EDITORIAL WORD

International Symposium "Exotic nuclei – EXON 2018"

From 10 to 15 September Petrozavodsk (Russian Federation) hosted the International Symposium on one of the most important and the most rapidly developing areas of nuclear physics – the physics of exotic states of nuclei – "EXON 2018". The organizers of the Symposium were the five largest scientific centers, where this area is being successfully developed – the Joint Institute for Nuclear Research in Dubna, the GANIL National Center (France), the RIKEN Research Center (Japan), the GSI Helmholtz Centre for Heavy Ion Research (Germany), the National Superconducting Cyclotron Laboratory (Michigan, USA). The Symposium was held with the active participation of Petrozavodsk Federal University (PetrGU).

Currently, the most complex physical experiments conducted with the use of the large accelerators facilities and requiring huge financial investments cannot be performed by a single, even highly developed, country. An example of this might be the construction of the Large Hadron Collider at the European Organization for Nuclear Research (CERN), the NICA collider and heavy-ion accelerators at the Joint Institute for Nuclear Research in Dubna, which includes 20 member countries. Therefore, these studies are carried out in close cooperation of research centers of several countries, each of which makes its financial and intellectual contribution to the construction of the largest facilities. These fundamental studies and methods used in them are also of great importance for the related areas of science and technology.

This is the nine Symposium on exotic nuclei held in Russia. The first symposium took place 27 years ago in 1991 in Foros (Crimea), later symposiums were held on Baikal Lake, in Peterhof, Khanty-Mansiysk, Sochi, Vladivostok, Kaliningrad and Kazan. The great interest in this research and new experimental possibilities that emerged with the launch radioactive ion beam facilities the collaboration extended to five research centers, which were the co-founders of the subsequent EXON workshops. Already in 2004, the co-founders of the symposium, held in Peterhof (near St. Petersburg) were GSI, GANIL, RIKEN, JINR and later MSU (Michigan, USA).

The Symposium "EXON 2018" was attended by about 140 scientists from 20 countries, most of whom are leading experts in the field of nuclear physics. The most representative delegations were from Japan, China. Research centers of these countries are interested in developing cooperation with JINR and scientific centers of Russia.

The Symposium will be devoted to the investigation of nuclei in extreme states and in particular, at the limits of nuclear stability (from very light neutron- and proton-rich up to superheavy nuclei).

The EXON 2018 symposium will deal with the following next topics:

- Properties of light exotic nuclei;
- Superheavy elements. Synthesis and properties;
- Rare processes and decays;
- Radioactive beams. Production and research programs;

• Experimental facilities and future projects.

The scientific program included invited talks on important areas of the physics of exotic nuclei and new projects of the largest accelerator complexes and experimental facilities. In addition, discussions with the participation of leading scientists from various research centers in the world were organized. They discussed issues of cooperation in the field of fundamental physics of heavy ions and applied research.

Exoticism in Nuclear Physics

It has been 27 years since the first International symposium on exotic nuclei (EXON) was held. One of the main trends in modern nuclear physics is to obtain and study the properties of nuclear matter (or nuclei) in extreme state. The appearance of powerful accelerators of heavy ions allows the synthesis of such nuclei. Exotic nuclei are basically a nuclear matter in a very unusual state. There are several unusual states that define nuclei as exotic: nuclei of large angular momentum («rabidly» rotating nuclei), nuclei of high excitation energy («hot» nuclei), strongly deformed nuclei (super and hyper-deformation, nuclei in unusual configuration form), nuclei with abnormally high number of neutrons or protons (neutron-rich and proton-rich nuclei), and super-heavy nuclei up to atomic number of protons $Z > 110$. The study of the properties of nuclear matter in its unusual state provides the important information about the properties of the microcosm and thus allows us to simulate various processes that take place in the Universe. Symposium EXON, we set ourselves several tasks:

1. The symposium should summarize the latest results obtained on the actual subject in collaboration with other research centers.

2. The symposium should take place only in exotic locations of Russia.

3. The symposium results should promote decisions on future program of the joint experiments.

4. All the symposiums should be based on local universities under active support and immediate participation of the students and teachers of these universities.

We seem to have managed to cope with all the set tasks according to the evidence of geography of the symposium venues. Exotic nuclei show unusual properties in reactions with other nuclei as well. There have recently been received a number of interesting results in the study of excitation functions of full cross sections of reactions, fusion-fission reactions and particle evaporation from the excited compound nucleus. These reactions were studied in the beams of radioactive nuclei ^{6}He, ^{8}He, ^{11}Li, and others.

This trend of research of reaction with exotic nuclei is one of the major ones in the programme of radioactive beam-factories.

Superheavy elements

During the Symposium, the results of recent experiments on the synthesis and study of properties of nuclei of new superheavy elements were discussed: the discovery of new superheavy elements shows high efficiency of international cooperation. Interesting results were obtained in joint experiments on chemical identification of elements 112 and 114, performed at the Laboratory of Nuclear

Reactions (FLNR) JINR (Russia), the GSI (Germany), and the Paul Scherrer Institute (Switzerland). A striking example of cooperation with US scientists is an experiment on the synthesis of element 117, held at the cyclotron of FLNR JINR under the leadership of Yu.Ts. Oganessian. In 2014 Moscow hosted the inauguration of element 114 (flerovium) and element 116 (livermorium) discovered in Dubna. In November 2016, the International Union of Pure and Applied Chemistry (IUPAC) and the International Union of Pure and Applied Physics (IUPAP) approved the discovery of new chemical elements of the periodic table of D.I. Mendeleev with atomic numbers 113, 115, 117, and 118.

For the element with atomic number 113 the discoverers at RIKEN Nishina Center for Accelerator-Based Science (Japan) proposed the name nihonium and the symbol Nh. Nihon is one of the ways to say "Japan" in Japanese, and literally mean "the Land of Rising Sun".

For the element with atomic number 115 the name proposed is moscovium with the symbol Mc and for element with atomic number 117, the name proposed is tennessine with the symbol Ts. These are in line with tradition honoring a place or geographical region and are proposed jointly by the discoverers at the Joint Institute for Nuclear Research, Dubna (Russia), Oak Ridge National Laboratory (USA), Vanderbilt University (USA) and Lawrence Livermore National Laboratory (USA). The name moscovium is in recognition of the city of Dubna, Moscow Region. The name Tennessine is in recognition of the contribution of the Tennessee region, including Oak Ridge National Laboratory, Vanderbilt University, and the University of Tennessee at Knoxville, to superheavy element research. For the element with atomic number 118 the collaborating teams of discoverers at the Joint Institute for Nuclear Research, Dubna (Russia) and Lawrence Livermore National Laboratory (USA) proposed the name oganesson and the symbol Og. The proposal is in line with the tradition of honoring a scientist and recognizes Professor Yuri Oganessian for his pioneering contributions to transactinoid elements research. His many achievements include the discovery of superheavy elements and significant advances in the nuclear physics of superheavy nuclei including experimental evidence for the "island of stability".

Thus, the experiments on synthesis of superheavy elements take a major part of research program of the leading research centers. In this regard, an important step in further understanding of the properties of superheavy elements were the experiments on research of the structure of transfermium nuclei. The experiments on measurement of gamma transitions in nuclei of 101, 102 and 103 elements have begun. These experiments are currently running at the University of Jyvaskylo (Finland), in GANIL (France) and in FLNR (JINR).

Interesting results were obtained in joint experiments on chemical identification of elements 105, 112 and 114, performed at the Laboratory of Nuclear Reactions JINR (Russia), the GSI (Germany), and the Paul Scherrer Institute (Switzerland). Radiochemists from Dubna, from Technical University of Munich and from GSI, who have performed the first experiments on chemical properties of super heavy elements, have made an important step in chemical identification of super heavy elements and in determination of their place in Mendeleev periodic table.

This important trend in research of the properties of superheavy elements is

expected to be continued in a broad collaboration of physicists and radiochemists of the leading centers.

New facilities – new projects

A special day of the Symposium was devoted to the present and future accelerator complexes for heavy ions and radioactive nuclei in the leading scientific centers of the world. Five laboratories, which are the co-founders of the Symposium, are now creating a new generation of accelerators, which will enable significant progress towards the synthesis and study of properties of new exotic nuclei. Projects SPIRAL 2, RIKEN RI Beam Factory, FAIR, DRIBs, NICA, FRIB presented by the heads of these projects – H. En'yo, S. Dmitriev, D. Ackermann, H. Savajols, J.J. Lawri, F. Ibrahim et al. A new accelerator complex NUSTAR in GSI, which includes pilot plants for precision studies of nuclear structure, is now under creation on international-collaboration-basis. At present, a new accelerator complex in RIKEN; it is intended to produce intense beams of stable and radioactive nuclei, which are going to be used to research the structure of exotic nuclei. Now, the GANIL accelerator complex for production of radioactive beams is under development. The complex SPIRAL in GANI has started the first experiments. There began the development of the SPIIRAL-2 project, which is scheduled to receive the first beams of heavy radioactive nuclei in 2018. Accelerator complex DRIBs3, new fragment separator ACCULINNA 2 and SHNF in Dubna will begin. The ALTO Project (Orsay, France) is based on acceleration of photo-fission fragments as well and in other major research centers. Thus, in 2018-2020 there will be launched a number of new accelerator complexes equipped with the unique experimental facilities, which will let us make a new step in synthesis and study of properties of new exotic states of nuclear matter.

One of the organizers and the basis of the Symposium was Petrozavodsk Federal University, which made a great contribution to the preparation of highly qualified personnel and joint research. For Kazan Federal University the contacts with leading scientists and heads of world's major research centers in the area of nuclear physics are the basis for future cooperation in the field of fundamental physics and applied research in related fields of science and technology, in particular, medicine, ecology, geology, information technology, etc.

Before the beginning of the Symposium, a satellite school "Contemporary physics and nuclear medicine" was held for two days. At the school, the leading JINR professors delivered lectures to students, post-graduates, and professors of KFU on modern problems of nuclear physics and nuclear medicine.

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