Field-effect transistors on 2D magnetic semiconductors

Alberto Morpurgo
University of Geneva, 24, quai Ernest-Ansermet, Geneva, Switzereland
alberto.morpurgo@unige.ch

Since the demonstration that magnetism persists in individual monolayers of van der Waals magnetic materials, transport measurements have proven to be a powerful technique to map the magnetic phase diagram as a function of magnetic field, temperature and thickness. In most cases, "vertical" transport measurements (i.e., measurements of current perpendicular to the layers) have been performed using the magnetic materials as tunnel barriers. Very limited work has focused on in-plane transport measurements using field-effect transistors, even though these devices are of extreme interest, as they allow the transport – and possibly the magnetic –properties to be tuned electrostatically with a gate. The reason for this is that the vast majority of compounds investigated in the first generation of 2D magnetic materials are semiconductors with extremely narrow bands (~100 meV), in which carriers localization effects dominate and prevent the measurement of in plane transport over any sizable distance.

In this talk, I will discus field-effect transistor measurements on different compounds having a bandwidth of 1 eV or larger, in which transport can be probed all the way down to cryogenic temperatures, deep in the magnetic phases of the 2D magnetic semiconducting materials used. I will first discuss the case of CrSBr, in which measurements reveal an astounding anisotropy of the transport properties, suggesting that the material behave as a collection of incoherently coupled 1D chains. I will then move to discuss experiments on CrPS4, in which a very large and gate-tunable magnetoconductance is observed, and in which the magnetic state itself can be controlled by the application of a gate voltage. IN this case, the analysis of the transistor characteristics as a function of temperature and magnetic field allow us to reveal the microscopic mechanism responsible for the large magnetoconductance observed.