# Dissipationless drag effect in double-layer graphene systems

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We consider a double-layer graphene system in the superconducting state. Assuming that each layer has a background flow which varies little and that the dynamics of the superconductor near $T = 0$ is the same as that of a normal fluid, we obtain the dispersion relations for the collective modes in the presence of background flow. Decomposing the background flow into two parts, the center-of-mass flow and counterflow, we focus on the properties of the counterflow. We first find an estimate of the change in the zero-point energy $\Delta E^0$ due to counterflow for a unit area of double layers making use of the collective mode dispersions. Combining this with the free energy $F$ of the system and taking the partial derivatives with respect to background velocities in the layers, we determine the current densities which reveal the fact that current in one layer does not only depend on the velocity in the same layer but also on the velocity of the other layer. This is the drag effect and we calculate the drag coefficient for the double-layer graphene system. We compare our results with those in semiconductor double-layer electron systems.[1, 2, 3]

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