POPULARNONAUKOWE STRESZCZENIE PROJEKTU (W JĘZYKU ANGIELSKIM)

The atomic nucleus is a very complicated quantum object, which is made out of two types of nucleons: protons and neutrons. Because of the complex nature of the interactions between them, the structure of atomic nuclei is difficult to predict. Therefore, its description uses different theoretical approaches, depending on the nucleus location on the map of nuclides. Particularly interesting are the areas of the chart of nuclei where energy gaps between consecutive proton and/or neutron orbits are significant. These corresponding numbers of nucleons are called magic numbers.

The properties of the nuclei in the immediate vicinity of double magical nuclides can be described by using a shell model with a closed core corresponding to the magic shells. These nuclei are spherical and their excitation energy spectra are dominated by single-particle excitations. The addition of nucleons outside the closed shells leads to core polarization and the appearance of deformation. The structure of such nuclei becomes complicated and difficult to describe within the shell model.

Most theoretical predictions use experimental results to fit key parameters of the given model. Information on stable nuclei or nuclei in their close vicinity is most easily available, with respect to nuclei farther away from stability, although knowledge is not complete. The development of radioactive beams has enabled a significant shift of the areas of available for research towards exotic nuclides. In particular, it is now possible to study experimentally the structure of neutron-rich nuclei, for which the shell structure observed for stable nuclei may disappear and other energy gaps leading to new, local magic numbers appear. It is worth noting that studying the properties of such exotic nuclei is very difficult and requires special, very advanced equipment for their production and detection. One of the World's leading centres where nuclei very far from stability can be investigated is CERN-ISOLDE (Switzerland) , where we perform our research.

The aim of this project is to gain a broader view of the structure of exotic nuclei around magic numbers. Understanding the properties of nuclear systems in which the equilibrium between the number of protons and neutrons is disrupted is one of the most important tasks of modern nuclear physics. Thanks to this, we can better understand the nature of nuclear interactions, looing for analogies between different areas of the nuclear chart. In particular, we want to concentrate on testing the magicity without closing in one area.

In the project proposed here, we want to focus on the study of the properties of single-particle states and the properties of nuclides in double-magic areas having:

- Z=28 (Ni), N=50 with focus on the neighbourhood of ^{78}Ni,
- Z=50 (Sn), N=82 with focus on the region close to ^{132}Sn.

In order to obtain as complete spectroscopic information as is necessary to validate the theoretical models, we need to know not only the energy of transitions, but also their properties. Therefore, in the proposed project we will use various experimental techniques giving complete knowledge of nucleus structure. The first stage will be the analysis of already existing spectroscopic data for nuclides around the double magical isotope ^{78}Ni, where in the fission of ^{238}U, ^{232}Th induced by neutrons, we have populated high-spine excited states. In the next stage, we will perform several experiments whose projects have been approved for performance in the CERN laboratory (ISOLDE), whose aim is to study the nuclides in the ^{78}Ni and ^{132}Sn regions. Thanks to high beam intensity and extremely advanced radiation detection technology it will be possible to measure the lifetime between beta particle and gamma and neutron radiation. Moreover, using the neutron detector we plan to measure the probability of emission of one or/and sequentially two neutrons in selected regions and build the first system in Europe using polarized beams.