Excitonic superfluid phase in Double Bilayer Graphene

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Spatially indirect excitons can be created when an electron and a hole, confined to separate layers of a double quantum well system, bind to form a composite Boson. Because there is no recombination pathway such excitons are long lived making them accessible to transport studies. Moreover, the ability to independently tune both the intralayer charge density and interlayer electron-hole separation provides the capability to reach the low-density, strongly interacting regime where a BEC-like phase transition into a superfluid ground state is anticipated [1,2]. Here we report observation of the exciton condensate (EC) in the quantum Hall effect regime of double layer structures of bilayer graphene [3]. Correlation between the layers is identified by quantized Hall drag appearing at matched layer densities, and the dissipationless nature of the phase is confirmed in the counterflow geometry. Independent tuning of the layer densities and the displacement field reveals a selection rule involving both the orbital and valley quantum number between the symmetry-broken states of bilayer graphene and the condensate phase, while tuning the layer imbalance stabilizes the condensate to temperatures in excess of 4K. Additionally, EC phase is observed for the first time beyond total filling fraction of one as well as in the electron-hole regime.

References

[1] Y. E. Lozovik and V. Yudson, JETP Lett. 22, 274 (1975).
[2] M. B. Pogrebinsky, Fiz. Tekh. Poluprovodn 11, 637 (1977).
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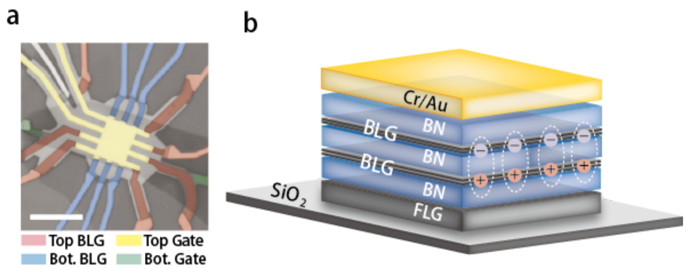

Figure 1: (a) Optical image of a double-bilayer graphene device, with graphite contact and local graphite back gate. The scale bar is 10 nm. (b) Cartoon cross-section of our device construction.

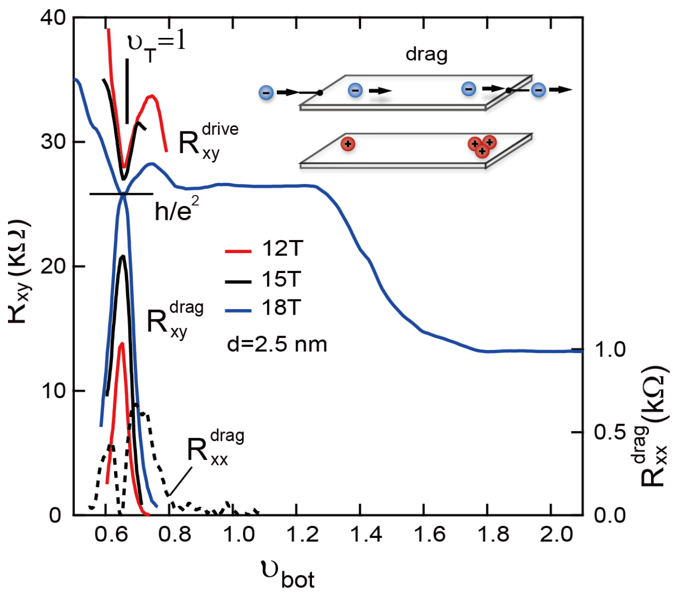

Figure 2: Linecut of the magneto-resistance of the drive and drag layers at vT=1.