The presented project aims to study the structure of exotic helium isotopes. Understanding the world around us, its origins, and evolution is closely dependent on advances in nuclear physics. One of the fundamental questions in nuclear physics, and still unanswered, are the forces that bind nucleons in the nucleus of an atom. Studies of light nuclei on the border of stability have recently brought many surprising results suggesting the need for a profound revision of our knowledge of these forces, based so far on the study of stable nuclei. These studies have shown, among other things, a significant role of three-body interactions, which is a unique situation in nature. The achieved results mean that the future of nuclear physics is focused on the research of nuclides beyond the stability path and the construction of new laboratories with an extensive selection of high-intensity radioactive beams and different energies. So far, studies of light nuclei on the border of stability have brought many surprising results. One of them is the discovery of the so-called "halo" nuclei, structures composed of a few nucleons but large, similar to the size of the heaviest nuclei. The most intensively studied of them are the isotopes of helium ($^{6,8}He$), lithium ($^{9,11}Li$), and beryllium ($^{7,11}Be$). This is dictated by the fact that these isotopes are currently produced and accelerated in several laboratories, and the intensity of accelerated beams, although still very low, allows for experimental work. This project is also devoted to the study of helium isotopes. According to theoretical predictions based on three-body models, ^{6}He nuclei consist of a compact center with dimensions typical for stable nuclei and two neutrons significantly separated from this center (neutron halo). Predictions based on the knowledge of nuclear forces so far say that in the case of ^{6}He, its ground state consists of two basic configurations. One is the alpha particle (core) and both valence neutrons - a "cigar" configuration, in which the two neutrons remain far apart. The other one is the dineutron configuration, in which two valence neutrons form a kind of particle - a dineutron. Here is the problem - the microscopic "ab initio" calculations of the properties of ^{6}He do not predict the existence of a bound state of two neutrons. However, this is not the end of problems. In addition to the structure alpha particle + two neutrons, in order to reproduce the binding energy of ^{6}He in the calculations, a significant contribution is needed from a completely different configuration of nucleons - tritium + tritium (t + t). That is, the ^{6}He nucleus, in this case, consists of two tritium nuclei. Confronting these predictions with experimental results concludes that the knowledge of the nuclear forces on which these predictions are based is unsatisfactory.

The project involves analyzing data obtained at the Joint Institute for Nuclear Research in Dubna, Russia. Based on the data, a differential cross-section for the reaction of the elastic scattering of helium-6 on deuterium will be obtained. In addition, the differential cross-section of the inelastic scattering reaction will be investigated, in which the excitation of the ^{6}He nucleus and its immediate decay occurs. The registration of the decay products will allow the determination of the excited states of this nucleus. During the experiment, the reaction of neutron transfer to the deuterium nucleus was also recorded - an unstable ^{5}He nucleus and tritium are formed. Simultaneous registration of the alpha particle into which ^{5}He decays and tritium will allow us to study the structure of this exotic nucleus.