The main goal of the project is a systematic characterization and analysis of various mathematical and physical aspects of non-Markovian evolution in quantum open systems. Non-Markovian evolution provides essential generalization of Markovian one since it takes into account memory effects coming from the interaction of the system in question with an environment. Such memory effects are neglected in the well studied Markovian regime which provides a useful approximation in several important physical systems. This notion (i.e. Markovianity/non-Markovianity) comes from the field of stochastic processes developed by Russian mathematician A. Markov - a process is Markovian if the corresponding conditional probability does not depend upon its history. A typical example is quantum optics where Markovian approximation is often legitimate due to the weak coupling between a system (atom) and the environment (electromagnetic field). However, such assumptions are not valid in general, and in many physically important cases the description of the reduced quantum evolution requires non-Markovian approach involving strong and long memory effects.

The detailed description of interaction between the system and its environment has fundamental implication for modern applications in quantum communications, quantum cryptography and quantum teleportation when the quantum coherence and quantum correlations (like for example quantum entanglement) play a crucial role. Recent technological progress calls for more refine treatment beyond the standard Markov approximation.

Proposed research project takes into account new dynamical feature of open quantum systems. Non-Markovian dynamics is still poorly understood and needs further detailed theoretical studies. In our project we plan to solve several problems and answer important questions. We plan to use new theoretical tools (like methods of quantum information theory) to attack problems from the theory of open systems. It should be stressed that we are open for all surprises of theoretical physics and we await to open new problems, formulate new questions and devise new methods and techniques.