

## PREFACE

The XXXVIII Mazurian Lakes Conference on Physics was held in Piaski, a vacation resort located at the lake of Beldany in the heart of the Great Mazurian Lakes District, from August 31<sup>st</sup> till September 6<sup>th</sup>, 2025. It was the 38<sup>th</sup> meeting in a series initiated over 50 years ago, in 1968, by Professor Zdzisław Wilhelmi and his students and collaborators. Throughout the years, the Mazurian conferences have gained a world-wide reputation for their high scientific merit and for a unique atmosphere. The 2025 edition was organized by the University of Warsaw and the National Centre for Nuclear Research, and chaired by Wojciech Satuła (University of Warsaw) and Krzysztof Rykaczewski (vice-chair, ORNL Oak Ridge). We acknowledge the generous support provided by the University of Warsaw within the Excellence Initiative — Research University framework, as well as by the University's Faculty of Physics, Institute for Experimental Physics and Institute for Theoretical Physics, the National Centre for Nuclear Research, and NuPECC.

The title adopted for the 2025 edition, *Probing fundamental properties of matter with rare isotopes*, highlighted the fundamental aspects of nuclear and atomic physics and their sensitivity to the signals allowing us to search for New Physics in ways that are complementary to other approaches.

The program was arranged with the invaluable help of the International Advisory Board and was built around several main topics:

- Fundamental processes at the intersection of nuclear and atomic physics,
- Weak interactions and neutrino physics,
- Nuclear structure at the extremes of weak binding, isospin, and angular momentum,
- Nuclear astrophysics and nucleosynthesis,
- Physics and chemistry of superheavy nuclei,
- Innovative experimental techniques and facilities, and
- Applications of nuclear physics in technology and medicine.

Our conference attracted 130 physicists from 21 countries, including a large number of young researchers (in particular 44 students). There were 88 oral contributions and 41 posters presented.

The program consisted of invited talks, and contributed presentations. Posters were available for viewing and discussions with their authors for the whole duration of the conference, and a dedicated poster session attracted much attention.

The conference began on Sunday evening with a general lecture — this year on studies of radioactive molecules and their possible connection to physics beyond the Standard Model — given by Ronald Garcia Ruiz from the Massachusetts Institute of Technology.

The first morning of the conference was focused on experiments looking for New Physics beyond the Standard Model. Future high-precision  $\beta$ -decay studies were discussed by Pierre Delahaye, who focused on the MORA experiment at the low-energy area of GANIL, and Maxime Brodeur, who presented beta-neutrino angular correlation measurements with the newly developed St. Benedict ion trap. Marcus Scheck addressed possible use of Mössbauer spectroscopy to search for CP-violating odd-electric and even-magnetic moments in octupole-deformed nuclei. Recent progress towards the development of a nuclear clock based on the isomer in  $^{229}\text{Th}$  was reviewed by Piet Van Duppen.

The meeting continued with talks on recent achievements in nuclear physics theory. Dean Lee reviewed new results from nuclear lattice simulations, while Marek Płoszajczak discussed properties of near-threshold nuclear states. Achim Schwenk explored *ab initio* calculations for medium-heavy nuclei, in particular in the context of uncertainty quantification, and Jie Meng presented numerous applications of the relativistic density functional theory to describe nuclear structure and dynamics.

The lectures on the second day covered various aspects of experimental studies.  $\beta$ -decay measurements were in the spotlight, both in the context of total absorption spectroscopy and shape of the beta spectrum (Charlie Rasco, Alejandro Algora) and structure conclusions from  $\gamma$ -ray spectroscopy following  $\beta$  decay (Agnieszka Korgul, Paul Garrett). Robert Grzywacz focused on the nuclear structure origins of measured beta-delayed neutron properties, and Elżbieta Stephan discussed experimental studies of deuteron breakup in collision with proton, exploring the role of the three-nucleon force. Hide Sakai introduced the concept of spin entanglement in nucleon–nucleon scattering and possibilities to determine its entropy from experimental data. Finally, Jagjit Singh discussed potential two-neutron halo candidates, and structure and reaction observables that can be used to pin them down.

We continued on the third day on the topic of nuclear astrophysics with presentations on stellar neutron sources (Michael Wiescher) and experimental techniques for surrogate neutron-induced reactions (Jolie Cizewski).

Melina Avila reviewed recent progress in the direct measurements of  $\alpha$ -induced reactions, and Steve Pain discussed possible approaches to constrain proton-capture reaction rates for odd-odd  $N = Z$  nuclides.

A session on European research infrastructures started with a presentation on findings and recommendations of the NuPECC Long Range Plan 2024, given by Marek Lewitowicz. Fanny Farget discussed the current status of GANIL/SPIRAL2, as well as planned future developments within this project, and Calin Ur introduced the Extreme Light Infrastructure — Nuclear Physics (ELI-NP) facility. Possible nuclear physics experiments at the future European IFMIF-DONES facility were presented by Łukasz Iskra. The session concluded with an introduction to collinear resonance ionization spectroscopy and a presentation of recent results from CRIS/ISOLDE given by Jessica Warbinek.

Sessions on the fourth day covered various aspects of studies of heavy and super-heavy nuclei. Kouji Morimoto discussed the status and perspectives of super-heavy element research at RIKEN. Dieter Ackermann reviewed recent decay spectroscopy studies of very heavy nuclei, while Michael Block focused on their ground-state properties explored via mass spectrometry and resonance-ionization laser spectroscopy. These were complemented by presentations on advances in nuclear theory relevant for this mass region: Ante Ravlić focused on new predictions of  $\beta$  and EC decay of super-heavy nuclei, and Michał Kowal, Krzysztof Pomorski, and Tomasz Cap addressed various approaches to nuclear fission.

The last day of lectures started by a session on recent detector developments and applications of nuclear physics. Luis Fraile discussed the potential of a new generation of inorganic scintillators in both nuclear spectroscopy and medical imaging. Kenjiro Miki focused on experiments addressing structure and dynamics of multineutron systems, and Tomasz Malkiewicz presented the EuroHPC initiative for high-performance computing and in particular the LUMI supercomputer infrastructure. Theodoros Mertzimekis discussed innovative radiation instrumentation developed for underwater exploration within the EU RAMONES project, and Letizia Bonizzoni presented how fission track dating of obsidian artifacts can be used to classify their provenance.

Finally, a special session honoured the recipients of the Zdzisław Szymański award (Benjamin Bally) and of the Tomek Czosnyka award (Katarzyna Hadyńska-Klęk). Awards for the best presentation given by a young researcher (Gururaj Kumar) and best posters (Cleméntine Azam, Alice Barbon, and Katharina Ide), sponsored by NuPECC, were presented by an international jury chaired by Paul Garrett. The conference was concluded by a lecture of Michael Wiescher discussing fascinating links between nuclear astrophysics and research in nuclear weapons.

A diverse social program that included activities like sailing with a regatta (won by an international crew led by Michał Warda), camp fire with a song contest, a classical music concert in the picturesque neo-gothic evangelical church in Wejsuny, and a crash course on the traditional Polish dance “Polonez” at the conference dinner, contributed to the unforgettable atmosphere of the Conference.

The Mazurian Conference ended with an invitation to the next nuclear physics conference in Poland, organized by physicists from Cracow, to be held in Zakopane in August/September 2026. The XXXIX Mazurian Lakes Conference on Physics will be held in the first half of September 2027, again in the Mazurian Lakes district.

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