Prediction of exciton condensation in biased bilayer graphene.

Harley D. Scammell[a], Oleg P. Sushkov[a]

[a]*School of Physics, the University of New South Wales, Sydney, NSW, 2052, Australia.*

An exciton, a bound state of electron and hole, can exist as an excitation in a band insulator. At a sufficiently strong electron-hole binding, the band structure is destroyed and excitons condense into a correlated superfluid liquid forming the novel quantum state of matter, the exciton insulator.

While excitons have been observed in numerous experiments, observation of an exciton condensate (exciton insulator) remains an open problem.

In the present work we have developed a novel theoretical method for analysis of exciton insulators in two-dimensional materials. Using this method we determine conditions necessary for the condensation.

Previous theoretical approaches addressed the quantum phase transition (QPT) from **metal** to **exciton insulator**. Analysis of this problem necessarily involves uncontrolled approximations. Instead, we consider the QPT from **band insulator** to **exciton insulator** and show that this analysis is fully controlled.

As an example we consider a bilayer graphene (BLG). In BLG the band gap can be tuned by external electric bias within the wide range 0-150meV. We predict that at appropriate tuning suspended BLG undergoes quantum phase transition from band insulator to excition insulator. The corresponding critical temperature Tc depends on the band gap value, see Fig.1, reaching up to 70K. In the semi-metallic state,

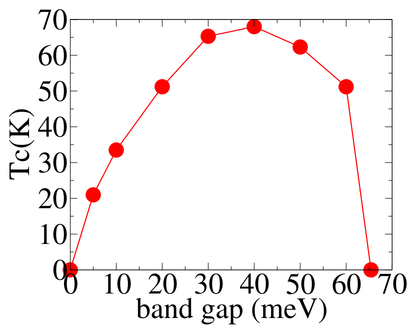

Figure 1: Berezinskii Kosterlitz Thouless temperature versus the band gap.

$\Delta = 0$, the critical temperature is very small. We argue that this is the generic situation and this explains why experimental searches of the effect have been unsuccessful so far.

We also discuss how the QPT in BLG can be observed using the quantum capacitance method.