SYPM 1: Precision Measurements at the Intersection of Atomic and Nuclear Physics

Time: Wednesday 14:30–16:30 Location: HS 1+2

Invited Talk SYPM 1.1 Wed 14:30 HS 1+2

Probing new bosons and nuclear structure with ytterbium isotope shifts — •Tanja Mehlstäubler[1,2], Chih-Han Yeh[1], Henning Fürst[1], and Laura Dreissen[1] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]Institut fuer Quantenoptik, Leibniz Universitaet Hannover, Germany

High precision spectroscopy in trapped cold ions enables sensitive tests of the Standard Model and the search for new physics. For example, isotope-shift spectroscopy is a sensitive probe for nuclear structure and fifth forces mediated by a new boson that couples electrons and neutrons. Deviations from a linear relation in the King-plot analysis can indicate new physics or higher-order SM effects. This powerful technique revealed for the first time King-plot nonlinearities in Yb. We present two-orders-of-magnitude improved spectroscopic measurements in all five stable spinless isotopes of this element. The transition frequency of the forbidden $^2S_{1/2}$ to $^2D_{5/2}$ and $^2S_{1/2}$ to $^2F_{7/2}$ transitions are determined with an accuracy of 6 and 16 Hz, respectively, yielding isotope shifts with a relative precision as low as 10^{-9}. We combine these spectroscopic results with new mass measurements with a relative precision of a few 10^{-12}. With this, we can extract a new bound on the mass and coupling strength of the potential new bosons. The results are also used to investigate higher-order nuclear structure effects along a chain of Yb isotopes. In combination with ab initio nuclear structure calculations, this provides a window to nuclear deformation and nuclear charge distributions along isotopic chains towards exotic, neutron-rich nuclei.

Invited Talk SYPM 1.2 Wed 15:00 HS 1+2

Probing the Stars: Nuclear Astrophysics with Stable and Radioactive Ion Beams — •Ragandeep Singh Sidhu — School of Mathematics and Physics, University of Surrey, Guildford GU2 7XH, United Kingdom

The elements around us, including those that make up our bodies, are forged in stars through nuclear fusion reactions. Some of these elements were first produced during the primordial Big Bang, while others continue to form in stars today. Understanding these processes involves conducting challenging experiments. These include studying reactions at extremely low energies in underground laboratories to create quiescent stellar conditions and using beams of radioactive nuclei to explore the reactions that occur in explosive events like supernovae, which involve unstable isotopes not typically found on Earth.

In this talk, I will present the current status and recent results of experiments conducted with stable and radioactive heavy-ion beams using storage rings in the GSI/FAIR laboratory in Germany. Additionally, I will discuss stable beam experiments performed underground at the Laboratory for Underground Nuclear Astrophysics in Italy and above ground at the University of Notre Dame in the USA.

Invited Talk SYPM 1.3 Wed 15:30 HS 1+2

Precision measurements and metrology applications at the borderline between atomic and nuclear physics — •Adriana Pálffy — Institute for Theoretical Physics and Astrophysics, University of Würzburg, Germany

Very precise atomic physics experiments can provide information on the properties of the atomic nucleus. On the other hand, atomic processes can drive nuclear transitions, especially for low-lying isomers which couple particularly well to the electronic shell.

The talk will follow two directions. First, it will discuss theoretical and experimental developments on the nuclear clock transition in ^{229}Th. This nucleus possesses the lowest known nuclear transition energy and promises a novel and unprecedently precise nuclear clock. The nuclear excited level is a metastable state with energy of 8.4 eV, that could just recently be driven by a vacuum-ultraviolet frequency comb [1]. Second, we will discuss recent proposals for nuclear excitation by electron capture employing precision mass measurements to monitor the nuclear state [2].

[1] C. Zhang *et al.*, Nature 633, 63 (2024).
[2] J. Zhao, A. Pálffy, C. H. Keitel and Y. Wu, Phys. Rev. C. 110, 014330 (2024).

Invited Talk SYPM 1.4 Wed 16:00 HS 1+2

Atomic parity violation: the seventh decade — •Dmitry Budker — Helmholtz Institute, JGU Mainz and UC Berkeley

Parity violation (PV) in atoms was considered by Ya. B. Zel'dovich in 1959, shortly after the discovery of parity violation in beta decay. However, a realistic experimental approaches and the first observations of the effects we only made in the 1970s. Today, atomic parity violation is a subfield of precision measurements, while observation of PV in molecules remains an unmet challenge. We will discuss what motivates present-day atomic and molecular experiments and mention a few of the ongoing and proposed experiments.