Recently, we can witness rapid experimental development of quantum simulators. They aim at realization of visionary idea by Feynman, who proposed that a well controlled quantum system can be used to simulate some problems, which otherwise would be practically impossible to solve. Nowadays they are implemented in many platforms, but perhaps the most famous one, and at the same time a little controvertial is a system produced by D-Wave Systems employing array of Josephson junctions.

One of the paradigms of operating such systems is the idea of adiabatic simulation. In such an approach the system is initialized in an easy to prepare state being the ground state of the initial Hamiltonian of the system, which is subsequently adiabatically evolved to the final Hamiltonian whose ground state contains information one would like to extract from the simulation. However, driving the system between two such fundamentally different states usually involves crossing a critical point. In that case extremely long times might be needed to ensure adiabatic dynamics.

In all realistic situations the time of the evolution is always finite. Nonequalibrium dynamics which results from driving the system across a critical points at a finite rate is captured by the Kibble-Zurek mechanism, which provides universal prediction on the number of defects created during such evolution. The main goal of this project is to develop strategies to go beyond the standard predictions of the Kibble-Zurek mechanism and limit the number of defects created during the quench. In particular, we plan to focus on possibility of employing inhomogeneous driving to that end. In such an approach the critical point is first reached at a local front that subsequently spreads throughout the system, completing the crossing of the phase transition. There is a growing evidence that the interplay between velocity of the front and the speed of information in the system enables to limit defects formation.

We plan to explore the limitations of inhomogeneous approach focusing above all on the systems with quench disorder. It naturally appears in the context of quantum annealers (e.g. above mentioned D-Wave) that encode combinatorial optimization problems. Of particular interest in this project is the role of dimensionality/locality of the system, frustrations and intrinsic correlations in the final state for viability of the inhomogeneous approach, as well as using this approach as a building block for designing general driving protocols in a controllable way. We plan to consider prototypical toy-models and study nonequalibrium dynamics related with crossing quantum critical points at a finite rate. Good understanding of such dynamics is one of research topics relevant for boosting the performance of adiabatic quantum simulators.