Portorož 2023: Particle Physics from Early Universe to Future Colliders

Monday, 10 April 2023 - Friday, 14 April 2023

Book of Abstracts

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Flavor, BSM / **1**

Tests of new-physics explanations of $a_{CP}(D \to \pi\pi)$ and $a_{CP}(D \to KK)$

Authors: Emil Overduin[1]; Maurice Schüßler[1]; Syuhei Iguro[2]; Ulrich Nierste[1]

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The LHCb combined measurements of $\Delta a_{\rm CP} = a_{\rm CP}(D \to K^+K^-) - a_{\rm CP}(D \to \pi^+\pi^-)$ and $a_{\rm CP}(D \to K^+K^-)$ are in tension with predictions employing the Standard Model and U-spin symmetry of QCD. I discuss explanations in terms of new physics and propose test of these explanations in other D decay modes.

Early Universe, BSM / **2**

Dark Matter Dilution Mechanisms and Large Scale Structure

Authors: Miha Nemevsek[None]; Yue Zhang[None]

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Entropy production is a necessary ingredient for addressing the over-population of thermal relics. It is widely employed in particle physics models for explaining the origin of dark matter. A longlived particle that decays to the known particles, while dominating the universe, plays the role of the dilutor. We point out the impact of its partial decay to dark matter on the primordial matter power spectrum. For the first time, we derive a stringent limit on the branching ratio of the dilutor to dark matter from large scale structure observation using the SDSS data. This offers a novel tool for testing models with a dark matter dilution mechanism. We apply it to the left-right symmetric model and show that it firmly excludes a large portion of parameter space for right-handed neutrino warm dark matter.

Posters, wine and cheese / **4**

Impact of $\Lambda_b \to \Lambda_c \tau\nu$ measurement on New Physics in $b \to c\, l\nu$ transitions

Author: Marco Fedele[1]

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Measurements of the branching ratios of $B \to D^{(*)}\tau\bar{\nu}/B \to D^{(*)}\ell\bar{\nu}$ and $B_c \to J/\psi\,\tau\bar{\nu}/B_c \to J/\psi\,\ell\bar{\nu}$ by the BaBar, Belle and LHCb collaborations consistently point towards an abundance of taus compared to channels with light leptons. However, the ratio $\Lambda_b \to \Lambda_c\tau\bar{\nu}/\Lambda_b \to \Lambda_c\ell\bar{\nu}$ shows a relative deficit in taus. The aim of this talk is to critically address whether data still points towards a coherent pattern of deviations, in particular in light of the sum rule relating these decays in a model-independent way. We find that no common new physics explanation of all ratios is possible within 2σ or 1.5σ, depending on the $calR(\Lambda_c)$ normalization to light lepton channels.

Colliders, BSM / **5**

Probing light quark Yukawa couplings at the (HL-)LHC

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Light quark Yukawa couplings are notoriously difficult to measure: the HL-LHC will be able to constrain the first generation couplings only by a factor of few hundred times their SM value.
I will discuss Higgs pair production and the Higgs off-shell measurement as potential probes of light quark Yukawa couplings. For the Higgs pair production process I will discuss also how interpretable machine learning might be of use for constraining the up and down Yukawa couplings.

BSM theory / **6**

Afflictions of the ”minimal” SO(10) GUT

Author: Vasja Susič[1]

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We present the latest progress in analyzing the minimal potentially realistic non-supersymmetric $\mathrm{SO}(10)$ GUT model, whose scalar sector consists of representations $45 + 126 + 10$. Although the model is expected to give a robust proton decay prediction, any analysis is hampered by tachyonic instabilities present in the tree-level scalar potential. The one-loop corrected effective potential indicates that in the perturbative regime the only phenomenologically viable breaking pattern to the Standard Model is through an intermediate $\mathrm{SU}(4) \times \mathrm{SU}(2) \times \mathrm{U}(1)$ symmetry. Most recent developments, however, show that this region of parameter space does not admit a suitable fine-tuning associated to the EW-scale Higgs doublet, implying that the model is perturbatively not viable.

Early Universe, BSM / **7**

Leptogenesis in the minimal flipped SU(5) unification

Author: Michal Malinsky[None]

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We study the prospects of leptogenesis in the framework of the minimal flipped SU(5) gauge model in which the heavy Majorana neutrino mass scale is connected to the scale of unification via two-loop radiative effects. We argue that, in spite of a lower-than-usual seesaw scale, a successful thermal leptogenesis can take place in several regimes yielding a firm upper limit on the absolute light neutrino mass scale.

Neutrinos / **8**

Neutrino mass from heaven and earth

Author: Thomas Schwetz[None]

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I discuss the interplay of terrestrial and cosmological neutrino mass determinations and highlight the exciting prospects for cosmological observations. Then I discuss a mechanism to modify neutrino evolution in the early Universe, to make "large" neutrino masses consistent with cosmology, and present a simple seesaw scenario to realise such a mechanism in a UV complete model.

Colliders, BSM / **9**

Left-Right Symmetry at FCC

Author: Fabrizio Nesti[None]

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Left-Right symmetry faces stringent constraints from flavor and direct searches, that motivate its scale to be in the tens of TeV regime. I will thus describe and review the prospects for probing this restoration of Parity at future hadron colliders.

BSM theory / **10**

New precision effects from the Brout-Englert-Higgs mechanism

Author: Axel Torsten Maas[None]

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Subtle, but long-known, field-theoretical aspects require a more refined treatment of gauge theories involving a Brout-Englert-Higgs effect. This refinement can be analytically done using the Fröhlich-Morchio-Strocchi mechanism. In the standard model, this leads to slight, but in principle detectable, quantitative changes in observables. For many theories beyond the standard model, the effects are more drastic, and call in to question the viability of various models. Both aspects have significant implications for future colliders.

BSM theory / **11**

Probing Grand Unification through Gravitational Waves, Proton Decay, and Fermion Masses

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Motivated by the direct discovery of gravitational waves (GWs) from black holes and neutron stars, there is a growing interest in investigating GWs from other sources. Among them, GWs from cosmic strings are particularly fascinating since they naturally appear in a large class of grand unified theories (GUTs). Remarkably, a series of pulsar-timing arrays (PTAs) might have already observed GWs in the nHz regime, hinting towards forming a cosmic string network in the early universe, which could originate from phase transition associated with the seesaw scale emerging from GUT.

In this talk, I show that if these observations from PTAs are confirmed, GWs from cosmic strings, when combined with fermion masses, gauge coupling unification, and proton decay constraints, the parameter space of the minimal SO(10) GUT becomes exceedingly restrictive. The proposed minimal model is highly predictive and will be fully tested in a number of upcoming gravitational wave observatories.

BSM, axions / **13**

Astrphobic axions, precisely

Author: Federico Mescia[1]

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We study the impact of running effects on QCD axion phenomenology. Focusing on variants of DFSZ model, it is possible to suppress simultaneously both the axion couplings to nucleons and electrons, realising the so-called astrophobic axion scenarios, wherein the tight bounds from SN1987A and from stellar evolution of red giants and white dwarfs are greatly relaxed. This suppsression is not spoiled once renormalization group effects are included in the running of axion couplings. Given that astrophobic axion models generally feature flavour violating axion couplings, we also assess the impact of renormalization group effects on axion-mediated flavour violating observables.

Neutrinos / **14**

The Neutrino Magnetic Moment Portal: Terrestrial Experiments and Astrophysical Probes

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Sterile neutrinos are well-motivated extension of the Standard Model. In this talk I will focus on the interaction between sterile neutrinos and light active neutrinos through the magnetic moment portal. I will show that strong constraints can be derived from SN1987A through the non-observation of active neutrinos and photons produced from sterile neutrino decays. Furthermore, sensitivity projections for several present
and near-future experiments such as Fermi-LAT, e-ASTROGAM, DUNE and Hyper-Kamiokande will be shown for the future galactic supernova event.

BSM, axions / **15**

The strong CP opportunity

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While the axion was originally introduced to “wash out”CP violation from strong interactions, new sources of CP violation beyond QCD (needed to explain the matter-antimatter asymmetry) might manifest themselves via a tiny scalar axion-nucleon component. The latter can be experimentally

probed in axion-mediated force experiments, as suggested long ago by J.E. Moody and F. Wilczek. In the present contribution, I will review CP-violating axion searches and highlight the special role of the QCD axion as a low-energy probe of high-energy sources of CP violation.

BSM theory / **16**

Triple-leptoquark interactions for tree- and loop-level proton decays

Author: Ilja Doršner[1]

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I discuss the impact of triple-leptoquark interactions on matter stability for two specific proton decay topologies that arise at the tree- and one-loop level if and when they coexist. I furthermore demonstrate that the one-loop level topology is, in such an instance, much more relevant than the tree-level one despite the usual loop-suppression factor. To support that claim I present detailed analysis of the triple-leptoquark interaction effects on the proton stability within one representative scenario, where the scenario in question simultaneously features a tree-level topology that yields three-body proton decay $p \to e^+e^+e^-$ and a one-loop level topology that induces two-body proton decays $p \to \pi^0 e^+$ and $p \to \pi^+ \bar{\nu}$.

Early Universe / **17**

Bubbletrons

Author: Filippo Sala[None]

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I will show how first order phase transitions (PT) in the early universe, with relativistic bubble walls, constitute particle accelerators and colliders. These 'bubbletrons' offer novel opportunities of observational access to very high energy scales, in addition to the gravitational waves from the PT. As two examples, I will discuss: i) non-adiabatic production of dark matter which is so fast to leave an imprint in the matter power spectrum, for dark matter masses of 10ˆ8-10ˆ9 GeV and a weak-scale PT; ii) production of relics beyond the GUT scale without the need for the universe to ever reach those temperatures.

Posters, wine and cheese / **18**

Searching for Low-Mass Resonances Decaying into W Bosons

Author: Guglielmo Coloretti[1]

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In the light of the current hints for new scalars at the LHC at 95 GeV and 151 GeV, I present an analysis of low mass resonances decaying into W bosons. Recasting and combining the SM Higgs analyses of ATLAS and CMS, our results give further support to the existance of such new Higgs bosons.

BSM, axions / **19**

Axion couplings

Author: Christopher SMITH[1]

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In this talk, recent advances in the theoretical description of axions and their interactions are presented. We start by recalling the principle of reparametrization invariance, based on the Goldstone boson nature of the axion. Using this principle as a tool, we discuss first the axion coupling to gauge bosons, and show that they are actually not driven by the anomalies. Then we describe the entanglement of the axion PQ symmetry with baryon and lepton numbers, and how this can be used phenomenologically for example to explain the neutron lifetime puzzle. Finally, we study how dark matter axions interact with SM fermions, and show that a direct EDM-like coupling for all charged fermions has been missed up to now. Being a prediction of the Dirac theory analogous to the g=2 magnetic moments, these EDMs would be rather large, possibly to the point of making the electron, neutron or atom EDMs our best probes for relic QCD axions over large swaths of parameter space.

BSM theory / **20**

Asymptotic Ultraviolet-safe Unification of Gauge and Yukawa Couplings: The exceptional case

Author: Giacomo Cacciapaglia[1]

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The ultimate dream of unification models consists in combining both gauge and Yukawa couplings into one unified coupling. This is achieved by using a supersymmetric exceptional E_6 gauge symmetry together with asymptotic unification in compact five-dimensional space-time. The ultraviolet fixed point requires exactly three fermion generations: one in the bulk, and the two light ones localised on the $\mathrm{SO}(10)$ boundary in order to cancel gauge anomalies. A second option allows to preserve baryon number and to lower the compactification scale down to the typical scales of the intermediate Pati-Salam gauge theory.

Colliders, BSM / **21**

Exploring High-Energy Physics at the LHC: Recent Results and Future Prospects from ATLAS and CMS

Author: Flavia De Almeida Dias[1]

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The Large Hadron Collider (LHC) at CERN has enabled us to explore the frontiers of particle physics and understand the fundamental nature of the universe. In this talk, I will present a comprehensive overview of high pT physics analyses conducted in Run 2 of the LHC by both the ATLAS and CMS experiments. These analyses cover a broad range of topics, including measurements of the Higgs

boson, searches for new physics beyond the Standard Model, and investigations into the properties of known particles.
In addition to presenting recent results, I will also provide a future outlook on High Energy Collider Physics, including the prospects for the High Luminosity LHC and future collider facilities.

Early Universe, BSM / **23**

nuEWBG: The scalar potential strikes back

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We perform a comprehensive scan of the parameter space of a general singlet scalar extension of the Standard Model to identify the regions which can lead to a strong first-order phase transition, as required by the electroweak baryogenesis mechanism. We find that taking into account bubble nucleation is a fundamental constraint on the parameter space and present a conservative and fast estimate for it so as to enable efficient parameter space scanning. The allowed regions turn out to be already significantly probed by constraints on the scalar mixing from Higgs signal strength measurements. We also consider the addition of new neutrino singlet fields with Yukawa couplings to both scalars and forming heavy (pseudo)-Dirac pairs, as in the linear or inverse Seesaw mechanisms for neutrino mass generation. We find that their inclusion does not alter the allowed parameter space from early universe phenomenology in a significant way. Conversely, there are allowed regions of the parameter space where the presence of the neutrino singlets would remarkably modify the collider phenomenology, yielding interesting new signatures in Higgs and singlet scalar decays.

Posters, wine and cheese / **24**

Rare $B_s \to l^+l^-$ decays in a Two-Higgs-Doublet model of type III

Authors: Martin Sebastian Lang[None]; Ulrich Nierste[1]

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Leptonic decays of neutral B mesons provide an excellent probe of physics beyond the Standard Model, due to the absence of tree-level flavour-changing neutral currents in the Standard Model and the corresponding smallness of the branching ratio. We present a Two-Higgs-Doublet model in which flavour-changing neutral Higgs couplings to up-type quarks can lift part of the SM suppression. The model contains three Yukawa spurions, allowing to systematically suppress FCNC couplings in the down-type quark sector. Within this model, the leading contributions to the scalar and pseudoscalar Wilson coefficients are calculated through next-to-leading order in QCD. Several experimental constraints from other $|\Delta B| = 1$ and $|\Delta B| = 2$ processes are discussed.

BSM theory / **25**

Dark multipole vectors below the GeV-scale

Author: Josef Pradler[1]

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In this talk, we consider the phenomenology of electrically neutral complex vector particles V with a mass below the GeV-scale, but with higher dimensional form factor interactions to the SM photon. The astrophysics, cosmology and direct detection phenomenology will be presented.

Flavor, BSM / **26**

Vector-Like Quarks and Leptons

Author: Andreas Crivellin[1]

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In this talk I review vector-like quarks in leptons in flavour physics and EW precision observables in light of the W mass and the Cabibbo angle anomaly.

Early Universe, BSM / **27**

”On the origin of cosmic antimatter

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TBA

BSM theory / **28**

Impact of Non-Perturbative Effects in t-channel Simplified Dark Matter Models

Authors: Dipan Sengupta[1]; Emanuele Copello[2]; Julia Harz[None]; Kirtimaan Ajaykant Mohan[None]; Mathias Becker[3]

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A non-minimal dark sector could explain why WIMP dark matter has evaded detection so far. Based on the extensively studied example of a simplified t-channel dark matter model involving a colored mediator, we demonstrate that the Sommerfeld effect and bound state formation must be considered for an accurate prediction of the relic density and thus also when inferring the experimental constraints on the model. We find that parameter space thought to be excluded by LHC searches

and direct detection experiments remains viable. Moreover, we point out that the search for bound state resonances at the LHC offers a unique opportunity to constrain a wide range of dark matter couplings inaccessible to prompt and long-lived particle searches.

BSM theory / **29**

Flavours of dark matter

Author: Raymond Volkas[1]

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I will briefly discuss two ideas in dark matter model building. They first is that axion dark matter may be connected with neutrino mass generation, baryogenesis and flavour-dependent Higgs Yukawa couplings. The second arises within a continuing search for a good theory of the dark matter mass scale in the asymmetric dark matter paradigm. In particular, I will present some recent results on how a dark QCD sector may be relevant, building on an infrared fixed point idea proposed by Bai and Schwaller.

Early Universe / **30**

State of Cosmology

Author: Anze Slosar[1]

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I'll review the current state of affairs in Cosmology. Data from Planck and from Stage III spectroscopic and photometric experiments have firmly established the flat ΛCDM as the standard cosmological model. Many parameters are now measured with the percent level precision. Nevertheless, some tensions remain, the strongest being the Hubble parameter tension between expansion rate of the Universe as constrained by cosmological probes and direct measurements. I will review the outcomes of community planning processes and describe the upcoming experiments such as CMB-S4 and MegaMapper. Finally, I will briefly discuss the new observation windows opened by gravitational waves, intensity mapping and lunar exploration.

Flavor / **33**

Getting chirality right: scalar leptoquarks as a simultaneous solution to the electron and muon g-2 anomalies

Authors: Innes Bigaran[1]; Raymond Volkas[2]

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Anomalies in the flavor sector have attracted significant attention in recent years. Of particular interest for this talk are those in the muon and electron magnetic dipole moments: the so-called g-2 anomalies. The present status of these could point towards the requirement for new physics that couples differently to leptons and muons. I will review the status of scalar leptoquark models as candidates for ameliorating these anomalies, focussing specifically on leptoquarks which have couplings to both left- and right-handed charged fermions as these can have an enhanced effect. We consider the case in which the electron and muon sectors are decoupled, and Yukawa couplings are specified using an up-type quark mass-diagonal basis. This allows us to identify a previously overlooked region of parameter space, where strong constraints from lepton flavor violating decays may be avoided. Whether or not these anomalies linger as the experimental landscape develops is an open question. Nonetheless, I will briefly outline why models capable of generating this type of signature are well-motivated for further study. This talk will be based on arXiv:2002.12544 and arXiv:2110.03707.

Colliders, machine learning / **34**

Standard Model PDFs for muon colliders

Author: David Marzocca[1]

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Collinear radiation emitted from high-energy leptons can be resummed by solving the corresponding DGLAP equations, resulting in parton distribution functions (PDFs) for leptons. When going above the EW scale, all SM interactions should be considered and the inclusion of EW interactions bring several novel features that are not present in QCD PDFs of a proton. In this talk I will discuss our implementation for such PDFs for multi-TeV muon colliders, and some interesting aspects.

Colliders, BSM / **35**

Rare b decays meet high-mass Drell-Yan

Author: Aleks Smolkovic[None]

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Rare b hadron decays are considered excellent probes of new semileptonic four-fermion interactions of microscopic origin. However, the same interactions also correct the high-mass Drell-Yan tails. In this work, we revisit the first statement in the context
of this complementarity and chart the space of short-distance new physics that could show up in rare b decays. We analyze the latest $b \to q l^+ l^-$ measurements, where q = d or s and l = e or μ, including the most recent LHCb $R_K^{(*)}$ update, together with the latest charged and neutral current high-mass Drell-Yan data, $pp \to l\nu$ and $pp \to l^+ l^-$. We implement a sophisticated interpretation pipeline within the flavio framework, allowing us to investigate the multidimensional SMEFT parameter space thoroughly and efficiently. To showcase the new functionalities of flavio, we construct several explicit models featuring either a Z' or a leptoquark, which can explain the tension in $b \to s\mu^+\mu^-$ angular distributions and branching fractions while predicting lepton flavor universality (LFU) ratios to be SM-like, as indicated by the recent data. Those models are then confronted against the global likelihood, including the high-mass Drell-Yan, either finding tensions or compatibility.

Flavor / **36**

Standard Model Predictions for Rare K and B Decays without New Physics Infection and Z' at Work

Author: Andrzej Buras[None]

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I will report on the recent strategies for the determination of the genuine Standard Model predictions for several branching ratios for rare K and B decays. Subsequently constraints on Z' models following from these strategies will be discussed and a new mixing matrix for Z' interactions with quarks that is analogous to the CKM matrix will be presented.

Neutrinos / **37**

Constraining non-standard neutrino physics with coherent elastic scattering

Authors: Rémi Faure[1]; Stephane Lavignac[1]

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Flavor, SM / **38**

Lifetimes of heavy baryons

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We present our predictions for lifetimes, lifetime ratios and semileptonic decay widths of single-charm (bottom) and double-charm baryons within the Heavy Quark Expansion (HQE) framework, including all known corrections. In contrast to earlier findings, our results accommodate the experimentally-favoured hierarchy of the singly charmed baryons. In the double-charm sector, we find a good agreement with the experimental value for the lifetime of Ξ_{cc}^{++}, and give predictions for the remaining two unmeasured lifetime ratios. Furthermore, we find an excellent agreement between the data and the experiment for the case of single-bottom baryons.

Flavor, SM / **40**

Revisiting B->K nu nu decays in the SM and beyond

Author: Olcyr Sumensari[1]

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In this talk, I will revisit the Standard Model (SM) predictions for $\mathcal{B}(B \to K^{(*)}\nu\bar{\nu})$ and discuss the opportunities that open up when combining its partial decay with that of $\mathcal{B}(B\to K^{(*)}\mu\mu)$. I will argue that the differential measurement of $B \to K\nu\bar{\nu}$ decays allow for an useful cross-check of the shape of the vector form-factor ($f_+(q^2)$), which is only computed at high-q^2 on the lattice and extrapolated to the physical region. I will then show that the ratios $\mathcal{B}(B \to K^{(*)}\mu\mu)/\mathcal{B}(B \to K^{(*)}\nu\bar{\nu})$ allow for a clean extraction of $C_9^{\mu\mu}$, which is independent of the $B \to K^{(*)}$ form-factors to a first approximation. Lastly, I will show that the same ratio also proves to be more sensitive to the presence of New Physics in many plausible extensions of the SM.

Early Universe / **41**

Polychronic Tunneling

Authors: Masahide Yamaguchi[1]; Naritaka Oshita[2]; Yutaro Shoji[None]

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The quantum tunneling in quantum field theory has attracted theoretical and phenomenological interests for a long time. Although it has been nearly established in the absence of gravity, there are subtleties in the presence of gravity. We re-formulated quantum tunneling with the Wheeler-deWitt equation and found that there is a possibility that a system may experience both Euclidean and Lorentzian evolution simultaneously. It allows us to consider a new class of tunneling processes having Euclidean evolution in one region and Lorentzian evolution in the others. We found that such a process can have a much higher tunneling rate than that of the well-known process with the Coleman-De Luccia bounce. We also found that the processes exist even in the decoupling limit of gravity and remain important at a low energy scale.

Colliders, BSM / **42**

Z′-mediated Majorana dark matter: suppressed direct-detection rate and complementarity of LHC searches

Author: Martin Gorbahn[None]

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We study the direct-detection rate for axial-vectorial dark matter scattering off nuclei in an SU(2) × U(1) invariant effective theory and compare it against the LHC reach. Current constraints from direct detection experiments are already bounding the mediator mass to be well into the TeV range for WIMP-like scenarios. This motivates a consistent and systematic exploration of the parameter space to map out possible regions where the rates could be suppressed. We do indeed find such regions and proceed to construct consistent UV models that generate the relevant effective theory. We then discuss the corresponding constraints from both collider and direct-detection experiments on the same parameter space. We find a benchmark scenario, where even for future XENONnT experiment, LHC constraints will have a greater sensitivity to the mediator mass.

Early Universe / **43**

Applications of the Tunneling Potential Formalism

Author: Jose Ramon Espinosa Sedano[1]

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The Tunneling Potential Formalism is an alternative to the Euclidean bounce for calculating tunneling actions, that control the decay of metastable vacua. In this talk I will discuss how this formalism can be extended to study other problems, from bubble-of-nothing decays to ungauged Q-balls and more.

BSM theory / **44**

New forces in the dark

Author: Diego Redigolo[1]

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I will discuss how dark matter long range interactions with itself or with the baryons leave unique signatures in precision cosmological observables. I will present exquisitely sensitive probes of these interactions in galactic surveys and in 21cm cosmology and discuss the challenges of the theory predictions.

Flavor, BSM / **45**

BSM probes with Charm

Author: Gudrun Hiller[1]

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Rare charm decays provide unique and complementary insights on flavor and BSM physics. We discuss status and progress in null test searches from theory on decays of charm mesons and baryons into invisibles, photons and leptons and where flavor experiments are currently pushing this frontier. We also discuss CP-violation together with sizable U-spin violation seen in hadronic 2-body decays.

Early Universe / **46**

Probing the anisotropic early Universe

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The early Universe is usually assumed to be thermalised, homogeneous and isotropic, with only small fluctuations. However many new physics scenarios violate these assumptions: Phase transitions or displaced scalar fields lead to large deviations from thermal equilibrium, while topological defects

like strings and domain walls represent large anisotropies. This talk will give an overview of these phenomena, and discuss their observable imprint in the form of gravitational waves and of CMB spectral distortions. Some recent progress in the study of phase transitions in strongly coupled theories will also be discussed.

Neutrinos / **47**

Experimental search for Heavy Neutral Leptons at LHC

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The latest experimental results from CMS collaboration on Heavy Neutral Leptons will be presented. Various HNL production and decay modes are considered to guide the searches. The analysis of the full Run II data leads to stringent constraints on neutrino mass model parameters.

Colliders, BSM / **49**

Probing Flavor in semileptonic transitions at High-p_T

Authors: Darius Faroughy[1]; Felix Wilsch[1]; Florentin Jaffredo[None]; Lukas Allwicher[None]; Olcyr Sumensari[1]

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The Drell-Yan processes $pp \to \ell\nu$ and $pp \to \ell\ell$ at high transverse momentum can provide important probes of semileptonic transitions that are complementary to low-energy flavor physics observables. We parametrize possible New Physics (NP) contributions to these processes in terms of form-factors, and derive the corresponding bounds by recasting the latest ATLAS and CMS run 2 searches for mono- and di-lepton resonances. Moreover, we study the validity limit of the Standard Model Effective Field Theory (SMEFT) in this regime by comparing the limits obtained for specific tree-level mediators and their EFT equivalent. Both analyses are performed using HighPT, a new Mathematica package for automatic extraction of high-p_T bounds.

Neutrinos / **50**

Hidden vectors from solar nuclear reactions

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Nuclear reactions in the solar core can produce light and weakly coupled beyond the standard model particles that subsequently reach the Earth. We analyze the second step of the proton-proton chain, and we investigate the flux of monochromatic 5.49 MeV massive spin-one particles. Focusing on two benchmark scenarios, which correspond to different communication mechanisms with the visible sector, we evaluate the expected flux on the Earth. Finally, we explore the sensitivity reach

of the next-generation large underground neutrino oscillation experiment Jiangmen Underground Neutrino Observatory (JUNO).

Early Universe / **51**

Cosmological solutions to naturalness problems

Author: Tevong You[1]

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The limitations of symmetry-based solutions to naturalness problems have led to seeking answers from the early universe. In this talk I will give an overview of cosmological solutions to naturalness problems, focusing on models of cosmological relaxation and self-organised localisation.

BSM, axions / **52**

The meso-inflationary QCD axion

Author: Andrea Tesi[1]

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I will discuss the possibility that the axion Peccei-Quinn symmetry is spontaneously broken after the beginning of inflation. This scenario interpolates between pre-inflationary and post-inflationary axion DM cosmology with significant phenomenological differences from both. In particular, large inflationary fluctuations are produced only at scales not constrained by CMB, avoiding the strongest isocurvature constraints. Nonetheless such large fluctuations lead to the formation of axion mini-clusters and are also constrained from Lyman-α forest and future CMB spectral distortion measurements. These aspects are common to a broad class of models where DM is produced by inflationary fluctuations: I will also comment on the generic features of such a scenario.

Early Universe, BSM / **53**

Saturon Dark Matter

Author: Georgi Dvali[None]

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Saturons are macroscopic objects with maximal microstate entropy. Due to this property, they can be produced via quantum transitions from a homogeneous thermal bath, bypassing the standard exponential suppression characteristic of ordinary extended objects. In this sense, saturons carry an advantage with respect to other macroscopic objects such as black holes and ordinary solitons. Due to unsuppressed thermal production, saturons can have interesting cosmological implications. In particular they can serve as viable dark matter candidates with some unique features. Unlike ordinary particle dark matter, the superheavy saturons can freeze-in at very low temperatures. A nucleation of a saturon can be described in terms of a saturated instanton. This has implications for various phase transitions.

Colliders, machine learning / 54

Some applications of ML to fundamental physics

Author: David Chen-Yu Shih[None]

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I will survey some recent applications of ML to the LHC and astrophysics, such as new methods for BSM searches and fast simulation at the LHC; and searching for stellar streams and measuring the local dark matter density using Gaia data.

Flavor, SM / 55

Hadronic contributions to the anomalous magnetic moment of the muon

Author: Gerardin Antoine[1]

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The 2021 measurement by the Fermilab experiment confirmed the 4 sigma discrepancy with the theory estimate based on the world average from the g-2 Theory Initiative. Since then, new lattice QCD results have been published and tend to reduce this tension.
In this talk, I will present some recent lattice calculations of the hadronic contributions to the muon g-2 and I will discuss their impact on the discrepancy with the experimental measurement.

Flavor, SM / 56

The orders of CP violation

Author: Christophe Grojean[1]

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CP violation breaking is accidentally small in the SM: flavour invariants measuring CP violation in SMEFT are constructed and consequences on various flavour assumptions on their sizes are scrutinised.

BSM theory / 58

Examples of 3HDM with DM candidates

Author: Margarida Nesbitt Rebelo[1]

[1] *Instituto Superior Tecnico (IST)*

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We discuss examples of three Higgs doublet models which can provide good dark matter candidates. The emphasis is on models with S_3 symmetry, with or without spontaneous CP violation. Some aspects of the Weinberg potential will also be discussed.

Flavor, BSM / **59**

What Can Vector-Like Quarks Do For You

Author: Gustavo Branco[1]

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We emphasize the analogy between Vector-Like Quarks (VLQ) and Right Handed Neutrinos, illustrating how VLQ lead to naturally supressed FCNC and naturally small violations of 3x3 unitarity in the CKM matrix. VLQ provide a simple solution to the puzzle of eventual lack of unitarity in the first line of the CKM matrix and also provide a framework to have a realistic model with spontaneous CP violation with a complex CKM matrix, generated by real Yukawa couplings.

Neutrinos / **60**

Probing the Nature of Heavy Neutral Leptons in Direct Searches and Neutrinoless Double Beta Decay

Author: Patrick Bolton[1]

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Direct searches at fixed target experiments and searches for neutrinoless double beta ($0\nu\beta\beta$) decay can be used to probe the Majorana vs. pseudo-Dirac nature of a Heavy Neutral Lepton (HNL) pair. Firstly, I will outline a phenomenological parametrisation relating the active-sterile mixing strengths to the neutrino oscillation data, assuming that the HNL pair generates masses for two light neutrinos. I will then consider the possible constructive or destructive interference of the HNL pair with the light neutrino contribution in $0\nu\beta\beta$ decay and the production and decay of HNLs in fixed target experiments. Finally, I will explore how signals at LEGEND-1000 and DUNE constrain the HNL parameter space; in particular, the mass splitting between the HNL pair.

BSM theory / **61**

Improved hot dark matter bound on the QCD axion

Author: Giovanni Villadoro[1]

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We strengthen the cosmological bound on the axion mass, by solving the momentum-dependent Boltzmann equations for axion-pion scatterings and by using a phenomenological production rate derived from pion-pion scattering data, overcoming the breakdown of chiral perturbation theory. Using present cosmological datasets we obtain m_a < 0.24 eV. To further improve the bound and exploit the reach of upcoming cosmological surveys, reliable non-perturbative calculations above the QCD crossover are needed.

Flavor / **62**

Flavor physics review

Author: Christoph Schwanda[None]

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Flavor physics review

BSM theory / **63**

Non Standard Model Higgs and the future of composite dynamics

Author: Francesco Sannino[1]

[1] *Syddansk Universitet (DK)*

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We critically analyse the future of composite dynamics via the impact of non standard model Higgs on the (non) observed g-2 and W-mass anomalies.

BSM theory / **64**

Axion Dark Matter and Gravitational Wave Detection with Microwave Cavities

Author: Raffaele D'Agnolo[None]

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Flavor, SM / **65**

On exclusive b –> c l nu decays

Author: Damir BECIREVIC[1]

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We discuss the current status of the exclusive $b \to c\ell\nu$ decay modes and review the situation with hadronic uncertainties as well as with the problems related to a reliable extraction of $|V_{cb}|$. We also discuss the lepton flavor universality both in the decays of mesons and in the decays of baryons, and emphasize the importance of studying the angular distribution of these decay modes in order to test for the presence of BSM physics at low energies.

Posters, wine and cheese / **66**

Analytic thin wall false vacuum decay rate

Author: Marco Matteini[1]

Co-authors: Lorenzo Ubaldi ; Miha Nemevsek [2]; Yutaro Shoji

[1] *Jožef Stefan Institute*

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We derive a closed-form false vacuum decay rate at one loop for a single real scalar field in the thin wall limit. We obtain the bounce solution, together with the Euclidean action, counter-terms and RG running, and we extract the functional determinant via the Gel'fand-Yaglom theorem. Our procedure is valid for a generic spacetime dimension D, and we provide an explicit finite renormalized decay rate in D=3,4.

Posters, wine and cheese / **67**

Lattice QCD study of Z_b and Z_c

Author: Mitja Sadl[None]

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We present two lattice studies: The $\bar{b}b\bar{q}q$ systems with various quantum numbers using static bottom quarks and $\bar{c}c\bar{q}q$ systems with $I(J^{PC}) = 1(1^{+\pm})$.
Only one set of quantum numbers that couples to Z_b and $\Upsilon\ \pi$ was explored on the lattice before; these studies found an attractive potential between B and $\bar{B}^*$ resulting in a bound state below the threshold. The first study ($\bar{b}b\bar{q}q$) considers the other three sets of quantum numbers. Eigen-energies are extracted as a function of separation between b and $\bar{b}$. The resulting eigen-energies do not show any sizable deviation from noninteracting energies of the systems $\bar{b}b+\bar{q}q$ and $\bar{b}q+\bar{q}b$, so no significant attraction or repulsion is found.
Our second study ($\bar{c}c\bar{q}q$) is the first study for four-quark states with $I(J^{PC}) = 1(1^{+\pm})$, a non-zero total momentum and two different lattice volumes. Our preliminary lattice results show that the energy shifts for eigenstates dominated by $D\bar{D}^*$ are very small in the 1^{++} channel and consistent with zero in the 1^{+-} channel. Our future plan is to determine the scattering amplitude for the coupled $J/\psi\pi - D\bar{D}^*$ scattering close to the $D\bar{D}^*$ threshold that reproduces experimental results and lattice spectra.