

Physics studies interaction between physical systems. Real systems are never isolated and interact with *external world* – environment. In the project we analyze systems where the quantum effects play essential role. A typical example is an atom interacting with electromagnetic field. Interestingly, even if the field is in the vacuum states the atom still *feels* its presence. The problem of describing the system together with the environment is very complicated. Environment usually defines a big system (rest of the world) and hence its description requires a lot of effort and numerical efficiency. In practice very often we are interested only in the system (atom) and not in the environment. In this approach the system becomes an *open system* contrary to the composed ‘atom - field’ system which is *closed*. A natural question arises: how to extract from the description of the closed ‘atom - field’ system the description of the open system alone — **this is the central problem of the project**.

It is clear that if the ‘atom - field’ interaction becomes stronger then it is more difficult to extract the description of the atom alone. It turns out that very often the interaction is sufficiently weak and one is able to perform effective approximations and to get a consistent description of the evolution of our open system (this is the case of atom interacting with electromagnetic field). Such approximation guarantees that the evolution of an open system is free from memory effects (one says that it is Markovian), that is, what happens in a moment depends only upon the current state of the system and not upon its history.

Recently, due to the remarkable progress in laboratory techniques one is able to investigate also strongly interacting systems where Markovian approximations are no longer valid. Such systems require completely new and more refined approach. In particular they display memory effects characteristic for *non-Markovian evolution*, that is, what happens in a moment depends not only upon the current state of the system but also upon its history. One says about dynamics **beyond Markovian regime**.

The research projects deal exactly with analysis of such systems. We are interested both in physics of the problem but also in the mathematical structure of the theory and mathematical techniques appropriate to deal with such kind of problems.