Description for general public

Current temperature of the outer space is about three degrees above absolute zero. However, it is not the lowest temperature in the Universe. Due to amazing progress in the field of natural sciences and technological change, the mankind is able to cool down a matter significantly below it. For example, characteristic phase transition of liquid helium ^{4}He to superfluid phase (known as lambda point) happens in around 2K (two degrees above absolute zero). In much lower temperature, around three-thousandths above zero, other isotope of helium ^{3}He also enters to superfluid phase. However, these temperatures are still much larger than the lowest temperatures achieved in world-famous laboratories.

In the end of century, very dilute gas of rubidium ^{87}Rb atoms was cooled down to temperature which is above absolute zero by 0,000000170 degrees (170 nanokelvins). In this way the first observation of the Bose-Einstein condensation was performed and completely new era of atomic physics was started — era of ultra-cold gases.

In such a low temperature, very unusual phenomena can emerge and typically they can be explained only in the framework of quantum mechanics. Thank to atomic physics it become possible to explore (with high accuracy and precision) phenomena which previously were beyond any experimental verification and had simple status of theoretical divagations. Now, over twenty years after first observation of the Bose-Einstein condensate, it became possible not only to cool down atoms to very low temperatures, but also to control mutual interactions between them as well as to control their number. Recent experiments showed that it is possible to prepare systems with exactly two, three, four, etc. quantum particles, to control them, and finally to measure their properties. In this way it became possible to study mesoscopic systems, i.e., systems which contain not many particles, but quite a lot to observe nontrivial many-body effects.

The proposed research project is devoted to a theoretical description of such a systems. In general, its goal is to perform very accurate and sophisticated theoretical analysis of a few atoms cooled down to extremely low temperatures and to study an influence of their mutual attractions to their dynamical properties.