Helical Superconductivity and the Anomalous Josephson Effect

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The interplay of spin-orbit coupling (SOC) and the Zeeman effect due to a magnetic field plays an important role in spintronics and in the realization of so-called topological superconductivity. The aim of our project is to theoretically study this interplay in novel materials such as transition metal dichalcogenide monolayers (TMDC) – two-dimensional systems similar to graphene but with two different atoms in the unit cell. They host a strong intrinsic SOC, often called Ising SOC, which acts as an effective Zeeman field perpendicular to the plane of the material and having opposite orientations at the two corners of the Brillouin zone, K and K'=-K (Fig.1).

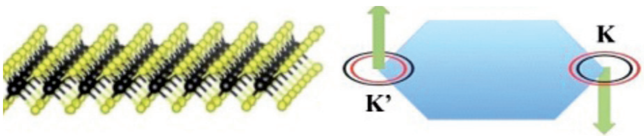

Fig. 1: Left: Crystal lattice of TMDC monolayers. Right: Schematic representation of the Ising spin-orbit coupling.

The Ising SOC plays a very important role in TMDC superconductors, where it causes unconventional pairing of Cooper pairs and, as a consequence, a great enhancement of the upper critical field [1]. We are interested in the properties of these "Ising superconductors" and their Josephson junctions, the effect of disorder on those properties, as well as possible topological superconducting phases that might appear and the ways to probe them.

OUTCOMES

[1] Enhancement of the upper critical field in disordered transition metal dichalcogenide monolayers, Phys. Rev. Lett 119, 117001 (2017).

[2] Weak localization in transition metal dichalcogenide monolayers and their heterostructures with graphene (in preparation).

Oral presentations:

Workshop "Superconductivity, spintronics and beyond", Grenoble, 14.11.2017
GDR meeting "Physique Quantique Mesoscopique", Aussois, 05.12.2017
Spring school "Transport in Nanostructures", Capri, 19.04.2018