Symposium SMuK Dissertation Prize 2025 (SYMD)

jointly organised by
the divisions of the Matter and Cosmos Section (SMuK)

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The Matter and Cosmos Section, with its divisions Extraterrestrial Physics (EP), Gravitation and Relativity (GR), Hadronic and Nuclear Physics (HK), Theoretical and Mathematical Physics (MP), Plasma Physics (P), Radiation and Medical Physics (ST), and Particle Physics (T), awards a dissertation prize in recognition of outstanding research in the context of a doctoral thesis and its excellent communication. The award committee selects up to four candidates from the nominations who will present their doctoral theses at this symposium. The winner will be announced at the beginning of the Awards Symposium (SYAS) on Tuesday at 11 am.

Overview of Invited Talks and Sessions

(Lecture hall ZHG011)

Invited Talks

SYMD 1.1	Mon	14:15–14:45	ZHG011	**Fluid-dynamic description of heavy-quark diffusion in the quark-gluon plasma** — •Federica Capellino
SYMD 1.2	Mon	14:45–15:15	ZHG011	**Fast and faithful effective-one-body models for gravitational waves from generic compact binaries** — •Rossella Gamba
SYMD 1.3	Mon	15:15–15:45	ZHG011	**Nuclear Structure Near Doubly Magic Nuclei** — •Lukas Nies
SYMD 1.4	Mon	15:45–16:15	ZHG011	**Optimisation strategies for proton acceleration from thin foils with petawatt ultrashort pulse lasers** — •Tim Ziegler

Sessions

SYMD 1.1–1.4	Mon	14:15–16:15	ZHG011	**SMuK Dissertation Prize 2025**

SYMD 1: SMuK Dissertation Prize 2025

Time: Monday 14:15–16:15 Location: ZHG011

Invited Talk SYMD 1.1 Mon 14:15 ZHG011
Fluid-dynamic description of heavy-quark diffusion in the quark-gluon plasma — •Federica Capellino — GSI Helmholtzzentrum Darmstadt

Relativistic heavy-ion collisions are a powerful tool to explore the phase diagram of Quantum Chromodynamics (QCD). Under the extreme energy conditions reached within these experiments, nuclear matter undergoes a transition to a deconfined phase, in which the active degrees of freedom are quarks and gluons, known as quark-gluon plasma (QGP). The characterization of the QGP and its transport properties constitutes one of the main goals of the high-energy nuclear physics program worldwide. Heavy quarks, i.e., charm and beauty, have long been established as excellent probes to characterize the QGP. Due to their large mass, heavy quarks can be produced only via hard partonic scattering processes that take place at the very beginning of the collision, before the QGP is formed. In this talk, I will present a new way of describing heavy-quark dynamics in the QGP based on fluid dynamics. On the one hand, our model allows us to phenomenologically access QCD properties such as the heavy-quark spatial diffusion coefficient. Secondly, it pursues the idea of a universal effective description unifying light and heavy degrees of freedom. It poses the fundamental question of whether the behavior of a complex system like the QGP, which spans over three orders of magnitude in mass scales (from MeV to GeV), can be described by a few macroscopic thermodynamic quantities defined in local kinetic equilibrium.

Invited Talk SYMD 1.2 Mon 14:45 ZHG011
Fast and faithful effective-one-body models for gravitational waves from generic compact binaries — •Rossella Gamba — UC Berkeley, Berkeley (CA), USA — Penn State University, University Park (PA), USA

The detection and analysis of gravitational waves (GWs) from compact binary systems rely on precise modeling of the expected signals. However, accurately modeling GWs emitted by coalescing binary black hole (BBH) and binary neutron star (BNS) systems remains a formidable challenge due to the complexity of the underlying physical processes.

In this talk, I will summarize my efforts toward the development of computationally efficient and accurate models for GWs emitted by generic compact binary systems within the effective-one-body framework. The term "generic" here encompasses both the nature of the binary components – black holes, neutron stars, or mixed systems – and the diverse properties influencing their evolution, including eccentricity, spin effects, and matter interactions. I will then discuss their application to real GW data analysis.

Invited Talk SYMD 1.3 Mon 15:15 ZHG011
Nuclear Structure Near Doubly Magic Nuclei — •Lukas Nies — CERN

In this contribution, we investigate the strong force in atomic nuclei, i.e. the way nucleons arrange themselves in a many-body system governed by the repulsive Coulomb interaction and the attractive strong interaction. We will focus on nuclear structure near nuclei with a "magic number" of Z protons and N neutrons, so-called doubly-magic nuclei, exhibiting a particularly stable configuration with respect to neighboring nuclei. Within the nuclear shell model, similar to the atomic shells, the magic numbers indicate shell closures accompanied by energy gaps. Nuclei at double-shell closures and their direct vicinity provide an important playground to benchmark nuclear theories and models that aim to predict the intricate interplay of the nucleons that lead to enhanced nuclear binding energies, significant changes in charge radii and transition strengths, etc. Of particular interest are nuclear isomers, long-lived excited states, in which the nucleon configuration is altered, resulting in a modification of their nuclear properties despite having the same number of protons and neutrons. In ^{99}In, one proton away from the important doubly-magic nucleus ^{100}Sn, we found the isomeric state exhibiting contrasting trends in binding energies and compared these with nuclear electromagnetic moments. In ^{79}Zn, near the doubly-magic nucleus ^{78}Ni, we discovered that the isomer shows signs of shape coexistence, which has strong implications on the magicity of ^{78}Ni. In this presentation, we will revisit these two isomers and put them into a greater context in modern nuclear theory.

Invited Talk SYMD 1.4 Mon 15:45 ZHG011
Optimisation strategies for proton acceleration from thin foils with petawatt ultrashort pulse lasers — •Tim Ziegler — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — TUD Dresden University of Technology, Dresden, Germany

Laser-driven plasma accelerators can produce pulsed multi-MeV ion beams with high peak currents by irradiating solid materials with ultra-intense laser pulses. This innovative concept attracts much attention for various multidisciplinary applications as a compact and energy-efficient alternative to conventional accelerators. The maturation of plasma accelerators from complex physics experiments to turnkey particle sources for practical applications requires breakthroughs in the generated beam parameters, their robustness and scalability.

In this work, new benchmarks for accelerator performance and understanding of the underlying interaction physics were achieved through combining innovative laser diagnostics, advanced measurement techniques and hybrid simulation approaches. This enabled precise tuning of interaction conditions for optimized performance in established acceleration regimes and facilitated the exploration of relativistically transparent targets. The results from this advanced regime far exceeded previous records, demonstrating the immense potential of this technology. The strategies outlined provide a roadmap for advancing and integrating plasma accelerators into scientific, industrial, and medical fields.