

BCS pairing of electrons and holes in graphene bilayers and films of topological insulators

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Bilayer electron systems with Dirac spectrum of carriers are considered as perspective ones for a realization of BCS pairing of electrons and holes and for an observation of a counterflow superconductivity (for which a supercurrent in one layer is accompanied by an oppositely directed supercurrent in the other layer).

In this report we present the results of computation of critical temperature with reference to a number of systems.

The first one is a graphene-based heterostructure where two graphene layers are separated by a thin dielectric layer and subjected by a perpendicular to the layers magnetic field B . Under certain conditions a state given by a BCS-like wave function that describes pairing of filled electron states in one graphene layer with empty electron state in the other layer in 0-th Landau level (LL) can be realized. It is shown that due to an addition four-fold degeneracy of LL in graphene such a state is realized if an imbalance of filling factors of the layers is created by an electrical field applied normally to the structure. Critical temperature is a nonmonotonic function of B and is maximum at $B \sim 0.5\phi_0/\pi d^2$, where ϕ_0 is the magnetic flux quantum, and d is the distance between graphene layers.

Another system under study is a thin topological insulator (TI) plate placed on a dielectric substrate. This system subjected by normal to the plate magnetic field may also demonstrate magnetoexciton superfluidity. The role of two-dimensional conducting layers is played by two surfaces of TI plate. In difference with the previous case, it is not required to apply normal to the TI plate electrical field.

In zero magnetic field both these systems may demonstrate BCS pairing of carrier from electron and hole subbands. The effect takes place under application of an electrical field normal the structure. This field controls the Fermi energy level V_g in the subbands. The critical temperature is a nonmonotonic function of V_g and strongly depends on d .