Progress toward new quantum technologies requires understanding and mastering coherent transport and dissipation phenomena. This project aims to develop a theoretical framework for exploring the origins of transport and dissipation in fermionic superfluids. At first glance, this may seem strange since viscosity for superfluid systems vanishes, and thus any flow should be dissipationless, without energy losses. This is indeed the the case provided that the superflow does not exceed a certain critical value, above which new dissipative processes activate. All of them originate from the quantum nature of the system. Coherent transport and dissipation control thus represent a backbone of quantum technologies that develop under the common name of atomtronics: a field inspired by the analogy between circuits with ultracold atomic currents and those formed by electron-based systems (electronics). With practical and accurate theoretical framework, constructed within this project, we will be able to advance our abilities to model and design atomtronical devices.

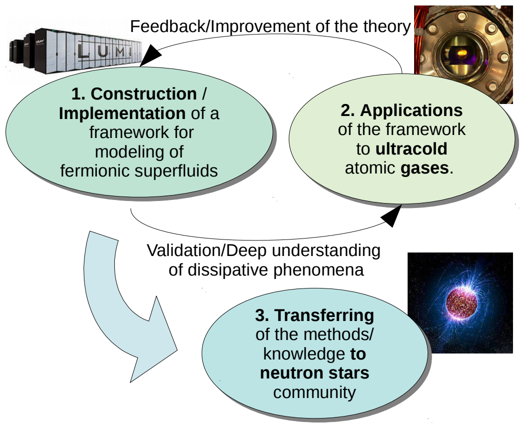

Figure 1: Main pillars of the project.

There are three main pillars of this project:

1. Development/construction of microscopic theoretical framework allowing for accurate modeling of fermionic superfluids, which accounts for finite temperature effects.
2. Applications of the framework to ultracold atomic systems, particularly in the context of atomtronical applications.
3. Transferring of the methods/knowledge to neutron stars community. The same techniques can simulate neutron/nuclear matter, as in neutron star crust: nuclear matter in fact, represents another example of a fermionic superfluid. We will use this opportunity and use constructed methods to support the research of the dynamics of neutron stars.

It will be a challenging project from a scientific as well as from a technical point of view. High-Performance Computing will be an essential part of this proposal. We plan to develop solutions that will be able to exploit capabilities offered by the biggest available supercomputers. All solutions/methods derived within this project will be publicly released in the form of open-source scientific software. The long-term goal will be to provide a trustable/professional simulator for ultracold atomic and neutron star communities.