Two Observations of an Exciton Condensate in Double Bilayer Graphene

Collaboration A: J.I.A. Li[1], T. Taniguchi[2], K. Watanabe[2], J. Hone[1], C.R. Dean[1],
1. Columbia University; 2. National Institute for Materials Science, Japan.

Collaboration B: X. Liu[3], K. Watanabe[4], T. Taniguchi[4], B. Halperin[3], P. Kim[3]
3. Harvard University; 4. National Institute for Materials Science, Japan.

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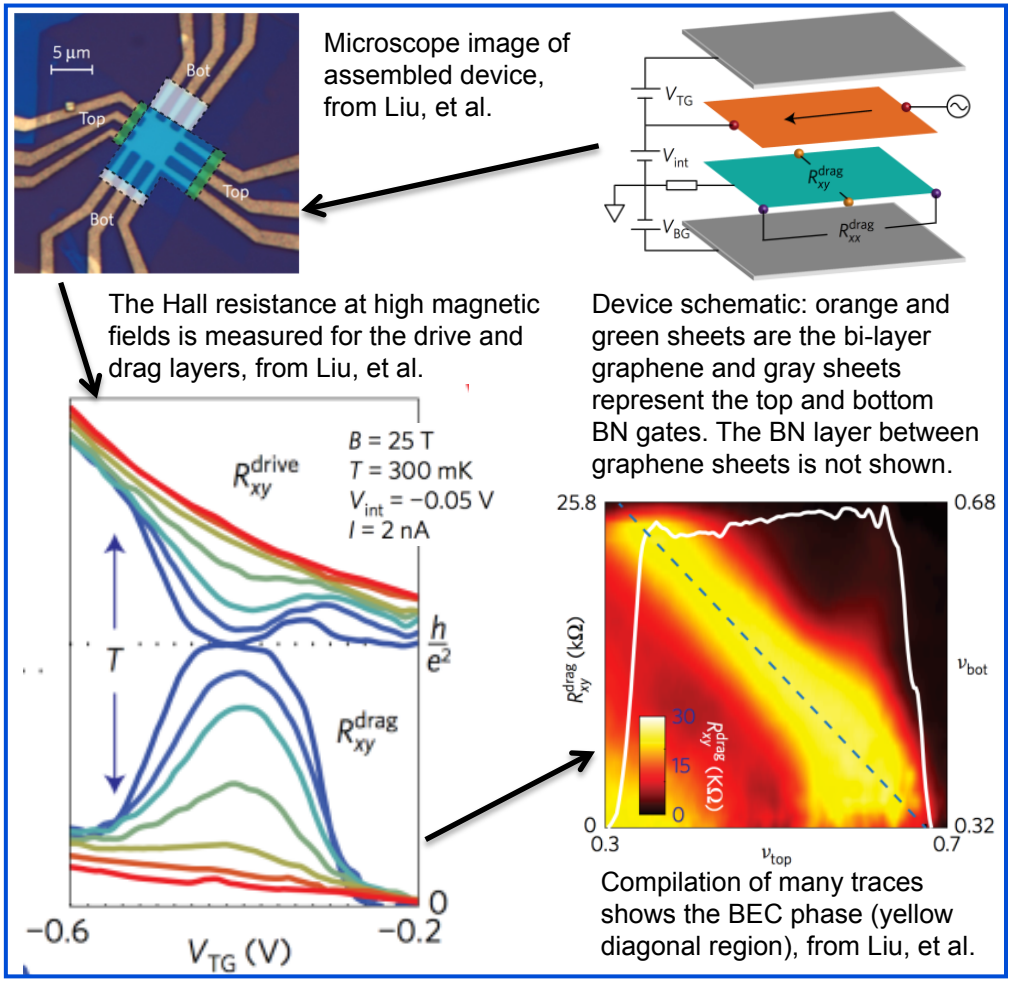
An exciton is created when an electron and a hole become bound together through the coulomb interaction. Recently, two independent teams used MagLab facilities to observe long-lived excitons in new double-layer electron systems, realized by alternating bi-layer graphene and hexagonal boron nitride (BN) sheets. Under a high magnetic field, electron-like and hole-like quasiparticles emerge from partially filled Landau levels in each graphene sheet. These can bind into long-lived excitons by Coulomb attraction across the middle layer of BN. *In the quantum Hall regime at high magnetic fields and low temperatures, the excitons, which are bosons, were observed to form a Bose-Einstein Condensate (BEC) phase.*

Exciton pairs are observed by driving a current through only one of the graphene layers (the "drive" layer), which produces a sizeable and nearly quantized Hall voltage in the other ("drag") layer at low temperatures (blue traces at 300mK). Here, the quantum Hall resistance, R_{xy}, becomes equal to h/e^2 in both the drive and drag layers. The quantization of these two values of the Hall resistance - coupled with the observation of the longitudinal resistivity in the drag layer, R_{xx}(drag), dropping to zero - provides strong evidence for the transition to an exciton condensate.



Facilities: DC Field Facility, Cell 9: 31 T resistive magnet; SCM 1: 20 T SC magnet with dilution refrigerator.

Citations: Collaboration A: *Excitonic superfluid phase in double bilayer graphene*, J.I.A Li, T. Taniguchi, K. Watanabe, J. Hone and C.R. Dean, **Nature Physics**, doi:10.1038/nphys4140. **Collaboration B:** *Quantum Hall drag of exciton condensate in graphene,* Xiaomeng Liu, Kenji Watanabe, Takashi Taniguchi, Bertrand Halperin and Philip Kim, **Nature Physics**, doi:10.1038/nphys4116.