Topic for Master 2 internship – Academic year 2021-2022

Theory of non-perturbative quantum circuits

General scope :

Hailed as a possible future platform for advanced quantum computations, superconducting circuits also offer a route to design interesting models for many-body physics. Several theoretical challenges need still to be addressed, due to the large number of bosonic degrees of freedom involved. For instance, the strong thermal and quantum fluctuations of the superconducting phase (Fig. 1) result in an enhanced sensitivity to random charges. The development of a general framework to describe reliably these phenomena, possibly under the influence of micro-wave drives used as spectroscopic probes, seems promising thanks to recent progresses in the context of many-body wavefunctions. Working hand in hand with state-of-the-art experiments in the lab (Fig. 2), investigations of novel architectures (dissipative open quantum systems, more resilient qubits,…) will also be addressed.

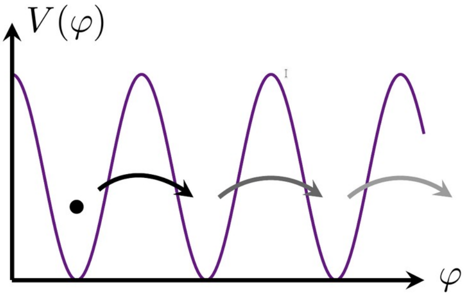

Fig.1 : Quantum tunneling of the superconducting phase

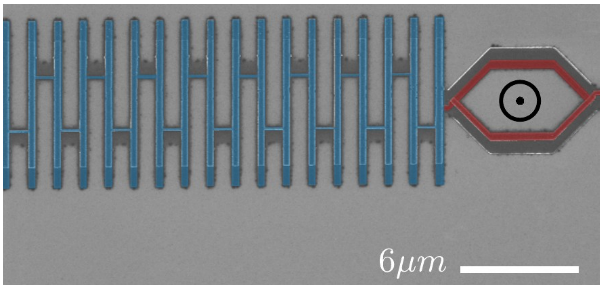

Fig. 2 : Non linear element (red) coupled to bosonic modes (blue)

Research topic and facilities available :

The internship will tackle dissipative quantum phase transitions triggered by the coupling of a single degree of freedom to a macroscopic environment. While a simple cartoon of the transition can be achieved by an effective Gaussian theory, non perturbative effects such as quantum tunneling of the phase do play a role. Taking those into account, the phase diagram for realistic devices will be determined using new many-body variational wavefunctions, combining analytical tools and numerics.

Possible collaboration and networking :

The work will take place within a well established collaboration, both locally and internationally. Experiments related to the project are currently performed by the team of Dr. Nicolas Roch at Néel Institute and by other groups in the USA. The theoretical team involves Dr. Denis Basko (LPMMC), Pr. Soumya Bera (IIT Bombay), Dr. Serge Florens (Néel Institute) and Pr. Izak Snyman (Wits University). If possible, traveling to the partners abroad will be encouraged.

Possible extension as a PhD :

Yes, provided funding can be successfully obtained by the applicant from the doctoral school.

Required skills :

The applicant must have a very solid background in fundamental science, and a training in theoretical physics. Good knowledge in advanced quantum mechanics (path integrals, perturbative Green's functions,...) and in solid state physics (superconductivity, band theory,...) will be also required.

Starting date : Spring 2022

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