Seminar on Particle Physics Phenomenology and Experiments

Report of Contributions

Contribution ID: **3** Type: **not specified**

Kaonic atoms studies at DAFNE: from SIDDHARTA-2 to future perspectives

Monday, 4 December 2023 13:00 (1 hour)

The DAFNE collider at INFN-LNF is a unique source of strangeness (low-energy kaons) in the world, it delivers a low-momentum (< 140 MeV/c) nearly monochromatic charged kaon beam, ideal for experimental studies of low-energy kaon-nucleon/nuclei interactions. Using the experience gained with SIDDHARTA experiment, which achieved the most precise kaonic hydrogen measurement of the 1s level shift and width to date, new X-ray studies focused on kaonic deuterium are ongoing in the framework of the SIDDHARTA-2 experiment, with the goal to determine the isospin dependent scattering lengths, which is only possible by combining the K-p and the upcoming K-d results. The experimental challenge of the kaonic deuterium measurement is the very small x-rays yield, the even larger width (compared to kaonic hydrogen) and the difficulty to perform x-rays spectroscopy with weak signals in the high radiation environment of DAFNE. It is therefore crucial to develop a new large area X-rays detector system to optimize the signal and to control and improve the signal-to-background ratio by gaining in solid angle, increasing the timing capability and as well implementing an additional charge particle tracking veto systems. An overview of the experimental improvements, the status and plans of SIDDHARTA-2 and future perspectives to measure other kaonic atom systems at the DAFNE collider will be given.

Presenters: SCORDO, Alessandro (INFN - Laboratori Nazionali di Frascati, Italy); SIRGHI, Florin (INFN - Laboratori Nazionali di Frascati, Italy)

Contribution ID: **4** Type: **not specified**

Study of the Femtoscopic correlation at HADES (GSI)

Monday, 11 December 2023 13:00 (1 hour)

Hadron femtoscopy emerges as a potent tool in high-energy nuclear collision studies, providing a means to uncover intricate details of the particle-emitting source. This technique examines momentum space correlations between pairs of particles, offering insights into the spatial and temporal characteristics of the emission region. By analyzing interference patterns arising from quantum statistics and final-state interactions, hadron femtoscopy facilitates the extraction of information regarding the size, shape, and duration of the particle-emitting source.

In recent decades, there has been extensive interest in understanding the properties of dense matter, particularly in the context of hypernuclei and hyperons. The presence of these exotic particles inside neutron stars has been linked to the softening of the Equation of State (EoS), imposing a constraint on the maximum mass of neutron stars (known as the "hyperon puzzle") to be below two solar masses. However, the scarcity of experimental data at high baryon chemical potential poses significant challenges in constructing an accurate EoS. To investigate matter under conditions akin to neutron star cores, low-energy heavy-ion collisions are employed. The study of strong interactions involving hyperons and clusters, such as nucleon-hyperon (e.g., $p-\Lambda$) or nucleon-cluster (e.g., $p - d$, $p - t$, or $p -3$ He), remains a challenge due to incomplete understanding of their interactions. Exploring two-particle correlations involving clusters allows for the investigation of the ground state of 4Li or the excited state of 4He. The information carried by created hadrons and clusters, available post thermal freeze-out, makes them valuable for studying earlier collision stages. Particularly, the use of photons, with their relatively long mean free path and emission throughout the system's evolution, proves beneficial for examining earlier collision stages.

Femtoscopy, a method enabling the examination of the space-time characteristics of collision generated systems, operates within a time-span of 10−23 seconds and a spatial scale of femtometers (10−15 meters). Experimental measurements provide insights into two-body interactions, system geometry, and dynamics. This work utilizes the HADES detector at GSI/FAIR (Germany), employing various detectors, including electromagnetic calorimeters capable of detecting neutral particles. Through the application of specialized software, a dedicated framework, and reconstruction algorithms, the study aims to identify γ-particles, Λ-hyperons, and clusters. The correlation functions for $p - \Lambda$, $p - d$, $p - t$, $p -3$ He, and $\gamma - \gamma$ will be presented.

Presenter: RATHOD, Narendra (Warsaw University of Technology)

Contribution ID: **5** Type: **not specified**

How special is the particle physics Standard Model?

Monday, 12 February 2024 13:00 (1 hour)

The Standard Model describes very well the results of our present experiments, from low energy precision measurements up to 13 TeV collisions at the LHC. How high in energy might it still work without need for new physics? Mathematically it is self-consistent up to the Planck scale. Physics-wise, if one extrapolates the Standard Model up to the Planck scale using renormalization group evolution, one finds that the vacuum is within about one standard deviation of being stable with any metastability setting in above 10^10 GeV. On the other hand, there are open puzzles: the tiny neutrino masses, the matter-antimatter asymmetry in the Universe, fermion families (why are there 3?), dark energy and dark matter plus primordial inflation. Here we give an introduction to these open questions and discuss how they might be resolved within the framework of an emergent Standard Model, with gauge symmetries "born" in a topological-like phase transition (without global order parameter) and dissolving in the extreme ultraviolet (instead of extra unification).

References:

SD Bass, Philosophical Transactions of the Royal Society A 382 (2023) 20230092, https://doi.org/10.1098/rsta.2023.0092

Presenter: BASS, Steven (Kitzbühel Centre for Physics, Austria)

Contribution ID: **6** Type: **not specified**

CP Violation and the Security in Quantum Protocols

Monday, 26 February 2024 13:00 (1 hour)

With the second quantum revolution, security in communication can be established through quantum phenomena. One of the most important tools to study the zoo of particles are symmetries and their violations by certain particles such as the CP symmetry (C…charge conjugation, P…parity). In this talk I will establish a connection between these two aspects.

Presenter: HIESMAYR, Beatrix (University of Vienna, Austria)

Contribution ID: **7** Type: **not specified**

Searches for dark matter using LAr TPC detectors

Monday, 22 April 2024 13:00 (1 hour)

Dark Matter searches are captivating as they hold the potential to unravel one of the universe's most enduring mysteries. The Global Argon Dark Matter Collaboration (GADMC) comprises the ArDM, DarkSide, DEAP, and MiniCLEAN dark matter direct detection experiments, with the collective aim of fully exploring the experimentally accessible dark matter parameter space down to the neutrino fog. While the experimental collaborations that formed GADMC all utilized argon-based detectors, they employed a variety of detector designs. This presentation will provide an overview of the DarkSide-20k detector, currently under construction by GADMC at the LNGS laboratory in Italy. DarkSide-20k is a two-phase Time Projection Chamber with low-radioactivity acrylic walls and optical readout using Silicon PhotoMultipliers (SiPMs). Notably, DarkSide-20k will be filled with Underground Argon, minimizing the cosmogenically-produced background of Ar-39. We will discuss the design, implemented background reduction techniques, expected sensitivity, and the current status of DarkSide-20k.

Presenter: HARAŃCZYK, Małgorzata (Jagiellonian University)

Contribution ID: **8** Type: **not specified**

Searches for rare events, role of underground laboratories

Monday, 3 June 2024 13:00 (1 hour)

Understanding of nuclear processes occurring at low energies (< 1 MeV) and observed in laboratories is of great importance for modern particle physics, astrophysics and cosmology. Current experiments include studies of neutrino properties, stellar evolution, the search for non-baryonic dark matter, proton decay or neutrino-less double beta decay. The discovery of the non-zero mass of neutrinos and their oscillations is now well established, however, the absolute scale of their masses is still unknown. It is also unknown whether the neutrino is a Dirac or Majorana particle, that is, whether it is its own antiparticle. These fundamental problems can be resolved by studying the double beta decay. If the neutrinos were a Majorana particles, the neutrino-less double beta decay should occur. It is only possible if the neutrino and the antineutrino are identical particles and lepton number is not conserved. Another extremely exciting problem is the structure of the Universe. A number of astronomical observations indicate that stars in galaxies and galaxy clusters are immersed in a halo of non-luminous matter, having a mass at least one order of magnitude greater than that of visible matter. Although indirectly the existence of dark matter is quite well documented, its nature is still unknown. Theories extending the Standard Model suggest the possibility of direct registration of cold dark matter particles (collectively referred to as Weakly Interacting Massie Particles - WIMPs), through interactions with atomic nuclei.

The discovery of WIMPs, neutrino-less double beta decay or the proton decay would be of great importance for modern physics. However, searches for these processes are very difficult due to the fact that the expected signal is extremely weak. The active masses of the detectors currently in operation are on the order of several hundred kilograms, and essentially no detector has so far registered an indisputably positive signal. In the new generation of experiments being prepared, the active masses will be at the level of many tons. However, in order to significantly improve their sensitivities, at the same time as increasing the mass, the background of the detectors must be reduced. The background comes mainly from the decays of natural radioisotopes contained in the construction materials and from cosmic rays. To reduce the latter the detectors are located in deep underground laboratories. Shallower laboratories, on the other hand, are necessary for material testing, selection and related R&D studies. We plan to conduct such measurements in an underground laboratory in Książ. In the talk construction of the site, preliminary results of measurements characterizing the site (muon flux, radon concentration) and research plans will be discussed.

Presenter: ZUZEL, Grzegorz (Jagiellonian University)

Contribution ID: **9** Type: **not specified**

Legacy of the Borexino experiment

Monday, 10 June 2024 13:15 (1 hour)

Borexino is the first experiment to have systematically codified techniques needed for studying neutrino physics with a threshold down to about 100 keV, reaching unprecedented levels of radiopurity. Currently, today's rare events and low-energy neutrinos experiments (as e.g. Juno, searches for dark matter and 0nbb decay) all have a program to obtain good radiopurity, which largely derives from Borexino. The experiment has closed a great circle of sky knowledge, opened in 1938 by Bethe and von Weiszackers' hypothesis on the pp and CNO cycles as engines that power the Sun and stars, by means of a multitude of measurements that give the entire spectrum of solar neutrinos and tell us how the Sun and main sequence stars work. During the talk, the most important results and experimental details will be discussed.

Presenter: MISIASZEK, Marcin (Jagiellonian University)