Portorož 2021: Physics of the Flavourful Universe

Tuesday 21 September 2021 - Friday 24 September 2021

Book of Abstracts

Contents

Flavor / **1**

(g-2)☒, B anomalies and DM: a loop model tale

Author: Marco Fedele[1]

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In this talk I will review how the anomalous magnetic moment of the muon and the B anomalies can be addressed by a combined explaination, by means of loop models characterized by minimal field content. Moreover, I will show how some of these model can also provide a viable DM candidate, accounting for the measured relic density while evading direct and indirect DM constraints.

Flavor / **3**

Exclusive Vub determination from QCD - solution to Vub puzzle?

Author: Blazenka Melic[1]

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We revisit light-cone sum rule predictions for the full set of local B ⟶ π form factors, with focus on the systematic uncertainties that affect this method and carry out a combined fit with the precise lattice QCD results for all form factors simultaneously, in order to provide the most up-to-date exclusive determination of |Vub|. From the world average of the semileptonic B0 ⟶ π l ν decay we obtain |Vub| = (3.77 ± 0.15) ·10−3, which is in agreement with the most recent inclusive determination at the 1σ level.
We provide numerical results for the form factor parameters –including their covariance —based on simultaneous fit of all three form factors to both the sum rule and lattice QCD result and give up-to-date predictions for B ⟶ π l ν observables that probe lepton-flavour universality and non-standard weak effective couplings.

Astroparticle and cosmology / **4**

B-Mesogenesis: Baryogenesis and Dark Matter from B Mesons

Authors: Gilly Elor[1]; Gonzalo Alonso-Álvarez[2]; Miguel Escudero[3]

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In this talk based on 1810.00880 and 2101.02706, I will present a new mechanism for Baryogenesis and Dark Matter production: *B-Mesogenesis*. Within the B-Mesogenesis paradigm, both the dark matter

relic abundance and the baryon asymmetry of the Universe arise from the CP violating oscillations of B mesons and their subsequent decays in the early Universe. This mechanism would have distinctive experimental signals that I will discuss in detail: i) the new decay mode of B mesons into a baryon and missing energy, and ii) a positive semileptonic asymmetry in neutral B meson decays. I will discuss the reach of current collider experiments to these signatures, and I will show that a combination of measurements at Belle II, LHCb, ATLAS & CMS can fully test B-Mesogenesis.

BSM / **5**

Nucleon decay fingerprints from SUSY GUT models (using SusyTCProton)

Authors: Christian Hohl[1]; Vasja Susič[1]; Stefan Antusch[1]

[1] *University of Basel*

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Ratios of nucleon decay rates between different channels can provide rich information about the specific GUT model realization in nature. To investigate this fingerprint in the context of SUSY GUTs and D=5 proton decay, we developed the software package SusyTCProton, which is an extension of the module SusyTC, itself to be used as a package of REAP. It takes the effective dimension 5 operators in the superpotential at the GUT scale as input, and assuming MSSM below the unification scale, computes the proton (neutron) partial decay rates into 7 (5) different decay channels.

We demonstrate the utility of this software on a pair of toy SUSY GUT models with different flavor structures. Performing a numerical fit and a subsequent MCMC analysis, we find that both models provide an equally good fit to the low energy data, while they differ in their prediction for nucleon decay fingerprints, making it possible, at least in principle, to experimentally distinguish between them.

The talk is based on 2011.15026 [hep-ph].

Astroparticle and cosmology / **8**

Phase transitions with ultra-relativistc bubbles.

Author: Aleksandr Azatov[1]

[1] *INFN - National Institute for Nuclear Physics*

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I will discuss the physics of the first order phase transitions in the early universe. The talk will be focused on the regime with ultra-relativistic bubble expansions. The new mechanisms for DM production and baryon asymmetry generation will be discussed

Neutrinos / **9**

The Neutrino Magnetic Moment Portal

Author: Joachim Kopp[1]

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We discuss neutrino magnetic moments as a way of constraining physics beyond the Standard Model. In fact, new physics at the TeV scale can easily generate observable neutrino magnetic moments - we discuss in particular possible connections to models aiming to solve the flavor anomalies. We then highlight the multitude of ways of probing neutrino magnetic moments, in particular using direct dark matter detection experiments (which are sensitive to neutrino magnetic moments because of the predicted modifications to the solar neutrino scattering rate), stellar cooling, and cosmological constraints from BBN and from the CMB. Looking into the future, we also mention possible constraints from a future Galactic supernova explosion, and from observations of high-energy astrophysical neutrinos.

BSM / **10**

Flavor anomalies confront asymptotic safety

Authors: Enrico Maria Sessolo[1]; Kamila Kowalska[2]; Yasuhiro Yamamoto[None]

[1] *NCBJ, Warsaw*

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I will discuss how the framework of asymptotic safety above the Planck scale can be employed to derive specific predictions for scalar leptoquark solution to the b to s flavor anomalies. The presence of an interactive UV fixed point in the system of gauge and Yukawa couplings imposes a set of boundary conditions at the Planck scale, which allows one to determine low-energy values of the leptoquark Yukawa matrix elements. As a consequence, the allowed leptoquark mass range can be significantly narrowed down. To be in agreement with the b to s anomalies, the leptoquark mass should lie between 4 and 10 TeV, which puts it entirely in reach of a hadron-hadron collider with 100 TeV c.o.m. energy.

BSM / **12**

An SU(5) Unification Model

Author: Ilja Doršner[1]

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I will present the most minimal realistic SU(5) unification model to date and discuss its main predictions. The particle content of the model is built entirely out of the first five non-trivial representations of the lowest dimensionality. It consequentially connects the neutrino mass generation mechanism to the experimentally observed mass disparity between the down-type quarks and charged leptons. The minimality of the particle content dictates that the neutrinos are purely Majorana fermions while one of the three neutrinos in the model is a massless particle.

Neutrinos / **13**

Reconstructing the mixing angles of a pseudo-Goldstone sterile neutrino

Author: Stephane Lavignac[1]

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Low-scale models of neutrino mass generation often feature sterile neutrinos with masses in the GeV-TeV range, which can be produced at colliders through their mix- ing with the Standard Model neutrinos. We consider an alternative scenario in which the sterile neutrino is produced in the decay of a heavier particle, such that its production cross section does not depend on the active-sterile neutrino mixing angles. The mixing angles can be accessed through the decays of the sterile neutrino, provided that they lead to observable displaced vertices. We present an explicit realization of this scenario in which the sterile neutrino is the supersymmetric partner of a pseudo-Nambu-Goldstone boson, and is produced in the decays of higgsino-like neutralinos and charginos. The model predicts the active-sterile neutrino mixing angles in terms of a small number of parameters. We show that a sterile neutrino with a mass between a few 10GeV and 200 GeV can lead to observable displaced vertices at the LHC, and outline a strategy for reconstructing experimentally its mixing angles.

Astroparticle and cosmology / **14**

Dark Matter from Dark Gauge Theories

Author: Michele Redi[1]

[1] *Universita e INFN, Firenze (IT)*

Corresponding Author: michele.redi@cern.ch

In this talk I will describe dark sectors made of non-abelian gauge theories with fermions neutral under the Standard Model. This leads to accidentally stable Dark Matter candidates that can be populated minimally through gravitational interactions. In the pure glue scenario DM is the lightest glueball while adding light fermions the lightest pion and baryon are the DM candidates. Despite the absence of SM interactions these scenarios are constrained by structure formation, Neff and limits on DM self-interactions.

Collider physics / **15**

Revisiting the Effective W Approximation at muon colliders

Author: Richard Ruiz[1]

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Starting from collider energies of a few TeV, electroweak vector boson fusion/scattering becomes the dominant production mode at lepton colliders for Standard Model and new physics processes that are relevant to studying the EW sector. We show that in this regime a muon collider would effectively act as a "high-luminosity weak boson collider," offering a wide range of opportunities to precisely measure electroweak and Higgs couplings as well as discover new particles. We also present recent

Monte Carlo developments in the context of the MadGraph5_aMC@NLO platform that allow for the precise exploration of arbitrary Standard Model and new physics processes.

Flavor / **17**

Muonic force behind flavor anomalies

Author: Admir Greljo[1]

[1] *Universitaet Bern (CH)*

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I will review our recent work on lepton flavor non-universal and anomaly-free U(1) gauge extensions of the SM. The phenomenological discussion will be centered around flavor anomalies in rare B-meson decays and muon g-2. This talk is based on 2103.13991 (AG, Stangl, and Thomsen) and 2107.07518 (AG, Soreq, Stangl, Thomsen, and Zupan).

Neutrinos / **19**

CP and T violation in neutrino oscillations

Author: Thomas Schwetz[1]

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We review the present determination of neutrino oscillation parameters within the standard 3 flavour scenario, discussing also the status of the CP (and T) violating phase. We emphasize the model-dependence of this approach. Then we show that a much more model-independent way to search for T violation is possible with future long-baseline oscillation experiments, by measuring the oscillation probabilities at the same energy but at different baselines.

BSM / **20**

Recent Highlights from ATLAS and CMS

Author: Greg Landsberg[1]

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In this talk, I'll cover recent experimental highlights from ATLAS and CMS, with an emphasis on the topics related to the physics of flavor and tests of violations of fundamental symmetries.

Astroparticle and cosmology / **21**

Review of Gravitational Wave Results from the LIGO-Virgo-Kagra Collaboration

Author: Odysse Halim[1]

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It has been 6 years since the first gravitational wave event GW150914. Here, I review some of the most recent and exciting gravitational wave results. I will discuss the status of the current gravitational wave detectors and their performance as a network. I will summarize the, gravitational wave detections of the past observing runs, as well as the perspectives of the future observing runs. I will also highlight several special events.

Collider physics / **22**

Symmetries, Safety, and Self-Supervision

Authors: Barry Dillon[1]; Gregor Kasieczka[2]; Hans Olischlager[3]; Lorenz Vogel[3]; Peter Rangi Sorrenson[4]; Tilman Plehn[None]

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Collider searches face the challenge of defining a representation of high-dimensional data such that physical symmetries are manifest, the discriminating features are retained, and the choice of representation is new-physics agnostic. We introduce JetCLR to solve the mapping from low-level data to optimized observables though self-supervised contrastive learning. As an example, we construct a data representation for top and QCD jets using a permutation-invariant transformer-encoder network and visualize its symmetry properties. We compare the JetCLR representation with alternative representations using linear classifier tests and find it to work quite well.

Collider physics / **23**

Bayesian Inference for Four tops at the LHC

Authors: Barry Dillon[1]; Federico Lamagna[None]; Darius Faroughy[2]; Ezequiel Alvarez de los Alvarez de San Luis[None]; Jernej Fesel Kamenik[3]; Manuel Szewc[4]

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Four-top production is one of the last benchmarks of the SM explored at the LHC, and the intersection of state of the art experimental techniques and theoretical calculations. In this talk, we give a brief review of the main problems one faces when trying to disentangle signal from background

in such a complex final state with a special empashisis on the role of Monte Carlo simulations. We then propose a relatively simple probabilistic mixture model where these simulations play the role of prior knowledge that can be updated with standard Bayesian techniques. Using a simulated dataset with deliberately untuned priors, we demonstrate that our method can mitigate the effects of large MC mismodellings leading to corrected posterior distributions that better approximate the underlying truth-level spectra, opening the door for a reduction of simulation systematics and a higher sensitivity to possible BSM effects.

Astroparticle and cosmology / **24**

Mesogenesis

Author: Gilly Elor[None]

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I will introduce a class of new mechanisms for low-scale baryogenesis and dark matter production that utilize the CP violation within Standard Model meson systems. Mesogenesis mechanisms operate at MeV scales and such, remarkably, are experimentally testable. I will first give an overview of B-Mesogenesis; in which baryogenesis proceeds through the oscillation and subsequent decay into a dark sector of neutral B mesons. B-Mesogenesis is testable at current hadron colliders and B-factories, and I will present results of recent studies that pave the way towards constraining (or discovering) this mechanism. Finally, I will present a recent proposal for D-Mesogenesis which relies on the CP violation of charged D mesons.

Flavor / **25**

From B anomalies to Kaon physics with scalar leptoquarks

Author: David Marzocca[1]

Co-authors: Sokratis Trifinopoulos [2]; Elena Venturini

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After reviewing combined solutions of flavor anomalies with the singlet and triplet scalar leptoquarks S_1 and S_3, I will present possible connections to Kaon physics observables. By assuming a flavor structure for the leptoquark couplings dictated by a minimally broken $U(2)^5$, we find that bound on $Br(K^+ \to \pi^+ \nu\nu)$ from NA62 puts already some tension in the model, while the present limits on $Br(K_L \to \mu^+\mu^-)$ and $\mu \to e$ conversion in nuclei can be saturated. Relaxing instead the flavor symmetry assumption we study what values for $Br(K^+ \to \pi^+ \nu\nu)$, as well as for $Br(K_L \to \pi^0 \nu\nu)$ and $Br(K_{L,S} \to \mu^+\mu^-)$, are viable compatibly with all other phenomenological constraints.

BSM / **26**

New Physics Solutions to Lepton Anomalous Magnetic Moments

Author: shaikh saad[1]

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Recent precise measurement of the electron anomalous magnetic moment (AMM) adds to the long-standing tension of the muon AMM and together strongly point towards physics beyond the Standard Model. An overview of new physics solutions to AMMs and their possible experimental probes will be presented.

Collider physics / **27**

Precision LHC Z physics in the flavourful SMEFT

Author: Martin Gonzalez-Alonso[1]

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Corresponding Author: martin.gonzalez.alonso@cern.ch

I will discuss the forward-backward asymmetry in $pp \to \ell^+\ell^-$ at the Z peak within the Standard Model Effective Field Theory (SMEFT). This observable provides per mille level constraints on the vertex corrections of the Z boson to quarks, which close a flat direction in the electroweak precision fit of the flavourful SMEFT. Moreover, we show that current LHC data are precise enough so that its inclusion in the fit improves significantly LEP bounds even in simple New Physics setups. Talk based on JHEP 08 (2021) 021 [Bresó-Pla, MGA and Falkowski].

Flavor / **28**

Anomalies in rare B decays after Moriond 2021

Author: Peter Stangl[1]

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Several observables in B-meson decays show discrepancies between experimental data and Standard Model (SM) predictions. Recently, LHCb has updated their measurement of the lepton flavor universality (LFU) observable R_K and, finding a 3.1 sigma; deviation from the SM, reports evidence for violation of LFU. This talk will give an overview of the anomalies in rare B decays and will discuss their new-physics interpretation in the weak effective theory.

Flavor / **29**

Flavorful leptoquarks at the LHC and beyond: Spin 1

Author: Ivan Nišandžić[1]

Co-authors: Gudrun Hiller [2]; Dennis Loose [3]

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Evidence for electron-muon universality violation that has been revealed in b⟶sℓℓ transitions in the observables R_{K,K^*} by the LHCb Collaboration can be explained with spin-1 leptoquarks in $SU(2)_L$ singlet V_1 or triplet V_3 representations in the $\mathcal{O}(1-10)$ TeV range. We explore the sensitivity of the high luminosity LHC (HL-LHC) and future proton-proton colliders to V_1 and V_3 in the parameter space connected to R_{K,K^*}-data. Future sensitivity projections based on extrapolations of existing ATLAS and CMS searches are worked out. While there is the exciting possibility that leptoquarks addressing the R_{K,K^*}-anomalies are observed at the LHC, to fully cover the parameter space pp-collisions beyond the LHC-energies are needed.

Neutrinos / **30**

New Physics from oscillations at DUNE near detector

Author: Jacobo Lopez Pavon[1]

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We will study the capabilities of the DUNE near detector to probe deviations from unitarity of the leptonic mixing matrix, the 3+1 sterile formalism and Non-Standard Interactions affecting neutrino production and detection, clarifying the relation and possible mappings among the three formalisms. Particular attention will be paid to the analysis of the ν_τ appearance channel and the impact of spectral uncertainties (which has been widely overlooked in the literature). We will show that this plays a very important role on the results. Nevertheless, even with our conservative and more realistic implementation of systematic uncertainties, we find that an improvement over current bounds in the new physics frameworks considered is generally expected.

BSM / **31**

Light scalars from triplet Higgs fields: neutrinos, cosmology, and colliders

Author: Ulrich Nierste[None]

Co-author: Gabriela Barenboim [1]

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Title: Light scalars from triplet Higgs fields: neutrinos, cosmology, and colliders

Content:

SU(2) triplet Higgs fields coupling to leptons are a means to generate Majorana masses for neutrinos. A priori the neutral scalar and pseudoscalar components S and A could be light, as e.g. realised in majoron models in which A is the Goldstone boson of spontaneously broken lepton number. Such a light particle mediating a new force between neutrinos can alleviate cosmological puzzles such as the scalar-to-tensor ratio in the cosmic microwave background and the different values of the Hubble constant observed at different cosmological scales. While all renormalisable triplet models do not permit to have either A or S light with the other neutral particle heavy

enough to forbid $Z \to AS$ as required by LEP data, I show that one can circumvent this roadblock with dimension-6 terms in the Higgs potential. If A or S are light, the singly (doubly) charged triplet Higgs boson is lighter than 280 GeV (400 GeV), which make the model falsifiable with better LHC data.

BSM / **32**

Perturbativity aspects of the minimal SO(10) Higgs model

Authors: Katerina Jarkovska[1]; Michal Malinský[2]; Timon Mede[3]; Vasja Susič[4]

[1] *Charles University in Prague*

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We shall present a brand new study of the minimal renormalizable SO(10) Higgs model focusing on its perturbativity aspects. With an essentially complete grip on the one-loop corrections to its scalar spectrum one can identify the symmetry breaking chains featuring an intermediate SU(4)xSU(2)xU(1) symmetry as a practically unique option for a potentially realistic model building.

Flavor / **33**

$K \to \pi\nu\bar{\nu}$ and ϵ_K in the Standard Model and beyond

Author: Martin Gorbahn[1]

[1] *Liverpool University*

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In this talk I will present the updated Standard Model prediction of the golden rare Kaon decay modes and the CP violating parameter epsilon_K. I will focus on the recent theoretical improvements which result in an increased sensitivity to physics beyond the Standard Model. I will also present a computer program that provides the results of the relevant perturbative calculations in a wide class of renormalisable models.

Astroparticle and cosmology / **34**

Pulsar hints for gravitational waves from cosmic strings?

Author: Kai Schmitz[1]

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The NANOGrav and Parkes pulsar timing array (PTA) collaborations have recently reported strong evidence for a new stochastic process affecting the pulsar timing residuals in their respective most recent data sets, raising the hope that they have thus caught the first glimpse of a stochastic gravitational-wave background at nanohertz frequencies. In this talk, I will review the properties of the detected signal and discuss its interpretation in terms of gravitational waves emitted by a network of cosmic strings in the early Universe. As I will demonstrate, both stable and metastable cosmic strings lead to a viable explanation of the signal across large regions in parameter space. This result serves as a powerful illustration of how PTA observations provide us with a unique chance to probe elementary particle physics at very high energies all the way up to the scale of grand unification.

BSM / 35

B-Physics anomalies: from data to New Physics models

Author: Claudia Cornella[1]

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The hints of Lepton Flavor Universality violation observed in semi-leptonic B decays, often referred to as the B-physics anomalies, are among the most interesting results reported by experiments in the last years. In this talk, I will discuss possible New Physics explanations of these phenomena, which generically imply large effects also in other observables, both at low and high energy. In particular, I will focus on a combined explanation involving the vector leptoquark, summarize its experimental signatures and briefly discuss a possible UV completion featuring flavor-non-universal gauge interactions.

BSM / 36

A new potential B-flavour anomaly in $B_{d,s} \to K^{*0}\bar{K}^{*0}$

Authors: Andreas Crivellin[1]; Martin Novoa-Brunet[2]; Joaquim Matias[3]; Marcel Alguero[4]; Sebastien Descotes-Genon[2]

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In the context of the recently measured non-leptonic decays $B_d \to K^{*0}\bar{K}^{*0}$ and $B_s \to K^{*0}\bar{K}^{*0}$ we analyse the anatomy of the $L_{K^{*0}\bar{K}^{*0}}$ observable that compares the longitudinal components of both decays. This observable is cleaner than the longitudinal polarisation fraction as it is afflicted only at subleading order in a $1/m_b$ expansion by the theoretical uncertainties arising in the transverse components entering the polarisation fraction.
We find for the SM prediction $L_{K^*\bar{K}^*} = 19.5^{+9.3}_{-6.8}$, which implies a 2.6σ tension with respect to the most recent data, pointing to a deficit in the $b \to s$ transition of the non-leptonic decay versus the corresponding $b \to d$ transition. We discuss potential New Physics explanations for this deviation at the level of the Weak Effective Theory and we identify that the two Wilson coefficients $calC_4$ and $calC_{8g}$ can play a central role in explaining this possible anomaly.

BSM / 37

g-2 from MeV ALPs

Author: Robert Ziegler[1]

[1] *KIT - Karlsruhe Institute of Technology (DE)*

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I will talk about the possibility to address the recent result for the muon (g-2) with an axion-like particle (ALP) at the MeV scale. This particle promptly decays to electrons, which permits to account for the XENON1T excess as in arXiv:2011.08919 and to identify the ALP with the QCD axion of arXiv:1710.03764.

BSM / 38

EFT calculations with on-shell methods

Author: Alex Pomarol[1]

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I'll describe how to use on-shell methods to calculate EFT Wilson coefficients, for example, those important for lepton violations. These methods allow to understand when these Wilson coefficients can be zero.

Collider physics / 39

Probing lepton dipole moments at colliders

Author: Dario Buttazzo[1]

Co-author: Paride Paradisi [2]

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Various possibilities for testing lepton dipole moments in high-energy collider experiments are investigated. A Muon Collider running at center-of-mass energies of several TeV could provide the first model-independent high-energy test of new physics in the muon g-2, being sensitive to deviations of few $\times 10^{-9}$, thus being able to shed light on the long-standing muon g-2 anomaly. At the same time, the current bound on the muon electric dipole moment can be improved by three orders of magnitude, down to few $\times 10^{-22}\, e$ cm. Stringent constraints on the tau dipole moment can instead be obtained from various high-energy processes (such as Drell-Yan, VBF, or tau production in association with a Higgs boson), or from precision measurements of rare Higgs decay modes.

Collider physics / 40

A novel approach to $\tau \to \ell$ + invisible

Author: Diego Guadagnoli[1]

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New particles ϕ in the MeV-GeV range produced at colliders and escaping detection can be searched for at operating b– and τ–factories such as Belle II. A typical search topology involves pair-produced τs (or mesons), one of which decaying to visibles plus the ϕ, and the other providing a tag. One crucial impediment of these searches is the limited ability to reconstruct the parents' separate boosts. We construct a novel strategy for such searches. We find an improvement by a factor close to 3 in the branching-ratio upper limit for $\tau \to e\phi$, with respect to the currently expected limit, assuming $m_\phi \leq 1$ MeV.

BSM / **41**

Probing new Physics with heavy hadron decays

Author: Fulvia De Fazio[1]

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The increasing number of observed flavour anomalies claims for the investigation of different processes and the identification of suitable observables that can lead us to indirect discovery of NP. To this aim, I discuss a number of recent proposal of modes and observables that can discriminate SM from NP.

Flavor / **42**

The story of Vcb, continued

Author: Kimberley Vos[1]

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The determination of the CKM element Vcb from inclusive semileptonic
b $\longrightarrow$ c semileptonic decays has reached a high precision thanks to a combination of theoretical and experimental efforts. Moreover, the long standing Vcb puzzle, a discrepancy between inclusive and exclusive determinations seems to be disappearing. In this talk, I will discuss the story of Vcb and how to continue towards even higher precision focusing on the inclusive determination. Specifically, I discuss two new strategies to improve the precision. The first is based on reparametrization invariances, which allows including higher power-suppressed terms in the heavy-quark expansion (HQE), the second is a method to control background effects using the HQE.

Astroparticle and cosmology / **43**

Dark Matter and Structure Formation

Authors: Matteo Viel[None]; Matteo Viel[1]

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I will review perspectives for indirect Dark Matter searches using different set of observables at small and medium scales and at low and high redshift.
I will also discuss neutrino constraints from cosmological data.

BSM / **45**

Perturbative unitarity constraints on generic Yukawa interactions

Authors: Pere Arnan[1]; Daniele Barducci[None]; Lukas Allwicher[None]; Marco Nardecchia[None]

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We study perturbative unitarity constraints on generic Yukawa interactions where the involved fields have arbitrary quantum numbers under an $\prod_i SU(N_i) \otimes U(1)$ group. We derive compact expressions for the bounds on the Yukawa couplings for the cases where the fields transform under the trivial, fundamental or adjoint representation of the various $SU(N)$ factors. We apply our results to specific models formulated to explain the anomalous measurements of $(g-2)_\mu$ and of the charged- and neutral-current decays of the B mesons. We show that, while these models can generally still explain the observed experimental values, the required Yukawa couplings are pushed at the edge of the perturbative regime.

Astroparticle and cosmology / **46**

Inflaxion dark matter

Authors: Lorenzo Ubaldi[1]; Takeshi Kobayashi[None]

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A kinetic mixing between the axion and the inflaton allows for a production of axion dark matter even if the inflationary Hubble scale is smaller than the zero-temperature axion mass. I will discuss the axion dynamics in this “inflaxion” framework, and present a cosmological scenario where the axion can drift away from its vacuum during the reheating epoch, giving rise to the observed dark matter abundance.

Collider physics / **47**

Unravelling toponium formation and four-top production in present and future LHC data

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With the expected amount of present and future LHC data, top-quark-related phenomena that very scarcely arise offer new ways to test the Standard Model and probe physics beyond it. In this talk, we focus on two of those phenomena: four-top production and toponium formation. In the former case, we examine effective field theory interpretations of current and expected limits, compare them with approaches based on simplified models and put forward a novel strategy to corner potential new physics effects. In the latter case, we show how reported deviations in top-antitop data could reflect the formation of top-antitop bound states at the LHC.

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(g-2)□, B anomalies and DM: a loop model tale

Neutrinos / **49**

Review on neutrinos, exp (abstract pending)

BSM / **50**

A theory of dark pions

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Hidden valley models are motivated by open questions in particle physics, notably the electroweak hierarchy and dark matter problems. They generically lead to "dark shower"signatures at the LHC, for which the effort to understand the hidden sector phenomenology and expand the experimental coverage is underway. For this purpose I present a complete theory of dark pions, broadly motivated by approaches to Higgs naturalness, that allows to parametrize the dark shower signals in a coherent framework and analyze the interplay with other probes, including low-energy searches at the intensity frontier. Based on work to appear in 2109.xxxxx with Hsin-Chia Cheng and Lingfeng Li.

Flavor / **51**

Lepton Flavor Violation and Dilepton Tails at the LHC

Authors: Andrei Angelescu[1]; Olcyr Sumensari[2]; Darius Faroughy[2]

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Charged Lepton Flavor Violation (LFV) is a very clean probe of New Physics since it is forbidden in the Standard Model (SM). The observation of neutrino oscillation implies nonzero LFV rates, which however are highly suppressed by the smallness of neutrino masses. This makes LFV an appealing target of experimental searches, as its observation would unambiguously point to New Physics.

In this talk, I will discuss the constraints on LFV effective operators that can be derived from LHC data. I will show that semileptonic operators can be constrained by existing searches of $pp \to \ell_i \ell_j$ (with $i \neq j$) at high-p_T. I will explore the complementary of these constraints with the ones obtained from low-energy observables, by showing, in particular, that LHC data provides the most stringent limits on quark-flavor conserving operators. The relevance of these results for leptoquark models aiming to explain the ⊠-physics anomalies will also be briefly discussed.

BSM / **52**

Flavour effects in low scale leptogenesis and their experimental tests

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Flavour effects play an important role for leptogenesis in the type-I seesaw model with Majorana masses below the TeV scale. The requirement to simultaneously explain the light neutrino oscillation data and the baryon asymmetry of the universe impose constraints on the neutrino Yukawa couplings that can be probed at accelerator experiments. These predictions depend on the number of heavy neutrino flavours, the light neutrino mass ordering, the lightest SM neutrino mass, and the phases in the PMNS matrix. If any heavy neutral leptons are discovered at the LHC or fixed target experiments, combining their data with neutrino experiments would allow for a first test of the hypothesis that these particles are responsible for the origin of matter in the universe.

Flavor / **54**

Review of flavour physics experimental results

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The past two decades have seen a remarkable advance in our understanding in our understanding of quark transitions, and in particular the production and decay of heavy flavour hadrons. In this talk I will review the present status of heavy flavour measurements constraining the CKM matrix which governs quark transitions in the Standard Model, as well as measurements probing rare and forbidden processes sensitive to physics beyond the Standard Model.

BSM / **55**

Scaling dimensions of fixed charge operators

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I will start with a brief pedagogic review of the semiclassical method for determining the scaling dimensions of fixed-charge operators in conformal field theory with global symmetries and then introduce a general strategy to determine the relation between a given charge configuration and the associated operators for a given global symmetry group. I will demonstrate how, by varying the charge configuration, it is possible to access anomalous dimensions of different operators transforming according to a variety of irreducible representations of the given non-abelian symmetry group without the aid of diagrammatical computations. I will illustrate the computational strategy by determining the anomalous dimensions of several composite operators to the NLO in the semiclassical expansion for the O(N) and U(M)xU(N) models. Connections to the scattering amplitudes involving many W, Z and Higgs bosons in the Standard Model at energies that may be approachable at the next generation of colliders and Higgsplosion program will be briefly discussed.

Flavor / **56**

Hadronic light-by-light contribution to the muon magnetic moment

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After the publication of the new measurement of the muon $g-2$ by the Fermilab experiment, a tension of about 4 sigma is observed with the Standard Model estimate published by the *Muon g-2 theory initiative*.
The theory error is completely dominated by hadronic uncertainties, namely the hadronic vacuum polarization (HVP) and the hadronic light-by-light (HLbL) contributions and the published SM value does not include the most recent lattice calculations.
In this talk, I will present a recent lattice QCD calculation of the HLbL contribution. I will discuss the main challenges of such calculations and compare the current status in view of the the future experimental precision expected in the next few years at Fermilab.

BSM / **57**

Convexity and large charge for the large-N vector model

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The large-charge expansion is very effective in extract physical information also for systems that have an alternative perturbative expansion.
I will show how to use it to derive the leading-N effective potential for the O(N) vector model without using Feynman diagrams and I will use its convexity properties to discuss the consistency of different possible phases in various dimensions.

BSM / **58**

Impact on BSM physics from S-matrix exclusion of de Sitter

We discuss how the consistency of S-matrix formulation of gravity excludes de Sitter vacua, both stable and meta-stable. In addition to nullifying an outstanding cosmological puzzle, by excluding any form of a constant from
the energy budget of our universe, this has profound implications for BSM physics. We explain how this finding forces the theta-parameter of QCD (or of any other gauge theory) to be unphysical and also review its implications for Higgs physics.

BSM / **59**

4321 at the LHC

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The '4321'models are promising extensions of the SM that give rise to the U_1 vector leptoquark solution to the B-physics anomalies. Both the gauge and fermion sectors of these UV-constructions lead to a rich phenomenology currently accessible at high-energy colliders. In this talk we describe some of the main LHC signatures and extract exclusion limits using run-ll data. In addition, we also discuss a 4321 extension with a dark sector leading to a Majorana dark matter candidate and a colored partner producing new signatures at the LHC.

BSM / **60**

Mirror world: some physical and astrophysical implications

I shall discuss a possibility that dark matter is
a matter of parallel mirror sector which has the particle physics
identical to our particles. I discuss the possible interactions
between the ordinary and mirror particles, and in particular
baryon and lepton violating interactions and their role in
co-baryogenesis of matter and dark matter. I briefly discuss
also implications for neutron stars and cosmic rays.

Flavor / **61**

The Cabibbo angle anomalies: indication of new physics at the TeV scale?

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Recent high precision determinations of V_{us} and V_{ud} indicate towards anomalies in the first row of the CKM matrix. Namely, determination of V_{ud} from beta decays and of V_{us} from kaon decays imply a violation of first row unitarity at about 3σ level. Moreover, there is tension between determinations of V_{us} obtained from leptonic $K\mu 2$ and semileptonic $K\ell 3$ kaon decays. These discrepancies can be explained if there exist extra vector-like quarks at the TeV scale, which have large enough mixings with the lighter quarks. However, only one type of extra multiplet cannot entirely explain all the discrepancies, and some their combination is required, e.g. two species of isodoublet, or one isodoublet and one (up or down type) isosinglet. These scenarios are testable with future experiments. A different solution can come from the introduction of the gauge horizontal family symmetry acting between the lepton families and spontaneously broken at the scale of about 6 TeV. Since the gauge bosons of this symmetry contribute to muon decay in interference with Standard Model, the Fermi constant is slightly smaller than the muon decay constant so that unitarity is recovered.

BSM / **62**

Interplay of New Physics effects in $(g-2)_\ell$ and $h \to \ell^+\ell^-$ in SMEFT

Author: Michele Tammaro[None]

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In this talk we study the correlation of NP effects between two observables, the lepton anomalous magnetic moment and the Higgs to two leptons decay, using one-loop improved SMEFT. Interestingly, only a small subset of five operators is needed to account for these effects and their mixing leads to chirally enhanced diagrams due to top-quarks in the loop. We compare the numerical results of this analysis with the current bounds on the observables and derive limits on the NP scale. Moreover, we build two simple UV extensions, Two Higgs Doublet Model and Scalar LeptoQuark, and show that the tree level matching with the SMEFT operators and the following running provides a good approximation of the full theory results for both observables.

BSM / **63**

On naturalness of muon anomalies in strongly coupled theories

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I will discuss the muon anomalies that have been persisting in data in the recent years, namely the muon g-2 and the lepton flavour non-universality in B decays, in the context of strongly coupled theories. I will show that these anomalies are natural in composite theories of the Higgs sector of the Standard Model. In particular, the characteristic scale of 2 TeV emerging from the muon g-2 points straightly to technicolor-like theories.

Flavor / **64**

Semileptonic B(s) decays

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Form factors describing exclusive semileptonic $B_{(s)}$ decays allow e.g. to extract the CKM matrix elements $|V_{ub}|$ and $|V_{cb}|$ or obtain predictions for R-ratios testing lepton flavor universality. Using the framework of lattice quantum chromodynamics, we present our results for the semileptonic $B_s \to D_s \ell\nu$, $B_s \to K\ell\nu$, and $B \to \pi\ell\nu$ decays.

First we obtain scalar and vector form factors with full error budget for the range of momentum transfer directly accessible in our simulations. Next we show z-parameterization fits to extend q^2 over the kinematically allowed range. These results are used to extract CKM matrix elements, predict R-ratios or perform comparisons to other works.

Flavor / 65

Leptoquarks and LFUV in B-decays

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We discuss the single LQ solutions to the problem of accommodating the observed hints of LFUV in B-decays. We then focus on the combination of two scalar leptoquarks R2 and S3 and formulate the model which can describe all of the anomalies. We update the previous results with a particular emphasis on the bounds arising from the high-pT tail of pp –> tau nu. We then consider several new quantities, not covered in our previous studies and point out the ways to verify the validity of our model experimentally.