Atomic nuclei are quantum systems composed of protons and neutrons, which are held together by strong interactions. Despite the discovery of the atomic nucleus over 100 years ago, the nature of the interactions binding nucleons still holds many mysteries. It remains unknown how many combinations of protons and neutrons can exist in a bound form. Particularly open is the question of how large the excess of one of these components can be and what the boundaries are for their formation as a bound system. Nuclei with an excess of protons or neutrons are called exotic. Although such exotic nuclei do not naturally occur in our environment, knowledge about them is crucial for understanding how the matter around us was formed.

Understanding the properties of exotic isotopes is essential to explain the process of nucleosynthesis and thereby reconstruct astrophysical processes from the distant past of the Universe that led to the distribution of chemical elements forming our world.

To illustrate the boundaries of knowledge about atomic nuclei, known nuclei are grouped according to the number of protons, and for each element, radioactive isotopes are presented. This graphical representation, known as the nuclide chart, illustrates the current state of knowledge about the interactions binding nucleons. Just as the periodic table revealed the similarities in properties of certain chemical elements, the nuclide chart helps identify common features among some atomic nuclei. Nuclei containing certain numbers of nucleons, known as magic numbers, stand out due to their properties among neighboring isotopes. They are more strongly bound, meaning that a lot of energy is required to excite them or to remove even one nucleon. While the magic nature of certain nucleon numbers has been confirmed and explained by the shell model of the atomic nucleus for stable and near-stable nuclei, the question of how well this concept applies to exotic nuclei remains a motivation for contemporary research.

Experimental investigation of exotic atomic nuclei is a significant technical challenge. Theoretical predictions suggest that the number of possible bound systems of protons and neutrons is several thousand, of which less than half are currently known. Due to the lack of Coulomb interaction between neutrons, the boundary for the existence of such systems on the neutron-rich side extends much further from the path of stability than on the proton-rich side. Consequently, the yet unknown nuclei are mainly isotopes characterized by a large neutron excess.

The development of new measurement techniques, including the use of radioactive beams, has opened new research possibilities in the "terra incognita" area. The most interesting nuclei from the standpoint of nuclear structure and astrophysical processes are still at the limits of what can be produced. Investigating these nuclei is only possible in specialized research centers, such as ISOLDE at CERN in Switzerland. Experimental data obtained at these centers are extremely valuable because they allow the verification of various theoretical models and their parameters, which model astrophysical processes and predict the boundaries of the formation of elements characterized by a significant number of neutrons.

Currently, on the neutron-rich side of the nuclide chart, systematic spectroscopic measurements for atomic nuclei above magic numbers are only possible around the nucleus ^{132}Sn. In my research project, we will focus on studying the beta decay properties of the nucleus ^{135}In, which has a significant neutron excess (N) relative to protons (Z) with an N/Z ratio of 1.8. This will enable the examination of whether the neutron excess affects the effective nucleon-nucleon interactions in this region of the nuclide chart. Verification of theoretical predictions in this area is crucial for modeling astrophysical processes, as the magic nature of the shell corresponding to the number of neutrons 82 is reflected in the dynamics of astrophysical processes responsible for the formation of about half of the nuclei heavier than iron. These studies also provide an important test for the shell model, which accurately reproduces the properties of similar systems close to stability.