RPP2021 virtuelles

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Tours

Book of Abstracts

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Hints for decaying dark matter from S8 measurements

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The 'S8 tension' is a longstanding discrepancy between the cosmological and local determination of the amplitude of matter fluctuations, parameterized as S8≡σ8(Ωm/0.3)^0.5, where σ8 is the root mean square of matter fluctuations on a 8 Mpc/h scale, and Ωm is the total matter abundance. In this talk, I discuss that it is possible to resolve the tension if dark matter (DM) decays with a lifetime of 1/Γ ~ 55 Gyrs into one massless and one massive product, and transfers a fraction ε ~ 0.7 % of its rest mass energy to the massless component. The velocity-kick received by the massive daughter leads to a suppression of gravitational clustering below its free-streaming length, thereby reducing the σ8 value as compared to that inferred from the standard ΛCDM model. I will show that the preference for decaying DM, while entirely driven by the local S8 measurements, does not sensibly degrade the fit to any of the cosmological data-sets, and that the model could explain the anomalous electron recoil excess reported by the Xenon1T collaboration.

Heavy Ions / 2

Impact of hadronisation process and hadronic cascades on the 2nd order susceptibilities studied with EPOS event generator

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Within the framework of the exploration of the phase diagram of nuclear matter, the susceptibilities are useful tools to probe the existence of a 1st order phase transition and a possible critical endpoint. In this context, STAR collaboration recently published some results of variances and 2nd order susceptibility ratios for electric charge (Q), protons and kaons (the last 2 being used as proxies for baryonic number B and strangeness S). Hence, we plan to simulate Au+Au collisions with the event generator EPOS, to reproduce STAR analyses and, in particular, study the impact of hadronisation and hadronic cascades on these quantities. We show here our first results for some BES program reactions, obtained with a preliminary version of EPOS 4 using the latest equation of state from the BEST collaboration.

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Dynamical Thermalization in heavy-ion collisions

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The development of the merged EPOS+PHSD approach is one way to study the influence of the initial non-equilibrium stage of the heavy-ion reactions on the final observables. The microscopic understanding of the initial phase of heavy-ion collisions is an intricate problem, in this respect, the EPOS and PHSD approaches provide a unique possibility to address this problem. We employ the EPOS to do the initial stage of Heavy-Ion Collisions based on a multiple Pomeron exchange in Gribov Reggeon Field Theory formalism. EPOS is a particularly successful event generator and universal model for all collisions. PHSD is a microscopic covariant dynamical approach for strongly interacting systems formulated based on Kadanoff-Baym equations.
Following injecting particles from EPOS to PHSD, we investigated the "flow behavior". The easiest way to study was to look at particle production. Once there are sufficient interactions, the magnitude of the flow increases, indicating that we are close to Thermalization. I am going to present our results concerning various observables like "elliptical flow" and "pt spectra" in EPOS+PHSD and make comparisons with EPOS+hydro, EPOS-hydro, and pure PHSD.

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Techni-Pati-Salam Model

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In the perspective of UV completion of Composite Higgs, the Techni-Pati-Salam model offers a unique approach. We extend a Composite Higgs scenario all the way to the Planck scale with the ambition of obtaining at low energy enough ingredients for flavour hierarchy and a dark matter candidate.

Beyond the Standard Model / 5

A negative cosmological constant in the dark sector?

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Following theoretical (high-energy physics) considerations, we explore the possibility that our Universe contains a *negative cosmological constant*, dubbed λ, on top of an additional component X accounting for the late-time accelerated stage of expansion. In this talk, I will present some of the cosmological implications of introducing λ. In particular, we will assess the viability of such models when considering Baryon Acoustic Oscillations, SNeIa and CMB (geometrical) measurements. We estimate the Bayesian evidence in various cosmological scenarios through a nested sampling of the parameter space, and compare it to base-ΛCDM for model selection. We will briefly comment on their capability to address the current Hubble tension when a high-H_0 is taken into account.

Pheno/Experimental / **7**

Top quark spin observables and EFT

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Measurements of top quark spin observables in $t\bar{t}$ events represents a unique possibility to test the standard model (SM) predictions and probe the new physics effects. Potential deviations from the SM expectations are parametrized within the framework of the Effective Field Theory (EFT). In this presentation, we introduce how to measure the spin correlation between top quarks and we cover the impact of introducing dimension-six operators spin observables.

Pheno/Experimental / **8**

Hight Granularity Timing Detector (HGTD)

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The large increase of pile-up interactions is one of the main experimental challenge for HL-LHC physics program. Covering the pseudo-rapidity region between 2.4 and 4.0, the Hight Granularity Timing Detector (HGTD) is therefore proposed for the ATLAS Phase-II upgrade. Using the ability to distinguish between interactions within an event at different ⊠ positions or time by high-precision timing information, HGTD is powerful to mitigate the effect of pile-up. One crucial element for this mitigation is to know the t0 of each of the 3.6 million channels, where t0 is the time of particles created at ⊠ =0. This is important to achieve the expected time resolution which expected to be around 15 ps, coming mainly from electronic jitters and geometrical effects, e.g. time of flight. These effects must be moderated and calibrated to minimised their contributions to time resolution. A calibration framework for time calibration is developed. In this presentation, we discuss in details the time calibration methodology and its performances using dedicated studies.

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Cold & Dense QCD: renormalization group resummation at NNLO

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QCD at finite temperatures and densities is plagued by infrared divergences that need to be resummed. The recently
developped renormalization group optimized perturbation theory (RGOPT) gives a RG-compatible resummation, that
substantially reduces the large residual renormalization scale dependence observed in more standard resummations
known as hard thermal loop (HTL) or hard dense loop (HDL) perturbation theory. Preliminary results for the cold and dense
QCD equation of state at three-loop order will be discussed, with possible applications to Neutron-Star physics.

Pheno/Experimental / 10

Single Leptoquark Solutions to the B-physics anomalies

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We discuss the minimalistic scenarios of new physics at the $\mathcal{O}(\mathrm{TeV})$ scale which involve one leptoquark state (LQ) and which are consistent with a number of measured low energy flavor physics observables, as well as with the results of the direct searches at the LHC. In particular we examine the scenarios which can accommodate the so-called B-physics anomalies i.e. experimental hints of the lepton flavor universality violation in B decays. We show which LQ can provide acceptable solution, and make predictions regarding the lepton flavor violating decay modes that can be probed experimentally and therefore test the validity of the proposed scenarios.

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Brane-Higgs fields

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The problematic huge hierarchy between the usual 4-dimensional Planck mass scale of gravity and the ElectroWeak symmetry breaking scale can interestingly disappear at some point-like location along extra space-like dimensions where the effective gravity scale is reduced down to the TeV scale. Field theories with point-like particle locations (3-dimensional brane-worlds) or point-like interactions deserve special care. In particular it can be shown that, in contrast with usual literature, brane-scalar fields – like the SM Higgs boson – interacting with fermions in the whole space (bulk) do not need to be regularized if rigorous 4- or 5-dimensional treatments are applied: standard regularization introduces a finite width wave function for scalar fields localized along extra dimensions. The variational calculus of least action principle must also be applied strictly to derivate the fermion (Kaluza-Klein) masses and couplings, in particular by distinguishing the natural and essential boundary conditions: the higher-dimensional model – based in particular on extra compact spaces of type interval or circle (orbifold) – must be defined either completely through the action expression [necessity then for new specific brane terms bilinear in the fermion fields] or partially from additional so-called essential boundary conditions. Besides, the correct action integrand definition requires to introduce improper integrals in order to remain compatible with the fermion wave function discontinuities induced by point-like Higgs interactions. Phenomenologically, the correct treatment of the brane-localised Higgs boson could be tested via the precise measurements of the Higgs coupling to di-photon or (flavour-changing) Yukawa interactions at hadron and lepton colliders.

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Asymptotic Grand Unification and other attractives features of the Renormalisation Group Equations.

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Since the Renormalisation Group (RG) scheme was introduced in the early 50's, it allowed to achieve great improvements in multiple domains of physics, from quantum field theory to solid-state physics. The RG can describe the evolution of interactions strengh depending on the energy scale of the process they are involved in. One of the main predictions it gave is in the domain of Grand Unification Theories (GUT) in which fundamental interactions (involved in the SM group) become one unique interaction at high energy. While classical GUT theories see unification as a crossing between the curves of the running couplings, my work proposes to see the unification as an asymptotic process where couplings unify asymptotically attracted by the same UV fixed point. I will present the minimal model in SU(5) with one compactified extra-dimension, which allows to get rid of the proton decay, introduces a dark matter candidate and can reproduce the baryon asymmetry observed in the Universe. Along with these features, larger models (as SO(10) models) could introduce leptogenesis and a natural description for the neutrino sector.
Renormalisation Group Equations (RGE) can also be used to model completely different problems, among which the evolution of the Covid-19 pandemic. I will briefly present the master equation permitting to follow the spreading at different geographical levels and for different features of the pandemic.

Pheno/Experimental / 13

New physics in B meson mixing: future sensitivity and limitations

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The mixing of neutral mesons is sensitive to some of the highest scales probed in laboratory experiments. In light of the planned LHCb Upgrade II, a possible upgrade of Belle II, and the broad interest in flavor physics in the tera-Z phase of the proposed FCC-ee program, I discuss constraints on new physics contributions to Bd and Bs mixings which can be obtained in these benchmark scenarios.

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Muon Telescope as Demonstrator of the JUNO Top Tracker Detector

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The Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose underground Liquid Scintillator detector with a target mass of 20 kt, a baseline of 53 km, and an energy resolution of 3% at 1 MeV. The main goal of JUNO is to determine the neutrino mass hierarchy to 3σ over six years of operation and provide accurate measurements of the neutrino oscillation parameters. JUNO will cover a rich physics program for measurements on geoneutrinos, solar neutrinos, atmospheric and supernovae neutrino, and searching for new physics beyond the Standard Model. JUNO detector is composed of 3 different parts: The Central Detector, the Water Cherenkov detector, and the Top Tracker (TT). TT is a 3-layer muon tracker located above the Central and Water Cherenkov detectors. It will provide precise atmospheric muon tracking. These reconstructed muons are essential in JUNO for rejecting cosmogenic background (*{}^{9}\textrm{Li}* ,{}^{8}\textrm{He}) induced in the Central Detector.

The Institut Pluridisciplinaire Hubert CURIEN (IPHC) group participating in JUNO is responsible for the TT's construction, installation and commissioning. It will also contribute to the analysis of TT data. The IPHC group has built a prototype of the TT called Muon Telescope. The detection system of this prototype is composed of the same elementary blocks as the TT but arranged in a different configuration. The Muon Telescope is equipped with Wavelength Shifting fibers and the same readout and trigger electronics deployed in the TT detector, allowing us to validate these electronics. This prototype also provides us the possibility to prepare and test the reconstruction algorithms to be used in the TT, using the atmospheric muon flux at Strasbourg.

For this talk, I will mainly focus on my Ph.D. thesis work on the Muon Telescope.

Keywords: JUNO, Top Tracker, Neutrino mass hierarchy, Muon Telescope, Calibration

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A probabilistic QCD picture of diffractive dissociation and predictions for future electron-ion colliders

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We study the diffractive dissociation of a small onium and of a virtual photon in the scattering off a large nucleus. In a well-defined parametric regime, the nuclear scattering of the onium is triggered by large-dipole fluctuations in the course of its rapidity evolution in the form of color dipole branching, and the diffractive dissociation with a minimal gap Y_0 out of total rapidity Y is tantamount to the probability that an even number of the dipoles in the onium Fock state effectively participate in the scattering, in a frame in which the onium is evolved to the rapidity $Y-Y_0$. Such picture allows to extract the asymptotic solution of the Kovchegov-Levin equation, established in QCD 20 years ago, which rules the diffractive cross section. Diffraction in electron-ion collisions, which can be linked to the same process in onium-nucleus scattering, is then studied based on numerical solutions of the original Kovchegov-Levin equation and of its next-to-leading extension taking into account the running of the strong coupling, with the aim to make predictions for the distribution of rapidity gaps in realistic kinematics of future electron-ion colliders. We show that the fixed and the running coupling equations lead to different distributions, rather insensitive to the chosen prescription in the running coupling case. The obtained distributions for the fixed coupling framework exhibit a shape characteristic of the above-mentioned picture already at rapidities accessible at future electron-ion colliders, which demonstrates the relevance of measurements of such observables for the microscopic understanding of diffractive dissociation in QCD.

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Advanced fluid dynamics for heavy-ion collisions: The impact of dimensionality

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In heavy-ion collisions, under extreme conditions, a deconfined state of the quark and gluon matter can be created, the Quark Gluon plasma (QGP). It was the dominant form of matter in the early universe, and now it can be reproduced in dedicated experiments such as BES II at RHIC, BNL. Among all unanswered questions about the QGP, the existence of a critical point in the phase diagram of the strong interaction is one of the most challenging and interesting.

From theoretical in-equilibrium physics, extraordinary behaviour such as huge fluctuations of the net baryon density are expected to occur at this point. On the experimental side, the QGP can only be studied using heavy ion collisions, which are extremely fast and out of equilibrium phenomena. Consequently, a realistic model of the dynamics of fluctuations in heavy-ion collisions is needed to properly relate experimental measurements and theoretical calculations.

We work on the dynamical modeling of critical fluctuations in the context of heavy-ion collisions. More precisely, we study a stochastic diffusion equation in 3+1 dimensions where the critical behavior is encoded in a potential obtained from a Ginzburg-Landau free energy functional. First, we present the successful benchmark. Then, we show that infinities arise in the correlation function in three dimensions. Such infinities have a strong impact in numerical calculations, and especially on the lattice spacing dependence of fluctuation observables . Finally, we show that the correlation length has an impact on sub-volume observations in higher dimensions.

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Dynamics of the critical fluctuations in heavy-ion collisions

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It is now known that a deconfined states of the strongly interacting matter can be formed under extreme conditions of temperature and density in heavy-ion collisions : the quark-gluon plasma (QGP). Intensive works has been done to understand its fascinating properties but many questions remain unanswered. Especially, theoretical studies suggest the existence of a critical point in the phase diagram of the QCD matter. For the moment, the supposed location of the critical point is outside the region accesible from first-principle calculations. Therefore, we need to rely on understanding the experimental data obtained from heavy-ion collisions.

In heavy-ion collision, the QGP undergoes a rapid expansion in the longitudinal direction and a very quick temperature decrease, it follows dynamical trajectories in the QCD phase diagram. This have an impact on the observables that are supposed to carry information about the critical point such as the higher-order cumulants of the net-baryon density. A reliable study of the impact of the dynamics on the critical fluctuations is then required to fully adress the following question : are we able to experimentally prove the existence of the critical point with heavy-ion collision ?

We investigate the diffusive dynamics of the critical fluctuations of the net-baryon density in the case of a relativistic heavy-ion collision undergoing a Bjorken-type expansion. The fluctuation observables are inferred from the study of a stochastic diffusion equation which incorporates both diffusive dynamics and intrinsic fluctuations.
In the vincinity of the critical point, the critical behavior of the fluctuations is encoded in the Ginzburg-Landau free energy functional. We demonstrate the growth of higher-order cumulants for trajectories passing near the critical point surviving the impact of net-baryon number conservation and dynamical effects. We also show that the behavior of the correlation function and of the higher-order cumulants as a function of the rapidity window are promising signals of the QCD critical point in heavy-ion collsions.

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Weak Gravity Conjecture and Scalar Fields

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Several extensions of the Weak Gravity Conjecture have been proposed in the literature. I plan to report on the proposal for the case of scalar self-interactions and sketch out some implications. This is based on work with K. Benakli and G. Lafforgue-Marmet.

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Dark Heating of Neutron Stars : Electron Edition

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Dark matter can deposit energy in neutron stars and heat them to temperatures that could be detectable by upcoming infrared telescopes like James Webb Space Telescope (JWST). These observations have a potential to complement and outperform terrestrial direct detection in a large range of dark matter masses. Electrons are also present in the neutron stars in significant proportion. Capture due to electrons can aid in the capture of leptophilc dark matter. Ultrarelativistic nature of these electrns make the calculation challenging. In this talk, I will discuss the fomulation of this capture calculaton and its interesting consequences for understanding the nature of dark matter.

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YM and QCD correlation functions from the Curci-Ferrari model at two-loop order

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During the last decade the Curci-Ferrari model has been widely used to study, in a perturbative approach, the infrared behaviour of both YM theory and QCD. One-loop results for two- and three-point correlation functions have shown in general a very good agreement with lattice data. In this talk I will present the natural step forward of this analysis: the extension to two-loop order. I will introduce the results for the ghost-antighost-gluon vertex in SU(2) and SU(3) YM theory in a particular kinematical configuration, and the results for two-point correlation functions in QCD with two degenerate quark flavours. In all cases two-loop corrections show an improvement with respect to one-loop results in comparison to lattice data. Quite remarkable is the case of the quark wave form factor. For this quantity, one-loop corrections were unable to reproduce the lattice data even at a qualitative level. As expected, two-loop corrections are of crucial importance in this case, solving this apparent mismatch between the model and the simulations.