Transport properties of quantum Hall bilayers with Andreev contacts

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Transport in bilayer systems has recently received increasing attention due to possibility of observing of quantum macroscopic order. The effect can be realized in AlGaAs double quantum wells, in graphene heterostuctures and in topological insulator (TI) plates. In such systems an electron from one well (graphene layer, TI surface) couples with a hole from the other one. Thereby spatially indirect excitons are formed. These quasiparticles are bosons and they may condense becoming the careers for the counterflow supercurrents.

Transport properties of such systems are quite unusual. The effects of negative drag of current and transformation of voltage at nanoscale are expected [1].

A strong magnetic field applied perpendicular to the bilayer system favors the exciton superfluidity for the total filling factor of Landau levels close to $\nu_T = 1$. Most of experimental studies of coherent exciton states in bilayers were done just for quantum Hall systems.

In this report we analyze interlayer drag of current and interlayer transformation of voltage in quantum Hall bilayers. Our model accounts the contact resistance caused by Andreev-like reflection at the interface between the coherent exciton and normal areas, and the contribution of charged vortexes (merons) to normal conductivity and counterflow resistivity (as described in the phenomenological model [2]).

We analyze transport properties with reference to the Hall bar and Corbino disk geometries. It is found the second one is more appropriate for the observation of negative drag and voltage transformation.The effect of the filling factor imbalance on interlayer drag and voltage transformation is also considered.

The model developed describes a number of experimentally observed features in quantum Hall bilayers.

1. H.Soler, F.Dolcini, A.Komnik, e-print arXiv:1203.0455 (2012).
2. D.V.Fil and S.I.Shevchenko, Phys. Lett. A **374**, 3335 (2010).