HK 42: Hadron Structure and Spectroscopy VIII

Time: Thursday 14:00–15:45 Location: J-HS A

Group Report HK 42.1 Thu 14:00 J-HS A

Measurement of the proton radius with hydrogen TPC at MAMI — •Vahe Sokhoyan — Universität Mainz, Institut für Kernphysik

The so-called "proton radius puzzle" originated due to significant discrepancies between some of the results for the proton charge radius measured in experiments with electronic or muonic hydrogen and in electron-proton scattering experiments. Very recently, the PRad Collaboration published new results favoring smaller proton radius compared to many of the previous electron-proton scattering measurements. Further scattering experiments utilizing new concepts for detection of particles in the final state are underway.

We are planning to perform a new measurement of the electron-proton scattering cross section at low momentum transfer (0.001 $\mathrm{GeV}^2 \leq \mathrm{Q}^2 \leq 0.04\ \mathrm{GeV}^2$) at the Mainz Microtron (MAMI). The project is conducted in collaboration between University of Mainz, Petersburg Nuclear Physics Institute, and collaborators from other contributing institutions. The experimental setup consisting of a Hydrogen Time Projection Chamber, Forward Tracker, and beam monitoring system will allow us to measure the energy and the angle of the recoil proton in combination with the angle of the scattered electron, and to determine the electron flux with high accuracy. The performance of this experiment will open avenue for further studies of this kind using deuterium and helium targets in combination with electron or photon beams. In this talk, the current status of this project and the future plans will be presented.

Group Report HK 42.2 Thu 14:30 J-HS A

Proton radius measurement in high-energy muon scattering at COMPASS — •Martin Hoffmann for the COMPASSplusplus/AMBER working group — Universität Bonn, Helmholtz-Institut für Strahlen- und Kernphysik, Bonn, Germany

The proton radius can be determined either by measuring the slope of the electric form factor via elastic lepton-proton scattering at low squared four-momenta Q^2 or by laser spectroscopy of hydrogen. Previous measurements of elastic electron-proton scattering and laser-spectroscopy of muonic hydrogen yielded contradicting results, which is known as the proton radius puzzle. In order to contribute to its solution, we propose a measurement using high-energy muon-proton elastic scattering at the M2 beam line of CERN's super proton synchrotron in 2022. A scattering experiment using muons instead of electrons is interesting for two reasons: (a) it has different systematic uncertainties and (b) it can test for lepton-flavour effects as a possible explanation of the puzzle. The transferred momentum to the proton will be determined using an active-target time projection chamber (TPC) filled with high-pressure hydrogen, yielding a high-precision measurement of Q^2. In order to over-constrain the reaction, the muon kinematics will be measured by the COMPASS spectrometer extended by precision silicon pixel detectors surrounding the hydrogen TPC. We present results from a test measurement in 2018 and plans for the final setup based on on-going Monte Carlo simulations. We also discuss the resolution on the proton radius that we plan to achieve.

Supported by BMBF.

HK 42.3 Thu 15:00 J-HS A

Surprising Features of the Neutron Electromagnetic Structure in Electron-Positron Annihilation — •Samer Ahmed[1,2], Alaa Dbeyssi[1], Paul Larin[1,2], Frank Maas[1,2,3], Christoph Rosner[1,2], and Yadi Wang[1] — [1]Helmholtz-Institut Mainz, Mainz, Germany — [2]Institute of Nuclear Physics, Mainz, Germany — [3]PRISMA Cluster of Excellence, Mainz, Germany

The neutron is one of the building blocks of visible matter. Its complicated structure emerges from the binding of three quarks by strong interaction. It cannot be calculated from first principles due to the large color charge of quarks and due to the self-interaction of gluons. The electromagnetic form factors represent the simplest structure observables and serve as a test ground for our understanding of the strong interaction. The data situation for the neutron structure from annihilation processes is very scarce. In this contribution, we show new results for the cross section of the $e^+e^- \rightarrow \mathrm{n}\bar{\mathrm{n}}$ process and the effective form factor of the neutron at 18 centre of mass energies in the range $\sqrt{s}$ = (2.0 - 3.08) GeV using data sets being collected at the BESIII experiment with an integrated luminosity of 647.9 pb^{-1}. The achieved accuracy of the results for the effective form factor of the neutron is of a similar level as those from the electron scattering data. The electric and the magnetic form factor of the neutron have been measured for the first time using data from the e^+e^- annihilation. In this contribution, the results for the disentangled electric and magnetic form factor of the neutron will be shown as well.

HK 42.4 Thu 15:15 J-HS A

Proton Radius in High-Energy Muon Scattering — •Christian Dreisbach for the COMPASSplusplus/AMBER working group — Technische Universität München, Physik-Department, Garching, Germany

The proton radius can be determined by measuring the slope of the electric form factor G_E at small squared four-momentum transfer Q^2. Numerous elastic-scattering and laser-spectroscopy measurements of the proton radius have been performed with contradicting results, the so-called proton radius puzzle. We propose to measure the proton radius in high-energy elastic muon-proton scattering at the M2 beam line of CERN's Super Proton Synchrotron in the year 2022. A high-precision measurement at low Q^2 realized with a high-pressure hydrogen TPC can contribute to a solution of the puzzle, especially in view of the systematics of this approach compared to electron scattering. We present results of the on-going analysis on systematic effects in elastic lepton-proton scattering to leading and next-to-leading order to reach the required precision in the low-Q^2 region and discuss ideas for a possible setup in 2022.

HK 42.5 Thu 15:30 J-HS A

Dispersive Calculation of the Rho Meson Mass Difference — •Philip Lüghausen — Technische Universität München

The mass difference between charged and neutral rho mesons is a critical parameter when accounting for chiral symmetry breaking in high-precision calculations. For a phenomenological determination, we employ a dispersive formalism analogously to the Cottingham formula. A resonance model is used to obtain numerical results. The current PDG estimate of $M_{\rho^\pm} - M_{\rho^0} = 0.7 \pm 0.8\,\mathrm{MeV}$ is compatible with our result in the range of $0.8 \ldots 1.4\,\mathrm{MeV}$.