Non-Classical Longitudinal Magneto-Resistance in Anisotropic Black Phosphorus

F. Telesio,[1] N. Hemsworth,[2] W. Dickerson,[2] M. Petrescu,[3] V. Tayari,[2] Oulin Yu,[3] D. Graf,[4] M. Serrano-Ruiz,[5] M. Caporali,[5] M. Peruzzini,[5] M. Carrega,[1] T. Szkopek,[2] S. Heun,[1] and G. Gervais[3]

[1] *NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, I-56127 Pisa, Italy*
[2] *Department of Electrical and Computer Engineering, McGill University, Montréal, Québec, H3A 2A7, Canada*
[3] *Department of Physics, McGill University, Montréal, Québec, H3A 2T8, Canada*
[4] *National High Magnetic Field Laboratory, Tallahassee, FL 32310, United States*
[5] *Istituto Chimica dei Composti OrganoMetallici-CNR, I-50019 Sesto Fiorentino, Italy*

Resistivity measurements of few-layer black phosphorus (bP) in a parallel magnetic field up to 45 T are reported as a function of the angle between the in-plane field and the crystallographic directions of the bP sample, see Fig. 1. Both a transverse magneto-resistance (TMR, $\varphi = \pm 90°$) and a classically-forbidden longitudinal magneto-resistance (LMR, $\varphi = 0°$) are observed. Surprisingly, they are both found to be strongly anisotropic as well as non-monotonic with increasing field. While an explanation of the low magnetic-field behavior can be found in the strong (Anderson) localization framework, the strong *positive* LMR overcoming the TMR above ~ 30 T field is inconsistent with such scenario. Considering the known anisotropy of bP, whose zigzag and armchair effective masses differ by a factor of approximately seven, our experiments provide a key test for LMR scenarios based on an anisotropic Fermi surface, as proposed by Pal and Maslov [1].

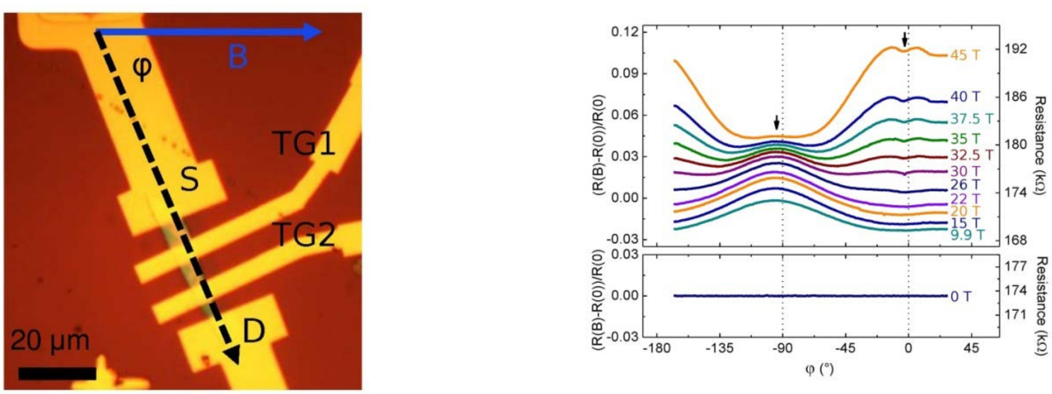

***Fig. 1**: Left: optical microscopy image of the device with labeling of source (S) and drain (D) contacts, top gates TG1 and TG2, as well as the definition of the angle φ as the angle between source-drain and the magnetic field (B) axis. Right top: Magneto-resistance, defined as (R(B) - R(0)) / R(0), vs. the in in-plane angle of rotation φ at various magnetic fields is shown in left axis. The raw resistance value is displayed on the right axis. Right bottom: Zero-field resistance value measured versus in-plane rotation angle φ.*

References

[1] H. K. Pal and D. L. Maslov, Phys. Rev. B **81**, 214438 (2010).