Investigation of the electronic and spin properties of novel quantum materials for future spintronic applications

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The discovery of graphene and further of topological insulators, mark the turnover in modern science when the high energy physics concepts start to be observed in condensed matter: Dirac dispersion is characteristic of the electronic states of graphene and of topological insulators, Weyl dispersion characterizes topological semimetals, exotic topological phases are also expected to host Majorana fermions.

From the practical point of view, all these materials are highly appealing for future electronic and particularly spintronic applications, not only due to their inherent low-dimensionality, but also due to the strong impact of spin-orbit interaction on their electronic properties where spin-polarized conduction immune to scattering is expected and spin-polarized electrons are naturally present in the material electronic band structures.

We propose the investigation of the electronic properties of nano-engineered topological insulators and related low dimensional materials such as transition metal (di)chalcogenides, Weyl semimetals as well as two dimensional electron gases created on the surfaces of different oxide materials by exploiting fully the potential of the APE beamline at Elettra and of the high-resolution/low-T STM laboratory, both operating within CNR-IOM, Trieste. This implies the utilization of the growth facilities (PLD and MBE) for the realization of nanoengineered materials and the utilization of techniques such as XPS, XAS/XMCD, STM, ARPES and spin-resolved ARPES for characterizing their structural, electronic and spin properties.

The available growth facilities allow to fine-tune the materials properties and explore their evolution as function of different parameters such as doping, strain and interfacing with other materials. The available growth and analytical tools represent a unique asset for complete control and characterization of the material electronic properties.

Furthermore, the students will also have the possibility to apply for and participate to the complementary experiments in other laboratories, in particular synchrotron radiation facilities world-wide, thus gaining the competences crucial for the realization and operation of recently initiated Elettra 2.0.