"**Using Majorana Polarization and other local order parameters to predict and detect solid state exotic phases**"

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Over the past few decades, the development of various experimental techniques such as the scanning tunnelling microscopy, as well as improving the fabrication techniques to achieve clean two-dimensional surfaces, has given rise to an entirely new point of view in the study of solid state systems. Thus, besides the golden standards of electrical and thermal transport and ARPES, a new set of local probes are now considered indispensable towards the characterization of a system. Among such probes we can mention of course the local density of states (LDOS) and correspondingly the Fourier transform scanning tunnelling spectroscopy who turned out to be most useful for the study of graphene and high temperature superconductors. Various improvements and access to more information has been achieved by modifyng these techniques for example to use superconducting or ferromagnetic tips. However the field of local probes in condensed matter systems is still under developement, and many improvements and spectacular steps are to be expected in the future from such techniques, both in what concerns technical advancements, as well as from conceptual ones.

Here we present a possible conceptual development for such techniques, applicable to the study of topological systems, as well as to other exotic systems that are prone to be studied by similar tools. Thus we first introduce a new local probe which we denote as the Majorana polarization. This quantity describes the same-spin electron-hole overlap for a given state, and thus captures the formation of Majorana states in a given system. The first goal of this project is to demonstrate its applicability to a large range of physical systems, in particular in the presence of inhomogeneous magnetic fields and interactions, as well to find methods to detect experimentally this quantity. Also we plan to compare the characterization of various states via the MP with one based on their braiding, and make the connection between the two. The third goal is to use a more standard local order parameter, such as the LDOS and spin-polarized LDOS to obtain information about exotic topological systems such as the Weyl semimetals, as well as about new hybrid systems precursor to topological states such as graphene doped with magnetic ad-atoms.

The tools that we will apply to investigate these topics are both analytical and numerical. The Majorana polarization was introduced in recent work (Phys. Rev. Lett. 108, 096802 (2012), Phys. Rev. B 92, 115115 (2015)) to describe the formation of Majorana fermions. A good knowledge of quantum field theory, Green's functions, many body physics, as well as solid state physics is necessary.