantum Anomalus Hall* (QAH) *State* when $\Delta_{\xi s} = \Delta_T$; *Quantum Spin Hall* (QSH) *State* when $\Delta_{\xi s} = \Delta$, with the respective order parameters, which composed rom the quadratic combinations from the components of wave functions for the Schrodinger equations with the Hamiltonian (1). These order parameters are characterized by the fact that they or preserve the reversal tine symmetry for the ground state, as for *H* (for LAF and QAH), or do not preserve (as for QVH and QSH states). We analyze the stability of each from the ground states as well as of some combinations for the mixed form of gap under external electric and magnetic fields response for the choice of realization of the digital kind of data transmission, storing for storage and transmitting elements on the graphene base.

In the case of elastic or non-elastic deformed graphene bilayer the parameters γ_i in the Hamiltonian (1) в гамильтониане are modified for the account of system response on the mechanical loading, which, in turn, influences on the electric bilayer conductivities. The non-elastic mechanical impact takes into account of the Stone−Wales defect appearance, as well as of the dislocations and its impact on the change of the electric and heat conducting properties of the AB bilayer on a base of exact matrix Green's function for the quasiparticle (not coinciding with the scalar metallic Green's function).

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