We are all witnessing fast progress in miniaturization of electronic devices. On of its consequences is that a computing power of our smartphone is as large as a computing power of the former supercomputer, filling the whole room. It allows for faster and faster data transmission, support for touch-screens and GPS antennas, and permits an operation of endless applications. There is no doubt that further efforts will be taken to minimize the electronics even further, because consumers expect still smaller, energy-efficient and faster devices. This unavoidably leads to the systems of the sizes of nanometers, which – do to their dimensions – are called *nanostructures*. However, in such systems the new phenomena start to play a major role, the phenomena related to the quantum nature of electrons and the fundamental interactions between them. In fact, not only are they the subject of various theoretical analyzes, but also particular observations and measurements performed on specially fabricated nanostructures.

An important example of possible to fabricate nanostructures are the *quantum dots*. In practice, they are usually nanometer-size areas of the interface between two semiconductors, defined with the metallic electrodes, separated from the semiconductors by a film of oxide. Due to the possibility of confinement of electrons at such a surface, the quantum dots behaves as traps or boxes for electrons. Moreover, when additional external leads are coupled, quantum dots can conduct an electric current. Importantly, one can to large extent tune their properties by appropriate choice of voltages between the electrodes. Thanks to this property one can hope for application of quantum dots in future electronics. However, to this end we should understand the phenomena occurring in these nonostructures, which are as complex as fascinating. The aim of the project is to investigate some of them.

One of the most basic phenomena in the systems of quantum dots is the *Coulomb blockade*. It consists in the following. The electron already trapped in a quantum dot repels the neighboring electrons by electrostatic force, causing them to avoid this quantum dot. Thus, the current cannot flow. However, when the temperature is sufficiently low, the mysterious think happens: as a result of virtual transitions, allowed in quantum mechanics, the current starts to flow, despite the electrostatic repulsion. This is called the *mesoscopic Kondo effect*, and was predicted and measured in quantum dots at the end of 20th century. Another quantum effect observed in quantum dot systems is the *interference* between the electrons hopping through the system with various paths. It proves that electron's has to some extent wave nature. Yet another peculiar phenomenon, sometimes exhibited by the electrons trapped in neighboring quantum dots, is a tendency to align their magnetic moments antiparallelly. Organizing the three quantum dots in a triangle leads to the situations, that this tendency cannot be fulfilled for all the pairs of neighbors. Such a system we call *frustrated*. It is usually quite susceptible for external perturbations.

All the phenomena described in the previous paragraph are the examples of so called *electronic correlations* and were already pretty thoroughly investigated separately. Some of them were also explored in systems with correlated leads, such as ferromagnetic or superconducting. In the present project we propose theoretical investigations of two systems, where multiple correlations occur simultaneously. This may cause completely new phenomena, perhaps providing the considered systems with properties promising for potential applications. The first of them consists of a double quantum dot embedded between two metallic leads and additionally situated in the proximity of the superconductor. The aim of this research is to determine the influence of the coupling to the superconductor on the Kondo effect and the interference. The second system is constituted by three quantum dots arranged in a triangle (thus frustrated), one of which is coupled to two ferromagnetic leads. In this system, the state stable at low temperatures is expected to have particularly interesting properties.

In summary, the project "*The Kondo effect in complex systems of correlated quantum dots*" is focused on theoretical investigations of the systems of quantum dots, where many correlations occur simultaneously. In this field the quantum phenomena are currently observed in the laboratories, and can soon become a foundation for some new devices. The proposed theoretical analyzes aim is to make predictions of the properties of two particular systems, which are in principle possible to fabricate in the laboratory. We hope for discovery of new phenomena or potentially desired properties.