Soutenance de thèse de doctorat

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Orme des Merisiers Amphi Claude Bloch, Bât. 774

Vardan Kaladzhyan

IPhT

Spin polarisation and topological properties of Yu-Shiba-Rusinov states

In this manuscript we first revisit the physics of Yu-Shiba-Rusinov subgap states, focusing on their spin polarisation. We start by showing theoretically that we can extract a considerable amount of information about the host superconductor, by analysing spin-polarised local density of states related to the presence of magnetic impurities. First, we demonstrate that the spin-orbit coupling in two-dimensional and one-dimensional systems, both superconducting and metallic, can be read-off directly and unambiguously via spin-resolved STM. We analyse the impurity-induced oscillations in the local density of states. In particular, we focus on the Fourier transform (FT) of the Friedel oscillations and we note that high-intensity FT features appear at a wave vector given by twice the inverse spin-orbit length. Second, in unconventional superconductors with both s-wave and p-wave pairing, by analysing the spin-resolved spectral structure of the Yu-Shiba-Rusinov states it is possible to determine the dominating pairing mechanism. Most strikingly, we demonstrate that a careful analysis of spin-polarised density of states allows not only to unambiguously characterise the degree of triplet pairing, but also to define the orientation of the triplet pairing vector, also known as the dvector.

Finally, we discuss two different ways of engineering and controlling topological phases with both scalar and magnetic impurities. We start with providing a microscopic theory of scalar impurity structures on chiral superconductors. We show that given a non-trivial chiral superconductor, the scalar impurities give rise to a complex hierarchy of distinct non-trivial phases with high Chern numbers. Second, we propose and study theoretically a new promising platform that we call 'dynamical Shiba chain', i.e. a chain of classical magnetic impurities in an s-wave superconductor with precessing spins. We have shown that it can be employed not only for engineering a topological superconducting phase, but most remarkably for controlling topological phase transitions by means of magnetisation texture dynamics.

This manuscript is organised as follows. In the first part, the essential introductory information on superconductivity, Friedel oscillations and Yu-Shiba-Rusinov states is provided. The second part is dedicated to spin polarisation of Yu-Shiba-Rusinov states and the properties that could be extracted by means of spin-resolved STM measurements. In the last part, two setups proposed for topological phase engineering based on impurity-induced states are presented, followed by conclusions with a brief summary of the thesis achievements and further directions to pursue.