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STUDY OF EXOTIC NUCLEAR PHENOMENA AT ATOMKI AND IN ESFRI ROADMAP INSTITUTES ABROAD

SZÉCHENYI 2020

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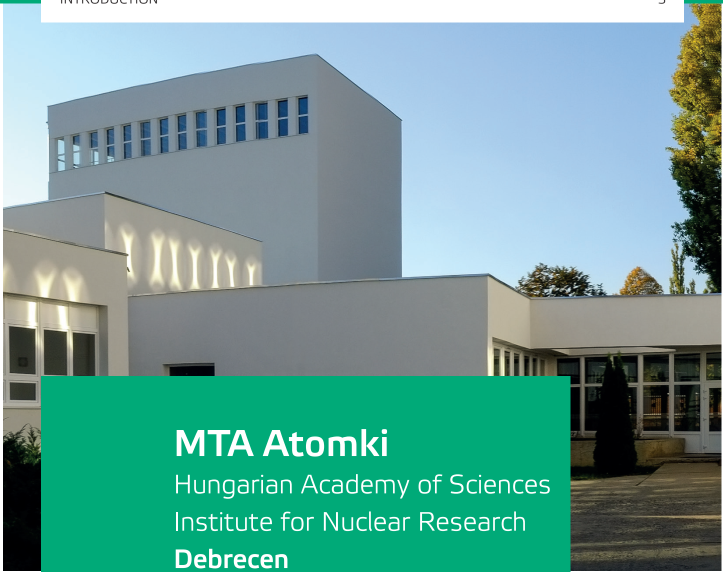


MTA Atomki

Hungarian Academy of Sciences
Institute for Nuclear Research
Debrecen

MTA ATOMKI

Founded in 1954

The Institute for Nuclear Research (short name MTA Atomki) situated in Debrecen, is one of the member institutes in the research network of the Hungarian Academy of Sciences. The primary activity of MTA Atomki is devoted to microphysical research for the understanding of the laws of nature which contributes to the results of scientific research in the world and to the sustainability of the scientific and technological culture in Hungary.

MTA atomki DEBRECEN

EGZOMAG

The nuclear spectroscopy research group of Atomki played a dominant role in achieving several outstanding results in experimental nuclear structure studies

Using the support of the present project we can purchase the most up-to-date pieces of equipment designed for nuclear physics. On one hand, with the new detectors, Atomki has the possibility to apply for membership to international collaborations which will shape the nuclear structure research in Europe in the coming decades. On the other hand, combining the new apparatus with the local accelerators the researchers of Atomki can join dark matter studies which are one of the greatest scientific challenges nowadays.

Webpage:
www.egzomag.atomki.hu

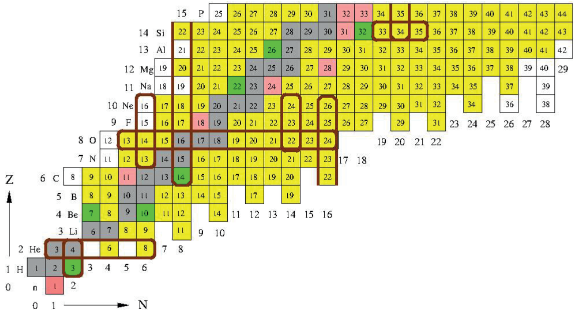
LABORATORY OF NUCLEAR PHYSICS

In the early years, the fundamental research field of Atomki was nuclear physics, and it is still one of the most successful topics in the institute

Besides the usage of the local accelerators at Atomki, the researchers of the institute have access to the infrastructure of the world-leading nuclear physics laboratories.

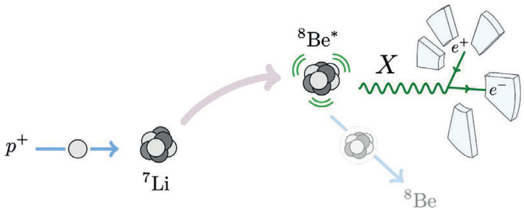
The scientists of the institute participated, among others, in the discovery of very deformed, so-called superdeformed nuclear shapes, in the investigation of phenomena related to the rotation of deformed nuclei and in the exploration of the special proton-neutron quartets appearing in nuclei with equal proton and neutron numbers.

They performed research in international collaborations in order to uncover the evolution of the magic numbers far from the stability in light, neutron-rich nuclei using radioactive ion beams, and to reveal the low-energy oscillations of the neutron skin.



In the last years, a research group in the Laboratory of Nuclear Physics at Atomki found an anomaly by studying the decay of highly excited states in ^{8}Be. This anomaly cannot be explained by any of the presently known nuclear physics phenomena, but it can be interpreted with the existence of a new boson which is beyond the Standard Model.

This inspired several experiments to be performed all over the world in order to investigate possible new physics connected to the anomaly.



RESEARCH

STUDY OF EXOTIC NUCLEAR PHENOMENA AT ATOMKI AND IN ESFRI ROADMAP INSTITUTES ABROAD

In the frame of the project, besides the investigations in Atomki, the nuclear structure research group is about to take part in experiments with detector arrays including several hundreds of crystals at European heavy-ion accelerators. Performing these measurements the researchers of the institute can exploit their decades of experience in gamma-spectroscopy

At the next-generation radioactive ion beam accelerators, much higher beam intensities and gamma rates are expected than before. The accelerators must be equipped with detector arrays of better resolution. Nowadays, two segmented, High-Purity Germanium gamma-ray tracking detector systems are under construction in the world: the GRETA in the USA and the AGATA in Europe. AGATA will have a special importance in the European nuclear structure studies in the next decades and be one of the key devices of the ESFRI Roadmap institutions. The ESFRI Roadmap contains the laboratories hosting infrastructures listed by the European Strategy Forum on Research Infrastructures as the most important pieces of research equipment in Europe.

Using the most state-of-the-art detector arrays we can answer the following questions cited with the highest priority in nuclear physics research by NuPECC, the Nuclear Physics European Collaboration Committee of the European Science Foundation:
How does the complexity of nuclear structure arise from the interaction between nucleons? What are the limits of nuclear stability? How does the nuclear chart emerge from fundamental interactions? How does nuclear structure evolve across the nuclear landscape and what shapes can nuclei adopt? How does the structure change with temperature and angular momentum? How to unify nuclear structure and reaction approaches? How complex are nuclear excitations?

The research topics of the project deal with the exploration of particular phenomena of nuclear physics which requires the most advanced detection techniques. In the nuclear reactions applied several different isotopes are produced. The cesium-iodide charged-particle detector named DIAMANT was developed and constructed by Atomki researchers in recent years, which is able to select the reaction channels and to assist the observation of rarely-produced isotopes. The DIAMANT detector is designed so that it can be used as an ancillary detector in the AGATA system, as well.

DIAMANT detector

SEARCH FOR A NEW PARTICLE IN THE NUCLEUS

The nucleus as a laboratory

The researchers of Atomki investigate the characteristics of atomic nuclei and their reactions. However, the nucleus itself is a small laboratory with continuous physical processes inside. All the interactions of Nature are present in the nuclear reactions. Two of the four presently known interactions, the strong and the weak ones, were discovered in the nucleus. If the dark matter is present in Nature with the abundance usually assumed by theorists, it affects the nuclear reactions, too.

Based on this assumption, a research group of the institute started to search for the dark matter inside the nucleus, and they managed to find an interesting anomaly which drives us beyond the limits of nuclear physics.

Electron-positron pair spectrometer constructed at Atomki

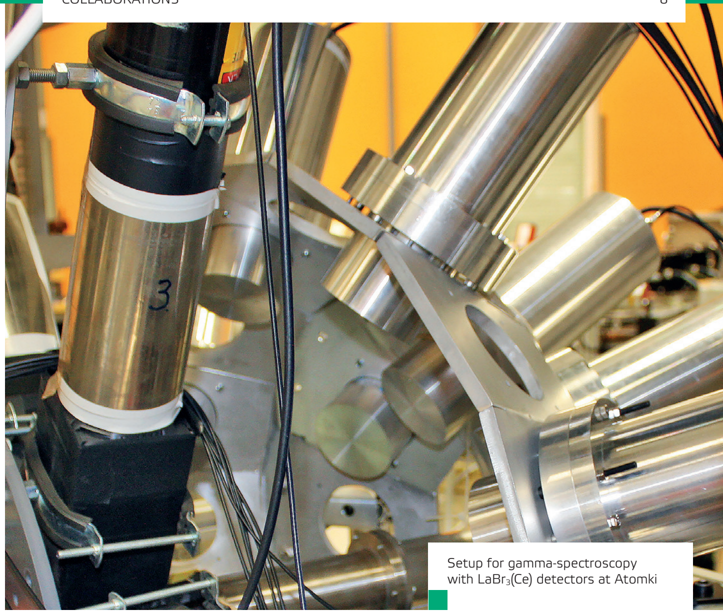
NEW INFRASTRUCTURE

PIECES OF EQUIPMENT DELIVERED IN THE FRAME OF THE GINOP PROJECT

We purchase the most state-of-the-art $LaBr_3$(Ce) scintillator, silicon pixel detector as well as a gamma-ray tracking Germanium detector of AGATA type

The AGATA detector will be part of the AGATA array, a next generation 4pi gamma-ray spectrometer. The $LaBr_3$(Ce) and the silicon pixel detectors will be used in experiments performed both in the institute and abroad. With these detectors, the institute can join international collaborations aiming to enhance the role of the European researchers in the modern nuclear structure studies. Furthermore, the devices will assist in a more detailed examination of the new phenomenon discovered at Atomki, which can even prove the existence of a new particle or a new interaction.

AGATA detector array at GANIL



Setup for gamma-spectroscopy with $LaBr_3$(Ce) detectors at Atomki

In the first year of the project, the procurement of the $LaBr_3$(Ce) detectors, the AGATA detector, and the related pieces of equipment will start. As a next step, in the second year, the installation and the commissioning of the $LaBr_3$(Ce) detectors will take place. The procurement of the silicon detectors is also expected this year. Due to the complicated manufacturing process, the AGATA detector and its cryostat will be delivered to the institute only in the third year. Thus, their installation will happen in the last year of the project.

COLLABORATIONS

AGATA collaboration is composed of hundreds of researchers from about 40 research institutes and universities of 12 European countries.

The AGATA detector system will be used in conjunction with the newly built accelerators with the help of the ENSAR2 project, exploiting the specialities of the large accelerator complexes that open new disciplines in Europe. ENSAR2 (European Nuclear Science and Applications Research 2) is a project to support basic and applied nuclear physics research in Europe in the framework of the Horizon 2020 (H2020) EU Research and Innovation programme for the period of 2014-2020.