MON 10: Standard Model and Beyond

Time: Monday 14:15–16:15 Location: ZHG103

MON 10.1 Mon 14:15 ZHG103

QCD chemistry and heavy-light diquarks — •Mikhail Shifman — William Fine Theoretical Physics Institute, University of Minnesota, MN 55455, USA

In connection with recent discoveries of heavy-quark containing exotic states publications discussing Qq diquarks (Q,q stand for a heavy and light quarks, respectively) proliferated in the literature. After a brief summary of the diquark concept I present various general reasons why the heavy-light diquark (with sufficiently heavy Q) does not exist. Then I argue (this is the focus of my talk) that the most direct way to confirm non-existence of the Qq diquarks is the study of pre-asymptotic corrections in the inclusive decays of Qqq baryons, e.g. Λb. Since the c quarks are much lighter than b, namely, the ratio (m_b)^2/(m_c^2) is of the order of 11, traces of the cq attraction in the color anti-triplet spin-0 state may or may not be present in the cqq baryons.

MON 10.2 Mon 14:30 ZHG103

Quarkonia spectroscopy in the quark-gluon plasma — •Georg Wolschin — Institute for Theoretical Physics, Heidelberg, Germany

In relativistic heavy-ion collisions at RHIC and LHC energies, the spectroscopy of heavy-quarkonia states such as J/ψ and $\Upsilon(nS)$ that are mostly produced in the initial stages of the collision is modified through the presence of the hot plasma of gluons and light quarks. Here, we investigate the in-medium effects on the Υ and χ_b states in our theoretical Heidelberg model.

It considers, in particular, screening of the real quark-antiquark potential, collisional damping through the imaginary part of this potential, gluon-induced dissociation of the six states involved below threshold, and reduction of the feed-down contribution to the $\Upsilon(1S)$ spin-triplet ground state because of the screening of the higher-lying states [1]. Centrality- and transverse-momentum dependent results are compared with CMS and STAR data for the $\Upsilon(nS)$ states, including recent CMS results [2] for $\Upsilon(3S)$. The model has also been applied to Υ physics in p-Pb collisions, where the hot-medium influence can not be neglected, although cold-matter effects are dominant – as is shown in a detailed comparison with LHCb and ALICE data.

[1] G. Wolschin, Int. J. Mod. Phys. A 35, 2030016 (2020).

[2] A. Tumasyan et al. (CMS Collaboration), Phys. Rev. Lett. 133, 022302 (2024).

MON 10.3 Mon 14:45 ZHG103

Extensions of Minimal SU(5) GUT — •Clive Reese — Georg-August Univesity, Göttingen, Germany

Grand Unified Theories (GUTs) extend the Standard Model (SM) embedding the SM gauge groups into one larger group that spontaneously breaks down to the SM at high energy scales. Thereby they predict the unification of gauge couplings and explain the charge quantization of the fermions. However, the minimal non-supersymmetric scenario based on the SU(5) group predicts too fast proton decay. In our work we extend the scalar sector of the model and study the resulting parameter space to find out if it is possible to obtain unification of the couplings at higher scale and to reconcile large masses for the proton decay mediators, while keeping the SM Higgs naturally light.

MON 10.4 Mon 15:00 ZHG103

On the Equivalence Principle in the relativistic and quantum domain — •Claus Lämmerzahl and Hansjörg Dittus — University of Bremen, Am Fallturm 1, 28359 Bremen

The Equivalence Principle (EP) states that all pointlike particles fall in the same way in a gravitational field or that inertial mass is equivalent to gravitational mass. While this is very clear in a non-relativistic classical framework there are open issues in a relativistic and quantum context. First, it is not clear how to introduce in a covariant way a violation of the EP without referring to a bi-metric theory which is ruled out with very high precision from light propagation experiments. Second, quantum states are non-local and, thus, fail to be pointlike which leads to an at least apparent violation of the EP. Here we propose a new covariant approach to violations of the EP in stationary relativistic space-times. This approach naturally includes gravitomagnetic degrees of freedom and, thus, leads to a notion of an EP including all kinds of relativistic degrees of freedom. All these various aspects in principle can be tested with, e.g., atom interferometry. However, one has to further refine the notion of an EP in the quantum domain so that apparent violations of the EP owing to the spatial extension of quantum systems can be uniquely identified. Finally, we are left with an EP which holds both in the relativistic and in the quantum domain.

MON 10.5 Mon 15:15 ZHG103

The Projected Sensitivity of the DELight Experiment — •Eleanor Fascione, Belina von Krosigk, and Francesco Toschi — Kirchhoff-Institute for Physics, Heidelberg University, Heidelberg, Germany

There is vast unexplored parameter space for dark matter masses below a few GeV, and the field of direct dark matter detection is constantly expanding to new frontiers. In particular, low mass dark matter candidates necessitate novel detector designs with lower thresholds and alternative target materials compared to e.g. the xenon-based experiments currently providing the strongest overall constraints on many dark matter models.

The Direct search Experiment for Light dark matter (DELight) will deploy a target of superfluid ^{4}He instrumented with large area microcalorimeters (LAMCALs) based on magnetic microcalorimeter (MMC) technology in a setup optimized for low mass dark matter searches. In this talk an overview of this upcoming experiment will be presented, including preliminary background models and sensitivity projections.

MON 10.6 Mon 15:30 ZHG103

Shaping DELight: signal propagation in superfluid helium-4 — •Francesco Toschi, Eleanor Fascione, and Belina von Krosigk — Kirchhoff-Institute for Physics, Heidelberg University, 69120 Heidelberg, Germany

Large dual-phase noble liquid TPCs strongly constrain the parameter space for dark matter candidates above the GeV/c^2 but can barely explore lighter candidates. Probing this low-mass regime requires ultra-low energy thresholds, which solid-state cryogenic detectors can reach by measuring phonons. However, their small target masses limit exposure and cannot scale in a monolithic way. The Direct search Experiment for Light dark matter (DELight) will use a superfluid helium-4 target instrumented with large area microcalorimeters (LAMCALs), combining the low threshold of phonon-based detection with the scalability of noble liquids. This allows DELight to explore masses down to below 100 MeV/c^2 with just 1 kg d of exposure.

DELight is in its design phase, and detailed simulations play a central role in informing the design and construction of the final detector. This talk will present the current GEANT4 simulation framework, with particular focus on the propagation of the different signal quanta deriving from an energy deposition in superfluid helium-4: photons, excimers, and quasiparticles, i.e. phonons and rotons. In particular, the role of quasiparticle collection efficiency in motivating the choice of a high aspect ratio (or 'pancake') geometry for the detector cell will be discussed.

MON 10.7 Mon 15:45 ZHG103

Towards dark matter detection with superfluid Helium: First results from the DELight Demonstrator — •Axel Brunold, Anna Bertolini, Christian Enss, and Belina von Krosig — Kirchhoff Institute for Physics, Heidelberg University

The search for light dark matter requires innovative detection techniques capable of probing weakly interacting particles with exceptional sensitivity. One promising approach involves studying elastic scattering interactions between dark matter particles and helium atoms in the superfluid phase at millikelvin temperatures.

As part of the Direct search Experiment for Light dark matter (DELight), a pilot experiment is conducted to investigate the behavior of magnetic microcalorimeters (MMCs) submerged in liquid helium referred to as DELight Demonstrator.

In this setup, a small copper cell (300 ml) is cooled to below 50 mK within a *He/*He dilution refrigerator and filled with *He. The liquid helium level, during both filling and operation of the MMC, is monitored using an LC circuit-based level meter. At these temperatures, *He is deep in its superfluid phase, enabling a long mean free path for phonons and rotons. An MMC fabricated on a 5 mm * 5 mm

silicon substrate and a resistive heater are submerged in the liquid helium. This experiment aims to explore the response of a small-scale athermal MMC (SAMCAL, small-area magnetic microcalorimeter) to phonons excited by the heater in the superfluid.

This contribution presents the DELight Demonstrator setup and recent developments in the project.

MON 10.8 Mon 16:00 ZHG103

Mitigating the low-energy excess in cryogenic detectors for low-mass dark matter searches: Advances from the CRESST experiment — •Anna Bertolini — Kirchhoff-Institute for Physics, Heidelberg University, 69120 Heidelberg, Germany

The low-energy excess (LEE) observed in cryogenic detectors, characterized by a steeply increasing event rate below 200 eV, poses a significant challenge to dark matter searches, particularly at low masses. The CRESST experiment has pioneered efforts to understand and mitigate this phenomenon through extensive studies of detector response, novel module designs, and innovative analysis frameworks. Recent observations highlight the time-dependent decay of the LEE rate, offering a practical mitigation strategy through long-term stable cryogenic operation. Coupled with advancements in detector technology, such as DoubleTES sensors and Mini-Beaker modules, these efforts enable a tenfold reduction in the LEE rate, significantly enhancing sensitivity to dark matter interactions. This presentation will detail the latest insights and results of the CRESST Experiment, emphasizing the critical role of detector design in pushing the boundaries of cryogenic detector performance.