Theory and Experiment in High Energy Physics

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Book of Abstracts

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Quantifying the Underlying Event in pp Collisions at LHC Energies using Non-extensive Statistics

Author: Gergely Gabor Barnafoldi[1]

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I present our study of the transverse momentum spectra and their evolution in function of the position of the azimuthal of the particles associated to the leading particle in this talk. Additionally, the behavior of the spherocity distribution in the same azimuthal bins is reported. The studies were made using proton-proton collisions at $\sqrt{s}$ = 13 TeV using PYTHIA8 Monte Carlo event generator. The Multiplicity and midrapidity transverse momentum spectra of charged hadrons have been analyzed in the non-extensive statistical framework. The results on the findings corresponding to the Underlying Event are reported.$v_2(p_T)$, depicting a change in meson- baryon elliptic flow at intermediate-pT, is studied for various collision systems and energies. The model is further evaluated by training it for different p_T regions. These results are compared with the available experimental data wherever possible.

Short talks / 27

Constraints on the Size of the Extra Compactified Dimensions from Compact Star Observations

Author: Anna Horvath[None]

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Compact stars with Kaluza-Klein excitations are considered and constraints on the size of compactified extra dimensions are given.

The model is a static, spherically symmetric Kaluza-Klein-based theory with one extra compactified dimension. Realistic equation of state has been introduced and applied in order to reproduce the compact star observables. Comparison of the theoretical calculation with available observational data led us to consequences on the size of extra dimensions within the Kaluza-Klein framework.

Lectures / **29**

Perturbative QCD at the precision frontier

Author: Gabor Somogyi[1]

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The successful operation of the Large Hadron Collider at CERN has opened up a new era of exploration in particle physics, whose outstanding highlight so far has been the discovery of the Higgs boson. However, as the direct detection of new phenomena not captured by the Standard Model of particle physics has eluded us so far, the search for subtle deviations of measured data from theoretical predictions is taking center stage. The increased sensitivity and precision of the experiments poses a formidable theoretical challenge though, as predictions must be computed at similarly high accuracies. In particular, the sophisticated modeling of the strong interaction (QCD) in particle collisions is indispensable. In this talk, I will give an overview on the status of perturbative QCD calculations and recent advances in computational techniques, as well as present some current directions of development. I will also touch on the precise determination of the strong coupling constant and highlight the important role played by precise perturbative QCD calculations in these measurements.

Short talks / **30**

Precise prediction for the W-boson mass in U(1) extensions of the standard model

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The theoretical prediction for the W-boson mass (M_W) is sensitive to physics beyond the standard model (BSM). Currently, there is a 2σ discrepancy between the standard model (SM) theoretical prediction and the measured value of M_W, obtained from the LEP 2, Tevatron and LHC experiments. Considering also the recent measurement of M_W with the CDF II detector, the discrepancy is severely aggravated and the precise determination of theoretical BSM corrections is necessary.

We perform the one-loop renormalization of particle physics models with gauge sectors extended by an extra U(1) gauge symmetry in order to compute the radiative corrections to the muon decay process. As a result, we obtain – to the best of our knowledge – for the first time in the literature a finite, gauge invariant prediction for M_W in U(1) extensions at one-loop accuracy.

In the literature only a truncated version of the prediction for M_W was available for U(1) extensions. We compare the truncated and full predictions for M_W for different sets of input parameters in order to explore the validity of neglecting several terms from the complete one-loop prediction.

The talk is based on `arxiv:2305.11931`

Lectures / **32**

NA62 Experiment at CERN and Physics Beyond the Standard Model

Author: Tomas Blazek[1]

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No direct signal of Beyond Standard Model (BSM) Physics has been found at the LHC experiments for over a decade. The NA62 Experiment searches for BSM Physics signals with high intensity beam at low energies. Designed to study rare - or forbidden in the Standard Model - kaon decays it is currently in its Run 2 stage. Its Run 1 results based on data from 2016-2018 include detection of twenty signal events in the golden K+ to pi+ nu nubar decay channel, and improved limits on various lepton flavor and lepton number violating decays to be discussed in the presentation. Run 2 search for exotic physics in the Beam Dump Mode presented at recent conferences will also be summarized. The golden channel will be analyzed in some detail from the perspective of SUSY with non-uniform SUSY breaking terms.

Short talks / **33**

Unitarity in multi-Higgs production

Authors: Gábor Cynolter[1]; Árpád Curko[2]

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In spontaneuosly broken scalar theories perturbative and semi-classical calculations show that multi-particle production grows rapidly with the number of scalar particles at sufficiently high energies. According to recent computations, for $\lambda n \gg 1$, where n is the multiplicity and λ is the self-coupling, the amplitude grows exponentially with the energy, resulting in a divergent propagator and predicting the violation of perturbative unitarity. In this talk I present the self-consistent solution of the Schwinger-Dyson equation of the scalar theory in the spectral representation and the transition rate is calculated. We find an amplitude growing quadratically with the energy which leads to an asymptotically decreasing propagator.

Short talks / **35**

Production of light flavour hadrons in the ALICE experiment at the CERN LHC

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The ALICE experiment is dedicated to studying the hot and dense nuclear matter created in heavy-ion collisions at the Large Hadron Collider. A crucial part of the ALICE physics programme is to study small collision systems, such as proton-proton and proton-lead collisions and compare them with the heavy-ion ones in order to disentangle effects coming from individual nucleon-nucleon interactions or from cold nuclear matter. In the contribution, state-of-the-art results on light-flavour hadron production from small (pp and p-Pb) to large collision systems (Xe-Xe and Pb-Pb) at various energies measured by ALICE will be reported.

Short talks / 36

Thermal regularization of t-channel singularities of scattering processes

Author: Michał Iglicki[1]

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In this talk, I will discuss the so-called t-channel singularities that may occur when a given t-channel scattering process is mediated by a massive, stable particle on its mass shell.

After providing conditions for the singularity to occur and presenting several examples of SM and BSM processes afflicted by the issue, I will describe a regularization method based on thermal field theory.

Taking into account interactions between the t-channel mediator and the environment allows to assign an effective decay width to the mediator. Consequently, the singularity can be regularized using a resummed propagator.

Short talks / 37

Confined covariant quark model.

Authors: Andrej Liptaj[1]; Anna Dubnickova[2]; Mikhail Ivanov[None]; Stanislav Dubnicka[3]

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Heavy quark factories, nowadays in operation, produce a large amount of data on heavy hadron decays. These enable us to extract various Standard Model parameters and also open discussion about new physic and exotic states. Theoretical predictions need, because of the quark confinement, to account for hadronic effects, which is difficult to do from first principles. We use the confined covariant quark model for that and we have, up to know, successfully predicted various hadronic observables. This Lagrangian-based model is suited for different multiquark states, incorporates electromagnetic interactions and quark confinement and has limited number of free parameters.

Short talks / 38

Speed of sound in a dynamical chiral quark model

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Gravitational waves offer an exciting chance to study dense matter and challenge theoretical models of dense EoS (Equations of State). A common class of models in dense matter, the standard NJL model, has the known problem that the speed of sound fails to approach the conformal limit. We investigate how a dynamical chiral quark model, which implements non-local interactions among quarks, can resolve the issue. The influence of confinement on quark number susceptibility and color superconductivity will also be explored.

Short talks / 39

Strangeness Enhancement in Small Collision Systems at ALICE: Role of Hard and Soft Processes

Author: Ishaan Ahuja[1]

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One of the first proposed signatures of QGP formation in heavy-ion collisions is the enhanced production of strange hadrons compared to non-strange ones.

Recent measurements in high-multiplicity proton-proton (pp) and proton-lead (p-Pb) collisions have exhibited features reminiscent of those observed in lead-lead (Pb-Pb) collisions. Among others, the observed enhancement of strange particles as a function of multiplicity, whose origin is still not well understood. In order to probe the underlying mechanisms behind this phenomenon, we differentiate between strange hadrons originating from jets and those arising from soft processes. This is attained by using angular correlations between high transverse momentum charged particles and strange hadrons for K^0_S, Ξ, and ϕ in pp collisions at $\sqrt{s}$ = 13 TeV and p-Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV.

Short talks / 40

AI learns the stellar spectrum

Authors: Balázs Pál[1]; Laszlo Dobos[2]

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Examining the properties of stellar populations in and around the Milky Way is a crucial step towards the understanding of galactic evolution. Gaining insight into this process can provide us valuable information about the large-scale and long-term characteristics of both ordinary and dark matter. In this study we focused on the spectroscopic aspect of this investigation, by looking into how well autoencoder-based neural networks (AEs) perform in the processing and analysis of stellar

spectra. We show that AEs are capable of learning the physical characteristics of stellar spectra to a considerable extent, even in noisy and low S/N conditions.

Short talks / 41

Self-Similar Solutions in Newtonian Cosmology

Author: Balazs Endre Szigeti[1]

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We present a dark fluid model described as a non-viscous, non-relativistic, rotating, and self-gravitating fluid. We assumed that the system has spherical symmetry and the matter can be described with the polytropic equation of state. The induced coupled non-linear partial differential equation system was solved by using a self-similar time-dependent ansatz introduced by L. Sedov and G. I. Taylor. These kinds of solutions were successfully used to describe blast waves induced by an explosion since the Guderley–Landau–Stanyukovich problem. We showed that these kinds of solutions can provide new solutions that are consistent with the Newtonian cosmological framework. We have found that such solutions can be applied to describe normal-to-dark energy on the cosmological scale.

Public lecture / 42

Public lecture: Principles of instrumental realism

Author: Ladislav Kvasz[1]

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Instrumental realism is a philosophical position that attempts to integrate into a coherent picture the different kinds of experience on which science is based. Besides ordinary sensory experience, it integrates different kinds of instrumental practices.

Lectures / 44

Neutrino masses, oscillations, and 0nbb-decay

Author: Fedor Simkovic[None]

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A new Quantum Field Theory (QFT) formalism for neutrino oscillations in a vacuum is proposed. The neutrino emission and detection are identified with the charged-current vertices of a single second-order Feynman diagram for the underlying process, enclosing neutrino propagation between these two points. The L-dependent master formula for the charged lepton production rate is derived, which provides the QFT basis for analyzing neutrino oscillations. The observation of neutrino oscillations and hence non-zero neutrino masses provided a milestone in the search for physics beyond the Standard Model. An open question remains whether neutrinos are Dirac or Majorana particles. A smoking-gun signature of Majorana neutrinos is the observation of neutrinoless double-beta decay 0νββ-decay. The recent progress in the experimental and theoretical study of 0νββ-decay is shortly reviewed. A mechanism of generating Majorana neutrino mass due to the spontaneous breaking of chiral symmetry and forming a quark condensate is presented. The present-day results of the double-beta decay nuclear matrix elements calculation are discussed. An impact of the quenching of the axial-vector coupling constant on double-beta decay processes is addressed. The related experimental and theoretical studies of single ⍰-decay, 2νββ-decay, muon capture processes, and double-charge exchange nuclear reactions are also addressed.

Short talks / **45**

Searching for dark matter through observations of compact stars and detections of cosmic rays

Author: David Edwin Alvarez Castillo[1]

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In this talk I will first present a review of the state-of-the-art physics of compact stars and then discuss the possibility of detecting dark mattermin their interior or in their vicinity. As an application I will consider the uniform rotation of compact stars admixed with dark matter, which also feature an extended halo. As a particular example I will discuss the rotation of such compact stars bearing the dark matter halo. For the derived results, the relativistic mean field model equation of state DD2 has been used. The resulting configurations contain a typical dark matter to baryonic matter fractions of the order up to 3%. I will provide a discussion on astrophysical scenarios that provide compact stars constraints like from the detected fastest rotating neutron star, the possible mergers of compact stars with dark matter halos, and modifications to the cooling of compact stars. Finally I will address the possibility of detecting dark matter through detections of cosmic rays, particularly focusing in cosmic ray ensembles which are potentially detectable by the CREDO experiment.

Short talks / **46**

Looking for the details of the pp collisions

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The coming runs of pp collisions at the LHC will significantly better the statistics, and later in the 30's in much increased pseudorapidity range will open the possibilities to measure rare probes .but also will offer an opportunity to measure in much details the transverse momentum spectra and other parameters like the anisotropic flow, HBT radii etc. In the present talk I will report on the the results of simulation of the pp spectra at low and high multiplicity, The use of event structure parameters are very important in the planned analyses. A new event structure parameter - the plannecity will be presented.

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Grand Unification approaching fifty - where do we stand?

Author: Michal Malinský[1]

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We shall review the status and prospects of unified gauge theories focusing on their calculability and testability at the existing and near future experimental facilities. The current standing of minimal unified models of the SU(5) and SO(10) type will be shortly commented upon.

Short talks / 48

Light flavor hadron production investigated in Xe-Xe collisions with ALICE experiment at the LHC

Author: Natalia Dzalaiova[1]

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Light flavor hadron production has been studied over the last years in pp, p-Pb, and Pb-Pb collisions. In 2017, the ALICE Collaboration collected data from the collisions between Xenon nuclei at center-of-mass energy per colliding nucleon pair of 5.44 TeV. Such medium-sized nuclei offer the opportunity to reach multiplicities covering the gaps between Pb-Pb and pp collisions, thus contributing to a detailed characterization of hadron production as a function of system size. In this contribution, the measurements of pions, kaons, (anti-)protons, ϕ mesons, as well as strange hadrons will be presented. These measurements will be discussed in the context of state-of-the-art particle production models.

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A less commutative version of quarkonium masses

Authors: Benedek Bukor[1]; Juraj Tekel[1]

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Quarkonium bound states are especially promising candidates to test the probable quantum structure of space-time, since they represent a system with reasonably small characteristic distance. The quantum mechanical interaction between the quarks is heuristically described by the Cornell potential. Here, we insert this system in a 3-dimensional rotationally invariant space which is composed of concentric fuzzy spheres of increasing radius called the fuzzy onion in order to extract some consequences of the non-trivial structure on its properties. The talk will be based on joint work with Juraj Tekel, arXiv:2209.09028.

Short talks / 50

Axion-Like-Particle Search Using Machine Learning for the Signal Sensitivity Optimization with Run-2 LHC Data Recorded by the ATLAS Experiment

Author: Ondrej Matousek[1]

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The neutral Standard Model Higgs boson was discovered in 2012 at CERN, and the search for further particles of extended models continues. In particular, the search for an Axion-Like-Particle (ALP). Using machine learning technologies, this analysis addresses the separation of ALP production from unwanted background reactions. In this project, the Run-2 data from the ATLAS detector are used and the efficiency as well as the significance of the machine learning algorithm is optimized as a function of the theoretical ALP mass.

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ALICE experiment –30 years of history and future

Author: Karel Safarik[1]

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In this presentation the development of the Alice experiment at the LHC will be described. The talk will continue with the main physics results of run-1 and run-2. During LS2 the Inner Tracking System (ITS) was completely replaced with a new silicon pixel tracker and the TPC readout was upgraded with GEM chambers. The Alice collaboration is preparing the third version of the ITS using bent silicon detectors. The last part of the talk will discuss the Alice-3 project, which was recently submitted to the LHCC.

Lectures / **52**

Multi-Higgs-doublet physics

Author: Bohdan Grzadkowski[None]

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This talk is to convince listeners that multi-Higgs-doublet models of electro-weak interactions offer viable and attractive extensions of the Standard Model. I will also discuss role that could be played by scalar singlets.