SYHB 1: Symposium Quantum Physics at the High-Energy Frontier: The Higgs Boson in the Standard Model and Beyond

Time: Wednesday 10:45–12:45 Location: ZHG105

Invited Talk SYHB 1.1 Wed 10:45 ZHG105
The Higgs Boson – Key to our Understanding of the Universe — •Milada M. Mühlleitner — Karlsruhe Institute of Technology, Karlsruhe, Germany

The Higgs boson was discovered 48 years after its postulation based on symmetry principles that are required to hold at the quantum level. It plays a central role in our understanding of the Universe: Through its couplings to all massive particles and as a door opener to dark sectors, it is able to give us answers to our most pressing open questions. These include the nature of Dark Matter and why there is more matter than antimatter in the Universe. Tested to highest precision at the quantum level, it builds a bridge between elementary particle physics, astroparticle physics, and cosmology. In this context, gravitational waves provide us with an exciting tool to investigate its role in the evolution of the Universe by connecting the quantum world with classical physics. The talk will shed light on the central role of the Higgs boson not only for the Standard Model of particle physics but also for our understanding of the Universe as a whole.

Invited Talk SYHB 1.2 Wed 11:15 ZHG105
The path to the discovery of the Higgs boson — •Karl Jakobs — Physikalisches Institut, Universität Freiburg, Freiburg, Germany

The announcement of the discovery of the Higgs boson on July 4, 2012 by the ATLAS and CMS experiments at the European Research Centre for particle physics, CERN in Geneva, marked an important milestone in the research on the fundamental building blocks of matter and the forces acting between them, and on the verification of quantum field theory-based predictions of the Standard Model of particle physics.

The Large Hadron Collider (LHC) was designed back in the 1990s to clarify the question of the existence of the Higgs boson, the last missing building block in the Standard Model. In this talk, the path from the establishment of the Standard Model and its quantum structure to the discovery of the Higgs boson and the first measurement of its properties will be described. In addition, insights into the realisation of the LHC and the associated experiments will be given.

Invited Talk SYHB 1.3 Wed 11:45 ZHG105
The Higgs boson revealed: What current experiments teach us about this unique quantum state — •Karsten Köneke — II. Physikalisches Institut, Georg-August-Universität Göttingen, Göttingen, Germany

At the heart of the Standard Model of particle physics lies the Higgs boson – an exceptional elementary particle distinguished not only by its spin-0 nature. It plays a crucial role within the quantum realm of particle physics in generating the masses of gauge bosons, fermions, and even itself. The Higgs boson is deeply connected to fundamental questions in quantum physics, the early stages of the Universe, and even the underpinnings of everyday chemistry. In this talk, I will present the latest Higgs boson measurement results from the ATLAS and CMS collaborations. I will also discuss ongoing efforts to observe the rare production of Higgs boson pairs – an essential step toward probing the structure of the Higgs potential.

Invited Talk SYHB 1.4 Wed 12:15 ZHG105
A Quantum Leap Forward: Unlocking the Higgs Boson at Future Colliders — •Markus Klute — Karlsruhe Institute of Technology, Karlsruhe, Germany

The Higgs boson stands out as the most intriguing and unique particle in the Standard Model – both a manifestation of the Higgs field and a potential key to new physics. While the Large Hadron Collider has opened the door, the precision frontier –where subtle deviations from the Standard Model may reveal themselves – lies ahead. In this talk, we explore how future experiments, from the High-Luminosity LHC to proposed next-generation colliders like the FCC, aim to transform the Higgs boson from a known particle into a precision tool. By measuring its self-interaction, rare decays, and couplings with unprecedented accuracy, we may uncover clues about the nature of electroweak symmetry breaking, the hierarchy problem, and possible connections to dark matter and the early universe. These future measurements are not just incremental steps – they are a quantum leap forward in our understanding of nature.