Second proposal of Master 2 Internship

M2 - ANNÉE UNIVERSITAIRE 2017/2018

Régis Mélin, Institut Néel, Grenoble

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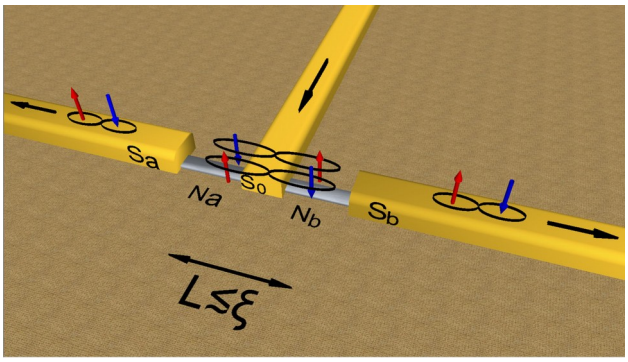
1. **Title of internship :** Wannier-Stark ladders in voltage-biased Josephson junctions
2. **Name and title of advisor :** Régis Mélin (Senior Research scientist, CNRS).
3. **Laboratory :** Institut Néel, Grenoble, France



Many experimental and theoretical works in the field of quantum nanoelectronics aim at manipulating **simple systems** with small numbers of degrees of freedom. Several implementations have been realized, on the basis of Josephson junctions. Those qu-bits are the building block of the complex architectures used to realize a quantum computer.

It was proposed recently [1] to use a Josephson junction to simulate some effects appearing in band theory. Superconducting phase between 0 and 2pi plays the role of wave-vector in the Brillouin zone. Physics is then related to Bloch oscillations and Wannier-Stark resonances. It is possible to realize a two-level system connected to superconducting leads, with time-periodic Hamiltonian.

On the other hand, it was proposed that correlations among four fermions could be obtained in those three-terminal Josephson junctions [2]. Those four-fermion correlations are obtained from Wick theorem, and those were confirmed experimentally [3,4]. Preliminary theoretical results have shown that the range of those correlations can be as large as 30 micrometers in experiments, which is considerable separation.

The goal of internship is to demonstrate phase coherence of those four-fermion correlations between two quantum dots separated by about 30 micrometers, in a nonequilibrium situation with finite bias voltages. The method is based on evaluation of the Floquet-Lippmann-Schwinger wave-function, providing access to the Wannier-Stark resonances mentionned above [1]. Repulsion between resonances will be the signature of phase coherence.

The internship is within on-going theoretical collaboration with Benoît Douçot (LPTHE, Jussieu, Paris, France) and with the experimental group of Moty Heiblum (Weizmann Institute, Israël).

[1] R. Mélin et al.,, Phys. Rev. B 95, 085415 (2017).

[2] A. Freyn et al., Phys. Rev. Lett. 106, 257005 (2011).

[3] A.H. Pfeffer, Phys. Rev. B 90, 075401 (2014).

[4] Y. Cohen et al., arXiv:1606.08436 (2016).