Magneto-exciton instability and quantum Hall breakdown in graphene

Emmanuel Baudin[1]
Aurélien Schmitt[1], Michael Rosticher[1], Takashi Taniguchi[2], Kenji Watanabe[2], Gwendal Fève[1], Jean-Marc Berroir[1], Gerbold Ménard[1], Christophe Voisin[1], Mark-Oliver Goerbig[3] and Bernard Plaçais[1]
[1]*Laboratoire de Physique de l'ENS, Paris, France*
[2]*National Institute for Materials Science, Tsukuba, Japan*
[3]*Laboratoire de Physique des Solides, Orsay, France*
emmanuel.baudin@phys.ens.fr

In this talk, I will present our study of the velocity-induced breakdown of the integer quantum Hall effect (QHE) in monolayer graphene [1]. Low-bias quantum Hall transport is notoriously described in terms of single-electron physics. The situation is different at large bias where electrons can couple to large-momentum collective excitations (magneto-excitons). It was previously revealed in bilayer graphene using radiofrequency shot noise [2] that an intrinsic drift-velocity limit of QHE is the collective magneto-exciton instability, with breakdown velocities mimicking the single-particle Zener inter-Landau-level tunnelling mechanism.
Using the same technique, we demonstrate in this work that the magneto-exciton instability takes a very different form in relativistic single-layer graphene, with a doping- and magnetic field-independent breakdown velocity. Based on theoretical calculations of the excitations spectra [3], we show that this instability takes place at a phase-velocity which is solely controlled by the strength of the interactions and is determined by a value of the magneto-exciton conductivity equal to a universal fraction of the Hall conductance.

References

[1] A. Schmitt et al. , arXiv:2302.14791 (2023)
[2] W. Yang et al. , Phys. Rev. Lett. 121, 136804 (2018)
[3] R. Roldan et al. , Phys. Rev. B 80, 085408 (2009)

Figures

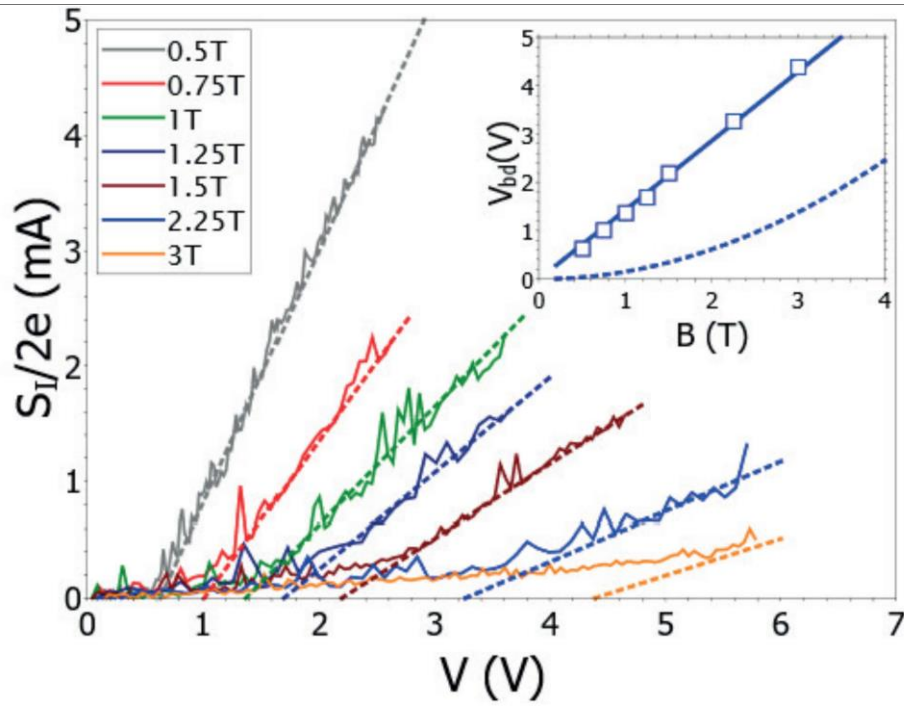

Figure 1: Breakdown shot noise as function of bias voltage, measured at a fixed charge carrier density n=2.10^{12} cm^{-2} for magnetic fields between 0.5T and 3T in a graphene transistor. Breakdown is signalled by a strong increase of noise. Inset shows the linear increase of breakdown voltage with B-field (blue line corresponding to a constant breakdown velocity v_{BD}=0.14v_F), that strongly deviates from the Zener inter-Landau-level tunnelling (dashed line).