COHERENT PHASES IN GRAPHENE AND GRAPHENE BASED NANOSTRUCTURES

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We discuss coherent electronic phases and collective phenomena in graphene and graphene based nanostructures, in particular peculiarities connected with graphene interesting electronic properties similar to ultrarelativistic physics.The collective properties of different types of quasiparticles in graphene is considered: 2D spatially indirect magnetoexcitons in two-layer graphene, magnetoexcitonic polaritons (magnetopolaritons) in a graphene layer embedded in an optical microcavity in a strong magnetic field and 2D indirect magnetobiexcitons in a slab of superlattice of graphene layers. We predict Bose-Einstein condensation (BEC) and superfluidity of indirect magnetoexcitons, indirect magnetobiexcitons and BEC of magnetoexcitonic polaritons in a strong magnetic field. Strongly correlated phases of of magnetoexcitons in bilayer graphene is predicted.

Besides BCS regime strong coupling regime is discussed for e-h pairing in bilayer separately biased graphene layers without magnetic field. The suppression of superfluid density and Kosterlitz-Thouless transition temperature by impurities is considered. The e-h condensation in coupled graphene sheets can be observed through Josephson-like phenomena etc. and can be used as nondissipative nanolectronic element.

Phonons and possible superconductivity in strongly doped graphene are analyzed.

The effective Hamiltonian of the gas of cavity polaritons in a graphene layer in high magnetic field are obtained and the BEC temperature as functions of magnetic field is calculated. A 2D gas of magnetopolaritons is considered in a harmonic potential trap and possible physical realizations of this are discussed.

Plasma oscillations, plasmon polaritons and instabilities in graphene and graphene array are discussed.

Quantum dots, nanotransistors and new type of nanoelements based on graphene are discussed.

The method of calculations of nanoelements based on graphene by generalized density functional approach for system with “ultrarelativistic” electronic spectra are developed. Possible NEMS based on graphene are analyzed.

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