Cosmology, Astrophysics, Theory and Collider Higgs 2024 (CATCH22+2)

Wednesday, 1 May 2024 - Sunday, 5 May 2024

DIAS

Book of Abstracts

Contents

Talks / **1**

Properties of the Weinberg 3HDM potential

Author: Per Osland[1]

[1] *University of Bergen (NO)*

Corresponding Author: per.osland@cern.ch

The Weinberg 3HDM potential may lead to spontaneous CP violation. The terms thus inducing CP violation are constrained by the measured properties of the discovered scalar at 125 GeV. In a wide range of parameter space, the potential leads to one or two light neutral states (below 125 GeV) that have a considerable admixture of CP-odd fields. The potential can accommodate a light state at 95 GeV, as suggested by recent data.

Talks / **2**

Sub-GeV Dark Matter Searches with QUEST-DMC

Author: Neda Darvishi[1]

[1] *Royal Holloway University of London*

Corresponding Author: neda.darvishi@rhul.ac.uk

In this talk, the potential for detecting sub-GeV dark matter through the QUEST-DMC experiment will be explored. The experiment employs a novel approach, utilizing superfluid Helium-3 (He-3) alongside quantum sensors. Superfluid He-3 is highlighted as an optimal medium for sub-GeV dark matter searches, particularly effective in spin-dependent interactions. The presentation will cover the projection sensitivity to diverse dark matter models and establish upper bounds on dark matter interactions due to stopping effects induced by atmospheric elements.

Talks / **3**

Imminent test of quantum gravity with gravitational waves

Author: Gianluca Calcagni[None]

Corresponding Author: g.calcagni@csic.es

We present a model of the early Universe stemming directly from a UV-complete, nonlocal, unified theory of quantum gravity and matter. The problems of the hot big bang are solved by virtue of the conformal invariance enjoyed by the theory without the need to invoke inflation. Primordial tensor and scalar spectra are naturally generated by, respectively, quantum and thermal fluctuations. Relying on very few assumptions, the theory predicts a blue-tilted tensor spectrum feeding a primordial stochastic background observable by DECIGO, as well as a lower bound for the tensor-to-scalar ratio detectable by BICEP Array within the next 4 years.

Talks / **5**

The Gravity of Particle Physics (Naturally)

Author: Cliff Burgess[1]

[1] *McMaster University (CA)*

Corresponding Author: cburgess@perimeterinstitute.ca

UV Priors for Light Scalars (and how they might be screened)

The recent advent of gravitational-wave observations allows testing gravity in a strongly relativistic regime, but decoupling - which beautifully explains why low-energy measurements are largely insensitive to UV details - seems to thwart the extraction of fundamental insights about UV physics from astrophysical or cosmological observations. This talk argues that a few UV features can penetrate the fog of decoupling in interesting ways, but that for historical reasons the most likely interactions at low energies are not being explored in the new comparisons with observations. A key question when seeking new light particles asks whether macroscopic objects couple simply as the sum of the couplings of their microscopic constituents, and the black-hole no-hair theorems show that the generic answer is "no". Such 'screening mechanisms' suggest that light particles might hide from present-day tests of gravity and this talk describes one such a mechanism that arises in the best-motivated class of low-energy interactions (that exclude standard screening mechanisms like Chameleons). If time permits I will more broadly explain how these ideas naturally emerge within the context of approaches to other problems like the Hubble tension and cosmological constant problem.

Talks / **6**

Neutron stars as a laboratory for particle and nuclear physics

Author: Aleksi Vuorinen[1]

[1] *University of Helsinki*

Corresponding Author: aleksi.vuorinen@helsinki.fi

I will review recent progress in the model-independent constraining of the properties of neutron-star matter using ab-initio tools from theoretical particle and nuclear physics. In particular, I will discuss results from a new study employing Bayesian inference methods and taking input from both electromagnetic and gravitational-wave observations, which point to the rapid conformalization of matter close to the central densities of the most massive stable stars. These results point towards the likely existence of quark-matter cores inside massive neutron stars, the likelihood of which we estimate to be around 80-90%.

In addition, I will briefly discuss, how a combination of ab-initio microscopic calculations and the eventual recording of a postmerger gravitational-wave signal can provide insights to the off-equilibrium dynamics of dense QCD matter and confirm the dynamical creation of deconfined matter during binary neutron-star mergers.

Talks / **7**

BSM parton showers in Herwig 7

Author: Aidin Masouminia[1]

[1] *IPPP, Durham University*

Corresponding Author: mohammad.r.masouminia@durham.ac.uk

I will discuss the inaugural investigation of BSM radiation processes, framed as a generalized, process- and model-independent parton shower algorithm within Herwig7, based on direct translations of UFO constructs via Herwig's "ufo2herwig" module. Additionally, I will address some phenomenological aspects of employing BSM parton showers, particularly in the context of models with extended Higgs sectors, to explore their implications and potential observable effects.

Talks / **8**

First-order electroweak phase transition in the SMEFT

Author: Rikard Enberg[None]

Co-authors: Eliel Camargo-Molina [1]; Johan Löfgren

[1] *Uppsala University*

Corresponding Authors: johan.lofgren@physics.uu.se, eliel.camargo-molina@physics.uu.se, rikard.enberg@physics.uu.se

A first-order Electroweak Phase Transition (FOEWPT) could explain the observed baryon-antibaryon asymmetry of the Universe, and its dynamics could yield a detectable gravitational wave signature, while the underlying physics would be within the reach of colliders. The Standard Model, however, predicts a crossover transition, so any hope of having a FOEWPT hinges on physics beyond the Standard Model (BSM). Most studies of the possibilities for a FOWEWPT consider new particles around the electroweak scale that contribute to the effective potential and help generate a barrier between the true and the false vacuum, facilitating a first-order transition.

On the other hand, the Standard Model Effective Field Theory (SMEFT) is a model-independent effective field theory extension of the SM that encodes new physics at the cutoff scale. It contains all SU(3)xSU(2)xU(1) invariant operators to a given order in the EFT expansion. Previous phenomenological studies of possibilities for a FOEWPT in the SMEFT have considered the case with a tree-level barrier and a negative Higgs quartic coupling. This requires a small new physics scale, which from an EFT perspective is undesirable. In a previous paper [1] we highlighted another possibility, where a FOEWPT is possible when the barrier between minima is generated radiatively, the quartic coupling is positive, the scale of new physics is higher, and there is good agreement with experimental bounds.

In this talk I will describe this work, and a continuation work where we make a systematic study of all possible types of phase transitions that occur in different regions of parameter space, with both tree-level barriers and radiatively generated barriers.

Our calculations are based on careful power counting of the scaling of parameters necessary to generate a barrier in the potential and are done in a consistent, gauge-invariant way. We perform global fits in the relevant parameter spaces and explicitly find points with a FOEWPT that agree with experimental data. We also briefly discuss the prospects for probing the allowed parameter space using di-Higgs production in colliders.

[1] J.E. Camargo-Molina, R. Enberg, J. Löfgren, "A new perspective on the electroweak phase transition in the Standard Model Effective Field Theory", JHEP 2021, 127 (2021), arXiv:2103.14022

Talks / **9**

Precision Neutrino DIS at CERN's Forward Physics Facility (and Beyond)

Author: Richard Ruiz[1]

[1] *Institute of Nuclear Physics (IFJ) PAN*

Corresponding Author: richard.physics@gmail.com

Building on the successes of the FASER and SND@LHC experiments, proposed programs at CERN's Forward Physics Facility (FPF) can build the world's largest dataset of neutrino deep-inelastic scattering (νDIS) in the TeV range for all neutrino flavors. These data will enable novel tests of neutrino-matter interactions but also complement ongoing short-baseline programs at FNAL as well as charged-lepton DIS programs at JLAB and BNL. To fully utilize these data, developments on the theory side will be needed. This includes includes state-of-the-art calculations at next-to-leading order in QCD and beyond, as well as higher twist corrections that extend the validity of the Factorization Theorem for inclusive DIS.

In this talk, we present the complete set of so-called "target mass corrections" (TMCs) to structure functions in ν and $\ell^{\pm}$ DIS off arbitrary nuclei. TMCs are formally beyond leading twist and are critical for correctly describing DIS at ultra-high rapidities, i.e., large Bjorken x and small Q^2. We show their relation to TMCs for DIS off protons, their numerical impact, as well as interesting conceptual connections.

arXiv:2301.07715

Talks / **11**

test parity violation signal from stochastic gravitational wave background

Author: qiuyue liang[1]

[1] *university of Tokyo*

Corresponding Author: qiuyue.liang@ipmu.jp

A successful measurement of the Stochastic Gravitational Wave Background (SGWB) in Pulsar Timing Arrays (PTAs) would open up a new window through which to test the predictions of General Relativity (GR). Astrometry on the other side also holds the potential for testing fundamental physics through the effects of the Stochastic Gravitational Wave Background (SGWB) in the ~ 1 − 100 nHz frequency band on precision measurements of stellar positions. In this talk, I will discuss how these measurements might reveal deviations from GR by studying the overlap reduction function, and its generalization in astrometry survey.

Talks / **13**

The Euclid mission: scientific forecast, overview and status

Author: Cristobal Padilla Aranda[1]

[1] *IFAE-Barcelona (ES)*

Corresponding Author: cristobal.padilla@cern.ch

The Euclid mission satellite was launched on July 1st, 2023 from Cape Canaveral, Florida, with a Space X Falcon 9 rocket . After one month journey it is set in its orbit around the Sun-Earth L2 point and has already finished its commissioning period. Euclid survey started in February 2024 and will map 15000 deg2 of the sky in the following six years observing more than 1 billion galaxies with unprecedented image quality. The survey will provide a 3D map of the universe and will improve out knowledge on the cosmological model by an order of magnitude with respect to current constraints. This talk will describe the Euclid mission, its instruments, its current status and first images, the

expected schedule on Data Releases, and describe the cosmological probes that will be measured and how it will contrubete to our understanding of the dark content of the Universe.

Talks / 14

Probing first-order phase transitions at LISA

Author: Germano Nardini[1]

[1] *University of Stavanger*

Corresponding Author: germano.nardini@uis.no

The LISA mission has been adopted, with launch scheduled in 2035. This leaves us with just a decade to complete the data analysis pipelines and prepare the science interpretation of the potentially observed signals. In this talk we will briefly review the status of the mission, some possible data analysis approaches to isolate the primordial stochastic GW background (SGWB), and some potential bounds on BSM models predicting first-order phase transitions.

Talks / 16

Tri-unification: a separate $SU(5)$ for each fermion family

Author: Avelino Vicente[1]

[1] *IFIC - CSIC / U. Valencia*

Corresponding Author: avelino.vicente@ific.uv.es

I discuss a grand unified theory that assigns a separate $SU(5)$ gauge group to each fermion family. The equality of the gauge couplings at the unification scale is enforced by means of a cyclic $\mathbb{Z}_3$ symmetry. Such tri-unification reconciles the idea of gauge non-universality with gauge coupling unification, opening the possibility to build consistent non-universal descriptions of Nature that are valid all the way up to the scale of grand unification. A minimal example which can account for all the quark and lepton masses and mixings will be presented, showing that it is possible to unify the gauge couplings into a single value associated with the cyclic $SU(5)^3$ gauge group while being consistent with the existing proton decay searches, in particular in the dominant $e^+\pi^0$ channel.

Talks / 17

Lepton-flavour-violating constraints from triality

Authors: Gabriela Lichtenstein[1]; German Valencia[2]; Michael Schmidt[3]; Raymond Volkas[4]

[1] *UNSW*

[2] *Monash University (AU)*

[3] *UNSW Sydney*

[4] *The University of Melbourne*

Corresponding Authors: german.valencia@monash.edu, m.schmidt@unsw.edu.au, g.lima_lichtenstein@unsw.edu.au, raymondv@unimelb.edu.au

Triality models are motivated by flavour structure theories. They produce charged lepton flavour violation channels mediated by a doubly charged scalar. However, the triality charges forbid decays such as muon to electron conversions, avoiding stringent experimental bounds. We have calculated predictions of charged lepton violation in this scenario and show the complementarity between Belle II and muTristan searches. We also present current 1-loop constraints from LEP and LHC in Higgs and Z decays and the predictions of future colliders' sensibilities, such as HL-LHC, FCC, ILC, and CEPC.

Talks / **19**

Phenomenological aspects of flavour (and CP) symmetries

Author: Claudia Hagedorn[1]

[1] *IFIC – UV/CSIC*

Corresponding Author: claudia.hagedorn@ific.uv.es

Flavour (and CP) symmetries can be the key to understand fermion masses and mixing. In theories beyond the Standard Model they can also be crucial in order to understand, for example, the suppression of certain flavour-violating signals and the correlation among the generated amount of baryon asymmetry of the Universe and the size of CP violation, potentially observable in neutrino experiments. We present examples in this talk.

Talks / **20**

Cutting rules and unitarity constraints for CP asymmetric processes

Authors: Peter Matak[1]; Tomas Blazek[1]; Viktor Zaujec[1]

[1] *Comenius University (SK)*

Corresponding Authors: peter.matak@fmph.uniba.sk, blazek@fmph.uniba.sk, viktor.zaujec@fmph.uniba.sk

The asymmetries in out-of-equilibrium decays or scatterings necessary for lepto/baryogenesis can only occur in sufficiently complex particle models, where irreducible phases of couplings are possible. Imaginary kinematics is required in loop diagrams. Even when these ingredients are present, the resulting asymmetry may vanish due to the CPT and unitarity constraints. In this talk, we show how to systematically generate a complete list of asymmetric reactions in any perturbative order, simplify their calculations, and identify the terms that cancel due to the unitarity and CPT symmetry. The work is primarily based on Phys. Rev. D 103, L091302, and includes recent applications to freeze-in leptogenesis with Dirac neutrinos.

Talks / **21**

Searching new physics via features of the stochastic gravitational wave background

Author: Sachiko Kuroyanagi[1]

[1] *IFT UAM-CSIC*

Corresponding Author: sachiko.kuroyanagi@csic.es

Characteristic patterns can emerge in the spectral shape of the stochastic gravitational wave (GW) background through various mechanisms. For instance, the GW background generated via second-order scalar perturbations, often discussed in the context of primordial black hole formation, exhibits a distinct spectral shape. Additionally, scalar-induced GWs excited during inflation and specific types of quantum gravity theories can produce a stochastic GW background with logarithmic oscillations. These specific shapes in the GW spectrum can be identified through template-based analysis methods. In this talk, I will present an example of a template-based search and constraints on scalar-induced GWs using the most recent LVK O3 data. Subsequently, I will discuss future prospects for third-generation GW experiments such as the Einstein Telescope, focusing on the example of the log-oscillation feature.

Talks / **22**

Physics with singlets

Author: Tania Natalie Robens[1]

[1] *Rudjer Boskovic Institute (HR)*

Corresponding Author: tania.robens@cern.ch

After the discovery of a particle that complies with the properties of the Standard Model Higgs particle, particle physics has entered an exciting era. Both theoretical and experimental uncertainties in principle still leave room for additional particles where the scalar sector can be augmented by additional particle content. In this talk, I focus on scenarios with singlet extensions. I will discuss current constraints and future prospects at possible future collider options.

Talks / **23**

Primordial black holes from stochastic inflation

Authors: Daniel Garcia Figueroa[1]; Eemeli Tomberg[2]; Sami Raatikainen[3]; Syksy Räsänen[None]

[1] *Departam.de Fisica Teorica-Facultad de Ciencias-Universidad Auto*

[2] *University of Lancaster*

[3] *University of Helsinki*

Corresponding Authors: sami.raatikainen@iki.fi, syksy.rasanen@helsinki.fi, daniel.figueroa@uam.es, e.tomberg@lancaster.ac.uk

Primordial black holes (PBH) are an interesting dark matter candidate. In single-field models of inflation that generate them, stochastic effects are typically important. I discuss how to model stochastic effects consistently and how they can greatly enhance the PBH abundance. I also discuss the role of stochasticity in collapse of matter into PBHs.

Talks / **25**

Can the QCD axion feed a dark energy component?

Corresponding Author: enrico.nardi@cern.ch

A pseudo Nambu-Goldstone boson (PNGB) coupled to a confining gauge group via an anomalous term is characterised, during the confining phase transition, by a temperature dependent mass $m(T) \propto T^{-n}$ with values of n not far from $n \sim 3$. We study the possibility that a hidden gauge group undergoing confinement at present time could provide a suitable time-varying mass to a dark PNGB. The occurrence
of a diabatic level crossing between this PNGB and the QCD axion during $m(T)$ evolution can convert a tiny fraction of dark matter axions into dark PNGB, which will then drive the accelerated expansion.

Talks / **27**

Light vector mediators at direct detection experiments

Author: Valentina De Romeri[1]

[1] *IFIC CSIC/UV (Valencia, Spain)*

Corresponding Author: deromeri@ific.uv.es

Solar neutrinos induce elastic neutrino-electron scattering in dark matter direct detection experiments, resulting in detectable event rates at current facilities. In this talk, I will present an analysis of recent data from the XENONnT, LUX-ZEPLIN, and PandaX-4T experiments from which we derive stringent constraints on several U(1)′ extensions of the Standard Model, accommodating new neutrino-electron interactions. In particular, I will present bounds on the relevant coupling and mass of light vector mediators for a variety of anomaly-free U(1)′ models. I will also present forecasts for improving current bounds with a future experiment like DARWIN.

Talks / **28**

Signs for a FOEWPT at the LHC?!

Author: Sven Heinemeyer[1]

[1] *CSIC (Madrid, ES)*

Corresponding Author: sven.heinemeyer@cern.ch

We discuss the possibility of a First Order Electroweak Phase Transition (FOEWPT) in the early universe, as required for EW baryogenesis, in the framework of the 2HDM. One corresponding prediction, the decay $A \to ZH$ with $H \to t\bar{t}$ may have been observed at the LHC. We present the phenomenological consequences for the detection of gravitational waves at LISA, as well as the prospects for the HL-LHC.

Talks / **29**

Pair production of Higgs Bosons at NLO

Author: Michael Spira[1]

[1] *Paul Scherrer Institute (CH)*

Corresponding Author: michael.spira@psi.ch

Higgs-boson pairs are dominantly produced via gluon fusion at hadron colliders, i.e. via a loop-induced process. This process will constitute the first direct access to the trilinear Higgs self-interaction. In recent years the NLO QCD corrections involving the full top-mass dependence became available by means of numerical integrations, since analytical methods available so far are not capable to solve the two-loop integrals with up to five energy scales. I'll discuss the method we have adopted to achieve the results with a summary of the outcome, i.e. with the particular emphasis on the scheme and scale dependence of the virtual top mass that induces the dominant theoretical uncertainties at present. This method has recently been extended to the cases of neutral Higgs-boson pair production within the 2HDM. Finally, I'll provide an outlook on the extension of the method to the full electroweak corrections to the same process within the SM.

Talks / **30**

Photo production from anomaly terms in supernovae and neutron stars

Author: Miguel Vanvlasselaer[1]

[1] *VUB*

Corresponding Author: miguel.vanvlasselaer@vub.be

Compact stellar objects like Supernovae (SN) and Neutron Stars (NS) are believed to cool by emitting axions via processes emission of neutrinos and possibly emission of axions, if they exist. In this talk, we study a previously overlooked contribution to the photo-production channel of interactions like $\gamma N \to N\nu\nu$ and $\gamma N \to Na$. This originates from the unavoidable anomaly-induced Wess-Zumino-Witten term $\propto \epsilon^{\mu\nu\alpha\beta}\, F_{\mu\nu}\, \partial_\alpha a\, \omega_\beta$ and $\propto \epsilon^{\mu\nu\alpha\beta}\, F_{\mu\nu}\, Z_\alpha\, \omega_\beta$. Such a term is inevitable within the Standard Model if one wants to explain the experimentally observed QCD processes that are disallowed by the symmetries of an effective Chiral Lagrangian. We find that due to those additional contributions, SN and SN can cool faster than what was previously thought, translating into stronger bounds on the axion decay constant f_a and modifying the cooling curve in general. Furthermore, the spectrum of axions and neutrinos emitted in the process is significantly harder than those originating from bremsstrahlung. The modified spectrum peaks around $6T$ and consequently helps us to uniquely discriminate between different cooling channels. In addition to this, these axions are also more likely to show up in the near future Water Cherenkov detectors.

Talks / **31**

Quo Vadis DM?

Author: Antonio Delgado[1]

[1] *University of Notre Dame (US)*

Corresponding Author: antonio.delgado@cern.ch

In this talk I will review several scenarios for DM that can be tested in the next generation of colliders and direct detection experiments.

Talks / **32**

The Primordial Black Holes Variations

Author: Stefano Profumo[None]

Corresponding Author: profumo@ucsc.edu

In the age of gravitational wave astronomy and direct black hole imaging, the possibility that some of the black holes in the universe have a primordial, rather than stellar, origin, and that they might be a non-negligible fraction of the cosmological dark matter, is quite intriguing. I will review the status of the field, describe search strategies and future prospects for detection across many decades in black hole mass, discuss how light primordial black holes could seed both baryonic and particle dark matter in the very early universe, and comment on how the search for primordial black holes may lead to a deeper understanding of the elusive Galactic "rogue planets".

Talks / 33

Hierarchies and conformal UV completions

Author: Manfred Lindner[1]

[1] *Max-Planck-Institut fuer Kernphysik, Heidelberg, Germany*

Corresponding Author: lindner@mpi-hd.mpg.de

Conformal UV completions of Standard Model extensions have interesting implications on small and bigger scale hierarchies. The talk will cover general features which will be exemplified by model realizations.

Talks / 34

PRyMordial: The first minutes of the universe, computed in seconds

Author: Anne-Katherine Burns[1]

[1] *UC Irvine*

Corresponding Author: annekatb@uci.edu

In this talk I will discuss PRyMordial: a program dedicated to the computation of observables in the early universe with a focus on the cosmological era of Big Bang Nucleosynthesis (BBN). The code is the first of its kind written in python and offers fast and precise evaluation of both the BBN light-element abundances and the effective number of relativistic degrees of freedom. PRyMordial was created for both state-of-the-art analyses in the Standard Model as well as for general investigation of New Physics present in the early universe. In this talk, I will review the physics implemented in PRyMordial and provide a short guide on how to use the code for applications in the Standard Model and beyond.

Talks / 35

Exploring loop-induced first order electroweak phase transition in the Higgs effective field theory

Author: Shinya KANEMURA[1]

[1] *Osaka University*

Corresponding Author: kanemu@het.phys.sci.osaka-u.ac.jp

We discuss how we can explore electroweak phase transitions (EWPTs) via collider experiments and gravitational wave (GW) observations. The nature of the EWPT is important to understand the thermal history of the early Universe and to determine the scenario of baryogenesis. To obtain model independent results, we focus on an effective field theoretical approach, which is known as the nearly aligned Higgs Effective Field Theory. We demonstrate that Higgs coupling measurements and GW observations can provide constraints on the scale of new physics models in which the first-order EWPT is realized. Our results show that we can determine the nature of the EWPT by the combination our results with direct new physics searches at current and future collider experiments.

Talks / **36**

Cosmic Axiverse Background

Author: Chris Dessert[1]

[1] *Flatiron Institute/New York University*

Corresponding Author: cdessert@flatironinstitute.org

Any light species in thermal equilibrium in the early universe, such as an axion, will contribute to the effective number of relativistic species, N_{eff}. In the context of the Axiverse, potentially hundreds of axions exist in the spectrum of nature and can thermalize with the Standard Model bath, but Planck data constrains the number of additional scalars to nine. Do they all contribute, vastly overproducing the observed value of N_{eff}? I discuss an ongoing computation of the Axiverse contribution to N_{eff} under various assumptions for the flavor structure of the axion-fermion couplings.

Talks / **37**

Connecting the baryons to the dark matter of the Universe

Author: Alejandro Ibarra[1]

[1] *Technical University of Munich*

Corresponding Author: ibarra@tum.de

The existence of dark matter in our Universe and the existence of an asymmetry between nucleons and antinucleons are two of the most solid evidences for physics beyond the Standard Model. Many mechanisms have been proposed to explain these two phenomena. On the other hand, these mechanisms typically involve different particles and different energy scales, therefore the observed similarity between the dark matter abundance and the nucleon abundance is merely coincidental. In this talk we will propose a scenario that can accommodate the observed nucleon-antinucleon asymmetry without fulfilling the Sakharov conditions. Further, our scenario predicts a stable dark matter candidate without invoking new ad-hoc symmetries, and with an abundance which is in the ballpark of the observed value.

Talks / **38**

Gravitational Waves as Probes of New Physics

Author: Stephen Frederick King[1]

[1] *University of Southampton*

Corresponding Author: stephen.king@cern.ch

We discuss some examples of how gravitational waves from either phase transitions or cosmological relics such as cosmic strings or domain walls, may be used to probe a variety of new physics ranging from neutrino mass, grand unification, inflation or even quantum gravity. The recent Pulsar Timing Array results from experiments such as NANOgrav may be the first indication of such signals.

Talks / 39

Natural Alignment and CP Violation Beyond the Standard Model

Author: Apostolos Pilaftsis[1]

[1] *University of Manchester (GB)*

Corresponding Author: apostolos.pilaftsis@manchester.ac.uk

The current LHC Higgs data suggest that the couplings of the observed 125 GeV Higgs boson must be remarkably close to the Standard Model (SM) expectations. This implies that any Beyond-the-Standard-Model physics due to an extended Higgs sector must lead to the so-called SM alignment limit, where one of the Higgs bosons behaves exactly like that of the SM. In the context of the Two Higgs Doublet Model (2HDM), this alignment is often associated with either decoupling of the heavy Higgs sector or fine-tuning the parameters of the 2HDM potential. In the first part of my talk, I will review the Higgs symmetries required for achieving natural alignment without decoupling or fine-tuning. However, the exact imposition of these symmetries lead to CP conservation in the Higgs potential. In the second part of my talk, I will then show how CP violation could be maximised in this case by spontaneous, soft and explicit breaking of these symmetries, while maintaining agreement with LHC data and constraints on a non-zero electron electric dipole moment. Finally, if time permits, I will discuss the collider signatures for a 2HDM Higgs sector in the natural alignment limit, which dominantly lead to third-generation quarks in the final state, like 4 tops, and can serve as a useful observational tool during the last upgraded phases of the LHC.

Talks / 40

Precision Calculations in the Next-to-Minimal Supersymmetric Standard Model (NMSSM) and Phenomenological Implications

Author: Milada Muhlleitner[None]

Corresponding Author: milada.muehlleitner@kit.edu

While the Standard Model (SM) cannot solve all our open questions, supersymmetry (SUSY) still remains an attractive and viable option to give answers to unsolved puzzles as e.g. the nature of Dark Matter. The Higgs sector of the next-to-minimal supersymmetric extension of the SM (NMSSM) contains two complex Higgs doublets and a singlet field, leading to a rich phenomenology. In SUSY

models, the Higgs masses are computed from the SUSY input parameters. The comparsion of precision predictions for the SM-like SUSY Higgs boson mass value with the experimentally measured Higgs mass of 125 GeV hence allows to indirectly constrain the NMSSM parameter space. In this talk, I present our precision predictions at two-loop order for the NMSSM Higgs boson masses as well as for the trilinear Higgs self-couplings in the CP-violating NMSSM. The latter are directly linked to the mass values through the Higgs potential, and their measurement gives important insights into the mechanism of electroweak symmetry breaking. I furthermore present the impact of our calculated two-loop corrections to the rho parameter and their effect on the W boson mass as well as the muon anomalous magnetic moment (AMM). Finally, the leptonic AMM and the electric dipole moment will be discussed in a variant of the NMSSM which includes the inverse seesaw mechanism. The talk highlights the importance of the interplay between precision calculations in SUSY extensions of the SM and the indirect constraints that can be derived on the allowed parameter space through the comparison with the experimental results.

Talks / 41

Baryogenesis from transient CP violation in the early Universe

Author: Jose Miguel No[1]

[1] *IFT-UAM/CSIC*

Corresponding Author: josemiguel.no@uam.es

Extended scalar sectors can yield baryogenesis at the EW scale. This is generally related to their providing the needed departure from thermal equilibrium (absent in the SM) via a first-order EW phase transition. Yet, BSM sources of CP violation are also required for baryogenesis, despite being very strongly constrained experimentally by electric dipole moments (EDMs). I show that extended scalar sectors may offer a solution to this problem too, by yielding a transient enhancement of CP violation in the early Universe that is a catalyzer for baryogenesis.

Talks / 43

Constraining BSM neutrino physics with CEvNS

Author: Mariam Tórtola[None]

Corresponding Author: mariam@ific.uv.es

Observing neutral-current coherent elastic neutrino-nucleus scattering (CEvNS) at the COHERENT experiment has opened a new window to search for new physics beyond the Standard model. In this talk, I will present the constraints on BSM neutrino physics searches obtained from a detailed statistical analysis of the COHERENT CsI and LAr data. In particular, I will focus on neutrino electromagnetic properties, neutrino nonstandard interactions, and the most general case of neutrino generalized interactions or the presence of light mediators or sterile neutrino states. I will also discuss the potential of upcoming reactor and accelerator CEvNS experiments to constrain nuclear properties and BSM neutrino physics simultaneously.

Talks / 44

On the initial singularity and extendibility of flat quasi-de Sitter spacetimes

Author: Ghazal Geshnizjani[None]

Co-authors: Erik Ling ; Jerome Quintin

Corresponding Author: ggeshnizjani@perimeterinstitute.ca

Inflationary spacetimes have been argued to be past geodesically incomplete in many situations. However, whether the geodesic incompleteness implies the existence of an initial spacetime curvature singularity or whether the spacetime may be extended (potentially into another phase of the universe) is generally unknown. Both questions have important physical implications. In this talk, we take a closer look at the geometrical structure of inflationary spacetimes and investigate these very questions. I will first discuss classifying which past inflationary histories have a scalar curvature singularity and which might be extendible and/or non-singular. Then, I will briefly go over derivation of a rigorous extendibility criteria of various regularity classes for quasi-de Sitter spacetimes that evolve from infinite proper time in the past. Finally, I will argue that past-eternal inflationary scenarios are most likely physically singular, except in situations with very special initial conditions.

Talks / 45

Chasing dark matter with pulsar experiments

Author: Nataliya Porayko[1]

[1] *University of Milano Bicocca*

Corresponding Author: porayko.nataliya@gmail.com

Pulsars are rapidly rotating, highly-magnetized neutron stars which emit electromagnetic radiation in the form of highly collimated beams, mainly observed in the radio wavelength regime. Pulsars can be instrumental in solving the puzzle, which has perplexed the minds of the scientific community for almost a century –dark matter. The ultralight scalar field dark matter (also known as "fuzzy" dark matter), consisting of bosons with extremely low masses of m ~ 10^(−22) eV, is one of the compelling dark matter candidates, which solves some of the problems of the conventional cold dark matter hypothesis. It was shown by Khmelnitsky and Rubakov that "fuzzy" dark matter in the Milky Way induces oscillating gravitational potentials, leaving characteristic imprints in the time of arrivals of radio pulses from pulsars. Fuzzy dark matter in the Galaxy are searched in the latest European Pulsar Timing Array dataset that contains the times of arrival of 25 pulsars regularly monitored for more than two decades. The results and obtained limits will be summarized in the talk. Other possible ways of constraining dark matter with pulsar experiments as well as prospects of dark matter detection with future radio astronomical facilities are discussed.

Talks / 46

Cosmic Matter-Antimatter Separation and Sterile Neutrino Dark Matter

Author: Mikhail Shaposhnikov[1]

[1] *EPFL - Ecole Polytechnique Federale Lausanne (CH)*

Corresponding Author: mikhail.shaposhnikov@epfl.ch

The lattice studies provided evidence of a smooth crossover between the hadronic and quark-gluon phases at high temperatures and zero chemical potential for baryonic number. We argue that these simulations might not rule out relatively weekly first-order phase transition. This first-order QCD phase transition may lead to cosmic separation of phases, creating temporarily macroscopic domains occupied by matter and antimatter. We demonstrate that this possibility enhances the keV scale

sterile neutrino production and may lead to its abundance consistent with the observable energy density of dark matter.

Talks / **47**

Light from darkness : history of a hot dark sector

Author: Michel Tytgat[None]

Corresponding Author: michel.tytgat@ulb.be

In this talk, I will present a study of a scenario in which the universe was initially dominated by a hot hidden sector. By this I mean that T' » T, with T' the temperature of the hidden sector and T that of the visible sector. As an extra rule, I will assume that dark matter belong to the hidden sector and that its abundance is set by standard thermal freeze-out. One of the key issues I will discuss is the various ways in which the entropy of the hidden sector may be transfered to the visible sector before big bang nucleosynthesis and the implication for the dark matter phenomenology. In such scenario, the mass of the dark matter particle could be as large as 10ˆ10 GeV or so. This will be discussed in the framework of dark QED, with dark fermions forming the dark matter and dark photons as mediator between the hidden sector and the visible sector.

Talks / **48**

Tracking Minima, Phase Transitions and Gravitational Waves with BSMPTv3

Authors: João Viana[1]; Lisa Biermann[2]; Milada Muhlleitner[2]; Rui Santos[3]

[1] *FCUL/CFTC*

[2] *KIT*

[3] *ISEL and FCUL/CFTC*

Corresponding Authors: rasantos@fc.ul.pt, jfvvchico@hotmail.com, milada.muehlleitner@kit.edu, lisa.biermann@kit.edu

We present an update of our code BSMPT that allows for the detailed study of phase transitions between evolving minima in the one-loop daisy-resummed finite-temperature effective potential.
BSMPTv3 tracks temperature-dependent coexisting minimum phases, calculates the bounce solution for regions of coexisting minima, and determines the characteristic temperatures and parameters of found first-order phase transitions and signals of sourced gravitational waves.
We compare BSMPTv3 to the widely-used code CosmoTransitions and comment on our respective improvements.

Talks / **49**

Search for cosmological phase transitions through their gravitational wave signals

Author: Marek Lewicki[1]

[1] *University of Warsaw*

Corresponding Author: marek.lewicki@fuw.edu.pl

We are currently witnessing the dawn of a new era in astrophysics and cosmology, started by the first LIGO/Virgo/KAGRA observations of Gravitational Waves (GW). Very recently, also the detection of a stochastic background of GWs at very low frequencies was announced by the Pulsar Timing Array collaborations. In this talk, I will discuss how such signals are produced in cosmological phase transitions and examine the possible implications of current data for this source as well as the prospects for detection in the upcoming next generation of GW experiments.

Talks / 50

Complex S3-symmetric 3HDM

Authors: Anton Kuncinas[None]; M. N. Rebelo[None]; O. M. Ogreid[None]; P. Osland[None]

CP violation plays a very important role in nature with implications both for Particle Physics and for Cosmology. Accounting for the observed matter–antimatter asymmetry of the Universe requires the existence of new sources of CP violation beyond the Standard Model. In models with an extended scalar sector CP violation can emerge either explicitly, i.e., at the Lagrangian level, or spontaneously.

We discuss a three-Higgs-doublet model with an underlying S3 symmetry, allowing in principle for complex couplings. In this framework it is possible to have either spontaneous or explicit CP violation in the scalar sector, depending on the regions of parameter space corresponding to the different possible vacua of the S3 symmetric potential. The classification is based strictly on the exact S3-symmetric scalar potential with no soft symmetry breaking terms. The scalar sector of one such model was explored numerically. After applying the theoretical and the most important experimental constraints the available parameter space is shown to be able to give rise to light neutral scalars at the O(MeV) scale.

Talks / 51

Criterion for ultra-fast bubble walls: the impact of hydrodynamic obstruction

Author: Xander Nagels[None]

Corresponding Author: xander.staf.a.nagels@vub.be

The Bodeker-Moore thermal friction is usually used to determine whether or not a bubble wall can run away. However, the friction on the wall is not necessarily a monotonous function of the wall velocity and could have a maximum before it reaches the Bodeker-Moore limit. In this talk, I compare the maximal hydrodynamic obstruction, i.e., a frictional force in local thermal equilibrium that originates from inhomogeneous temperature distribution across the wall, and the Bodeker-Moore thermal friction, where the former is studied in a fully analytical way, clarifying its physical origin and providing a simple expression for its corresponding critical phase transition strength above which the driving force cannot be balanced out by the maximal hydrodynamic obstruction. For a large parameter space, the maximal hydrodynamic obstruction is larger than the Bodeker-Moore thermal friction, indicating that the conventional criterion for the runaway behavior of the bubble wall must be modified.

Talks / 52

Sourcing electroweak baryogenesis

Author: Marieke Postma[None]

Co-authors: Graham White [1]; Jorinde Marjolein Van De Vis

[1] *Southampton*

Corresponding Authors: g.a.white@southampton.ac.uk, mpostma@nikhef.nl, jorindevandevis@outlook.com

In electroweak baryogenesis the observed matter-antimatter asymmetry in the Universe is created during a first order electroweak phase transition. The scenario requires
new physics at the electroweak scale, which can be tested by current and upcoming experiments. Unfortunately, theoretical pedictions for the baryon asymmetry may vary by orders of magnitude, depending on the approximation scheme used. A careful and systemetic analysis of the so-called vev-insertion-approximation scheme shows that the leading order contributions to the asymmetry cancel exactly, making this approach much less efficient than previously thought.

Talks / **53**

Searches for Higgs boson pair production at ATLAS

Author: Jana Schaarschmidt[1]

[1] *University of Washington (US)*

Corresponding Author: jana.schaarschmidt@cern.ch

ATLAS is one of the main experiments at the Large Hadron Collider, with focus on Standard Model (SM) measurements and searches for new physics at the TeV scale.
One of the most active fields currently is the search for Higgs boson pair production. Models with an extended Higgs sector predict that Higgs boson pairs are produced via the decay of new heavy scalars. Models with extra dimensions predict the existence of spin-2 resonances that can decay to DiHiggs. Some models beyond the SM suggest increased rates of the decay of new resonances to a 125 GeV Higgs boson and another scalar with a different mass. The Standard Model predicts the non-resonant production of DiHiggs via the Higgs boson self-coupling lambda. Such a measurement would allow to establish the shape of the Higgs potential. Deviations of lambda from the SM prediction however can lead to increased DiHiggs rates and would indicate new physics.
During the last years, DiHiggs searches have profited from refined analysis techniques with an extensive usage of machine learning as well as advancements in particle identification, especially in the area of b-tagging, leading to much improved sensitivities. This talk will present a selection of these ATLAS searches for both resonant and non-resonant DiHiggs production, with a focus on new results. The latest DiHiggs combinations will also be discussed.

Talks / **54**

Status and Future Prospects of the search for Dark Matter Annual Modulation in NaI

Author: Maria Martinez[None]

Corresponding Author: mariam@unizar.es

The annual modulation of the dark matter signal in direct detection experiments stands as one of the most promising distinctive signals for providing a positive detection. For over two decades, the DAMA/LIBRA experiment in the Gran Sasso underground laboratory has observed a modulation in its low-energy data that is compatible with that expected from Weakly Interacting Massive Particles (WIMPs) in the galactic halo. However, these results do not align with the negative outcomes from other direct detection experiments employing different target nuclei. To resolve this puzzle, it is imperative to replicate the DAMA experiment using the same target material (NaI). This objective is pursued by several experiments worldwide, two of which—ANAIS-112 and COSINE-100—have

already yielded results narrowing down the interpretation of the DAMA signal as dark matter. In this presentation, I will review the current status and future prospects of these experiments.

Talks / 55

Contributions to N_{eff} from freeze-in production of light relics

Author: Patrick Stengel[1]

[1] *INFN Ferrara*

Corresponding Author: pstengel@fe.infn.it

Light relics produced by freeze-in, while more dependent on both the specific BSM physics scenario and the reheating temperature than freeze-out, are generic for models in which the light relic couples to the SM plasma more weakly than necessary for full thermalization. In particular, rates for light relic production associated with non-renormalizable interactions typical of BSM scenarios can grow with temperature more quickly than the Hubble rate. Thus, for couplings smaller than those probed in freeze-out production, current and next generation CMB experiments can be sensitive to contributions to the effective number of neutrino species, N_{eff}, associated with light relics produced by freeze-in. We investigate several representative BSM scenarios, for which we calculate contributions to N_{eff} in corners of parameter space not previously considered and discuss the sensitivity of CMB experiments.

Talks / 57

Hide and seek: how PDFs can conceal new physics

Author: Maeve Madigan[1]

[1] *Heidelberg University*

Corresponding Author: madigan@thphys.uni-heidelberg.de

The Standard Model Effective Field Theory (SMEFT) provides a powerful theoretical framework for interpreting subtle deviations from the Standard Model and searching for heavy new physics at the LHC. Accurate interpretations of LHC data, however, rely on the precise knowledge of the proton structure in terms of parton distribution functions (PDFs). I will discuss the interplay between PDFs and the search for new physics. I will showcase a scenario for the High-Luminosity LHC in which the PDFs may completely absorb such signs of new physics, thus biasing theoretical predictions and interpretations. To address this challenge, I will present a simultaneous determination of PDFs and the SMEFT using the SIMUnet methodology. This approach integrates both PDF and SMEFT determinations into a single, coherent framework, making possible an assessment of the regions of parameter space in which the interplay is most phenomenologically relevant, both at the LHC and HL-LHC.

Talks / 58

Axion screening of the CMB

Author: Cristina Mondino[1]

[1] *Perimeter Institute for Theoretical Physics*

Corresponding Author: cmondino@perimeterinstitute.ca

Cosmic microwave background (CMB) photons can convert into axion-like particles as they cross the halo magnetic fields of non-linear structure. Resonant conversion occurs when the axion mass matches the photon plasma mass, induced by the ionized gas within halos, leading to a frequency-dependent transition probability. Therefore, axions induce a frequency-dependent anisotropic screening of the CMB, which imprints secondary anisotropies in the observed CMB temperature and polarization fields. I will discuss how to compute these axion signals and their expected correlations on the sky, including cross-correlations between CMB and Large Scale Structure. I will then show that existing and future surveys can be complementary and improve upon other astrophysical axion searches for masses between 10^{-13} and 10^{-12} eV.

Talks / **59**

Back to the phase space: thermal axions

Author: Francesco D'Eramo[1]

[1] *University of Padua*

Corresponding Author: francesco.deramo@pd.infn.it

Scattering and decay processes of thermal bath particles in the early universe can dump relativistic degrees of freedom in the primordial plasma. This talk will focus on the QCD axion and it will feature recent and significant improvements in the predicted amount of axion dark radiation. First, I will present novel calculations for the production rate across the different energy scales during the expansion of the universe. I will then present a phase-space approach to improve the predictions for the axion dark radiation abundance. This methodology allows for studying light particles that never reach equilibrium across cosmic history, and to scrutinize the physics of the decoupling when they thermalize instead. I will show how spectral distortions are typically expected due to a non instantaneous decoupling, and I will quantify how this translates into a corrected prediction for the dark radiation abundance.

Talks / **61**

Searches for additional low-mass Higgs bosons at the LHC

Author: Susan Gascon-Shotkin[1]

[1] *Institut de physique des 2 infinis de Lyon/Université Claude Bernard Lyon 1 IN2P3-CNRS*

Corresponding Author: susan.shotkin.gascon@cern.ch

This talk will present the latest results on searches for additional Higgs bosons with low mass by the ATLAS and CMS experiments at the LHC. It will include searches for the 125 GeV Higgs boson decaying to lower-mass scalars.

Talks / **62**

Two ideas in dark matter model building

Author: Raymond Volkas[1]

[1] *The University of Melbourne*

Corresponding Author: raymondv@unimelb.edu.au

The first idea relates to the asymmetric dark matter mass scale. To explain the cosmological coincidence between the ordinary and dark matter mass densities, one needs a rationale for why the dark matter mass scale is of the order of the proton mass. I present an analysis of how infrared fixed points in the running of the ordinary and dark QCD coupling constants can be used to achieve this aim. The second idea, to be covered more briefly, is about relating axion dark matter to neutrino mass generation, leptogenesis and inflationary cosmology within a variant DFSZ framework for solving the strong-CP problem. These ideas are obviously orthogonal to each other. Both should be taken as thought experiments.

Talks / 63

Applications of the Tunneling Potential Formalism

Author: Jose Ramon Espinosa Sedano[1]

[1] *IFT-UAM/CSIC Madrid*

Corresponding Author: jose.espinosa@cern.ch

The Tunneling Potential formalism offers an alternative to the Euclidean bounce formalism for calculating tunneling actions. These actions govern the exponential suppression of metastable vacua decay in quantum field theory. In this talk, I will discuss how this formalism elegantly describes gravitational effects on vacuum decay, bubble-of-nothing decays, domain walls, and more.

Talks / 64

CP violation with ALPs and with singlet scalars

Author: Belen Gavela[1]

[1] *UAM*

Corresponding Author: belen.gavela@uam.es

Novel bounds on CP-odd fermionic couplings of ALPs and of a general singlet scalar are presented and compared. In both cases, we improve present constraints by several orders of magnitude. The impact of an additional Peccei-Quinn symmetry will be discussed as well.

Talks / 65

Aspects of Models with Vector-like Quarks

Author: Gustavo Branco[1]

[1] *U. Lisbon*

Corresponding Author: gbranco@tecnico.ulisboa.pt

In recent years, interest in vector like quaks (VLQs) has been increasing, due to their contributions
to
new physics effects that can be tested in experiments at LHC and High-Lumi LHC. The existence of

VLQs leads to flavour-changing neutral currents at tree level and deviations from unitarity of the CKMmatrix, introducing rich phenomenological implications. In my talk I shall address some of these aspects of models with VLQs.

Talks / 66

Impact of Loop Corrections to the Trilinear Higgs Couplings and Interference Effects on Experimental Limits

Authors: Georg Ralf Weiglein[1]; Kateryna Radchenko Serdula[2]; Milada Muhlleitner[3]; Sven Heinemeyer[4]

[1] *Deutsches Elektronen-Synchrotron (DE)*

[2] *DESY*

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

[4] *CSIC (Madrid, ES)*

Corresponding Authors: sven.heinemeyer@cern.ch, kateryna.radchenko@desy.de, milada.muehlleitner@cern.ch, georg.weiglein@desy.de

We investigate the reliability of a comparison between the experimental results and the theoretical predictions for the pair production of the 125 GeV Higgs boson at the LHC. Recent experimental results for di-Higgs production provide already sensitivity to triple Higgs couplings (THCs) in models beyond the Standard Model (BSM). In our analysis within the Two Higgs Doublet Model (2HDM) we find that potentially large higher-order corrections to the trilinear couplings and the interference effects arising from additional heavy states have a strong impact on the expected shape of the differential cross section and the value of the total cross section. Both effects have to be taken into account for a correct interpretation of the experimental results. In particular, we demonstrate that neglecting the interference of the contributions of heavy Higgs resonances with non-resonant (background) diagrams, as done by the experimental collaborations, can lead to unreliable exclusion limits.

Talks / 67

Higgs+DM searches in CMS

Author: Alicia Calderon Tazon[1]

[1] *Universidad de Cantabria and CSIC (ES)*

Corresponding Author: alicia.calderon@cern.ch

Determination of the nature of dark matter is one of the most fundamental problems of particle physics and cosmology. This talk presents searches for dark matter particles associated with the production of a Higgs or a dark Higgs. The results are based on proton-proton collisions recorded at sqrt(s) = 13 TeV with the CMS detector at the Large Hadron Collider.

Talks / 68

Freeze-in at stronger coupling and the highest temperature in the Universe

Author: Francesco Costa[None]

Corresponding Author: francesco.costa@uni-goettingen.de

When the Dark Matter (DM) mass is higher than the temperature of the thermal bath, DM can produced via the freeze-in mechanism with coupling as high as $O(1)$. This leads to an observationally attractive scenario compared to the standard freeze-in couplings that are $O(10^{-10})$. In fact, it can be probed by direct detection experiments and at LHC.

We display this mechanism in the scalar DM case. We then present a UV-completed framework where the maximal SM temperature coincides with or is approximately the reheating temperature. We exemplify this in the case of the inflation primarily decaying into feebly interacting right-handed neutrinos.

Talks / 69

Transport equations for electroweak baryogenesis

Author: Kimmo Juhani Kainulainen[1]

Co-author: Niyati Venkatesan [2]

[1] *University of Jyvaskyla (FI)*

[2] *University of Jyväskylä*

Corresponding Authors: kimmo.kainulainen@cern.ch, niyati.a.venkatesan@jyu.fi

An integral part of the BSM physics model building is testing if the new models can provide the answer to the origin of the baryon asymmetry in the universe (BAU). This test requires solving the CP-violating out-of-equilibrium particle distributions near the expanding phase transition front. The quantum transport theory for this purpose, the semiclassical method, is well understood and applicable in the limit of reasonably wide walls. The SC-equations are usually solved in the diffusion equation limit or in the moment expansion approximation, relying on the two lowest moments of, essentially the perpendicular particle velocity to the wall front. Here I will present a generalisation of the moment expansion approach to an arbitrary number of moments N and show that the result for BAU converges, albeit rather slowly, as a function of N. I will also make a comment on the historical development of the transport equations for the EWBG, including the competing VIA-method, and outline further developments in quantum regime beyond the SC-method.

Talks / 70

Exclusion bounds for Z' bosons

Author: Zoltán Péli[1]

Co-author: Zoltan Laszlo Trocsanyi [2]

[1] *ELTE, Eötvös University, Hungary*

[2] *ELTE Eotvos Lorand University (HU)*

Corresponding Authors: zoltan.peli@ttk.elte.hu, zoltan.trocsanyi@cern.ch

We study how the recent experimental results constrain the
gauge sectors of $U(1)$ extensions of the standard model
using a novel representation of the parameter space.
We determine the bounds on the mixing angle between the massive
gauge bosons, or equivalently, the new gauge coupling as a function of
the mass $M_{Z'}$ of the new neutral gauge boson Z' in the
approximate range $(10^{-2}, 10^4)$\,GeV/c^2.
We consider the most stringent bounds obtained from direct

searches for the Z'. We also exhibit the allowed parameter space by comparing the predicted and measured values of the ρ parameter and those of the mass of the W boson.
Finally, we discuss the prospects of Z' searches at future colliders.
The talk is based on arXiv:2402.14786.

Talks / 71

Astrophysical Probes of Self-Interacting Dark Matter

Author: Tesla Jeltema[None]

Corresponding Author: tesla@ucsc.edu

Models of the cosmological dark matter featuring strong non-gravitational particle-particle interactions have received significant attention, as they may help alleviate, or even explain away, tensions between the standard cold dark matter paradigm and observations, including the observed diversity of galactic rotation curves. Self-interacting dark matter (SIDM) models give a number of testable predictions, including changing the inner density profiles and shapes of dark matter halos and potentially leading to the formation of black holes as a result of the gravothermal collapse. I will review a set of observational projects giving constraints on SIDM models.

Talks / 74

Gamma-ray Astronomy: a Unique Probe of the Universe

Gamma-ray astronomy is challenging. The fluxes are low, and gamma-rays cannot be focused, leading to relatively poor angular resolution. Yet the scientific payoffs are considerable –gamma rays allow us to probe the Universe in a new way and have the potential to provide new insights into dark matter, quantum gravity, and more. This talk aims to provide an overview of gamma-ray astronomy from space and from the ground, and what future instruments such as CTA and SWGO may reveal.

Talks / 77

BSM at FCC

Talks / 80

Precise Predictions and New Insights for the Migdal Effect

Corresponding Author: maitiu.o.dolain@gmail.com

The scattering of neutral particles by an atomic nucleus can lead to electronic ionisation and excitation through a process known as the Migdal effect. I will describe the necessity of revisiting previous calculations to provide more accurate predictions which allow for large nuclear recoil velocities and incorporate the effects of multiple ionisation. These results are relevant for dark matter direct detection searches, as well as ongoing experiments involving neutron sources.I will also discuss the sensitivity of the HydroX proposal to dope the LZ experiment with hydrogen using the Migdal effect.

HydroX could have sensitivity to dark matter masses as low as 5 MeV for both spin-independent and spin-dependent scattering, with XLZD extending that reach to lower cross sections. This technique would substantially enhance the sensitivity of direct detection to spin-dependent proton scattering, well beyond the reach of any current experiments.

Talks / 81

How Viable Is Electroweak Baryogensis ?

Corresponding Authors: mjrm@sjtu.edu.cn, mjrm@physics.umass.edu

Talks / 83

Dark branes for PTA signal and dark matter

Corresponding Author: quiros@ifae.es

The Pulsar Timing Array signal at the nHz frequency can be described by the first order phase transition of a conformal sector with a confinement scale around the GeV. We model this effect in a 5D warped theory with an IR dark brane at the GeV scale. The dark sector, located in the dark brane, interacts only gravitationaly with the SM. A simple model of a fermionic dark matter is presented, with the correct relic density and passing all direct (but outside the neutrino floor) and indirect dark matter measurements. The mass window for both successful dark matter (and PTA signal) is between 150 MeV and 2 GeV.

Talks / 84

QCD Baryogenesis

Corresponding Author: sipek@physics.carleton.ca

Talks / 85

Deconstructing Flavor:ThePrivately Democratic Higgs

Corresponding Author: nausheen.shah@wayne.edu

Talks / 86

Coherent Elastic neutrino-Nucleus Scattering with directional detectors

Corresponding Author: daristi@gmail.com

In this talk I will review a few aspects of Coherent Elastic neutrino-Nucleus Scattering (CEvNS). In particular I will focus on measurements using neutrino beams from pion decay-in-flight, as those used at FNAL. I will show that, combined with directional detectors, these beams offer an avenue for CEvNS measurements at a different energy scale. Such measurements will provide complementary information to that coming from pion decay-at-rest neutrino sources as well as from reactor neutrino facilities.

Talks / 88

SUSY searches at CMS

Corresponding Author: jaana.kristiina.heikkilae@cern.ch

Talks / 89

Composite 2HDM at the LHC: Single & Double Higgs

Corresponding Author: stefano.moretti@cern.ch

Talks / 90

Testing the Electroweak Theory with multi-boson polarization measurements

Corresponding Author: joany.andreina.manjarres.ramos@cern.ch

Experimental measurements of multiboson interactions serve as tests for the Standard Model (SM) electroweak sector and its mechanism of spontaneous symmetry breaking (EWSB). One direct avenue to probe this sector is through the study of weak boson polarizations, offering a direct insight into EWSB. As longitudinal polarization modes only exist for massive bosons, they are directly linked to the Higgs mechanism, which provides the $W^\pm$ and Z bosons with their mass.
In this talk, we delve into the latest public results from ATLAS regarding multiboson measurements, shedding light on the intricacies of multiboson interactions, the experimental challenges and discuss their implications for our understanding of fundamental particle physics.

Talks / 91

Collider-cosmology synergy for strong dynamics signals

Corresponding Author: decurtis@fi.infn.it

To explore BSM scenarios from underlying strong dynamics, the key ingredients are new particles as composite states. Extended Higgs sectors with pNGB Higgses can give distinctive signatures at colliders, for example in the double-Higgs production process, and can be linked to the thermal history of the Universe for triggering a strong first order EW phase transition.

Talks / 92

Semisymmetries in 2HDM

Corresponding Author: bohdan.grzadkowski@fuw.edu.pl

The Two Higgs Doublet Model invariant under the gauge group SU (2) × U (1) is known to have six additional global discrete or continuous symmetries of its scalar sector. We have discovered regions of parameter space of the model which are basis and renormalization group invariant to all orders of perturbation theory in the scalar and gauge sectors, but correspond to none of the hitherto considered symmetries. We therefore identify seven new symmetries of the model and discuss their phenomenology.

Talks / 94

Diphoton jet signals from light fermiophobic Higgs boson at the HL-LHC

Author: Jeonghyeon Song[1]

[1] *Konkuk University*

Corresponding Author: jeonghyeon.song@gmail.com

In this study, we explore the signatures of a light fermiophobic Higgs boson within the type-I two-Higgs-doublet model at the HL-LHC. Our parameter scan identifies a mass range between 1 and 10 GeV, challenging to detect due to soft decay products. We propose a discovery channel with the final state consisting of four photons, one lepton, and missing transverse momentum. However, the merger of photons into a single jet intensifies QCD backgrounds. To address this, we devise a strategy to identify diphoton jets. Our simulations across 18 benchmark points show signal significances exceeding
5 sigma at 3/ab integrated luminosity, enabling accurate mass reconstructions for the fermiophobic Higgs boson and the charged Higgs boson. Additionally, machine learning techniques boost significance in scenarios with heavy charged Higgs bosons.

Talks / 95

Entanglement in flavored scattering

Corresponding Author: kamila.kowalska@ncbj.gov.pl

I will discuss entanglement between two final-state particles in 2 to 2 scattering, induced by the S-matrix which depends on both the momentum and flavor degrees of freedom. I will describe different ways to quantify the entanglement in such a system and the resulting constraints on the interactions' structure. An example of scalar scattering in 2HDM will be discussed.

Talks / 96

Naturally small neutrino mass from asymptotic safety

Corresponding Authors: enrico.sessolo@ncbj.gov.pl, enrico.sessolo@gmail.com

I will discuss the possibility of dynamically generating arbitrarily small Yukawa couplings in the framework of trans-Planckian asymptotic safety. This effective mechanism may provide an interesting alternative to other dynamical means to generate small neutrino masses, e.g., the see-saw mechanism, and can be applied to various new physics scenarios requiring feeble Yukawa interactions (freeze-in dark matter, etc). I will show that this mechanism can be consistent with first-principle calculations in quantum gravity and I will discuss possible gravitational-wave signals arising from the connection between these extreme UV and IR sectors.

Talks / **97**

Stochastic effective theory for scalar fields in de Sitter spacetime

Corresponding Author: a.rajantie@imperial.ac.uk

The dynamics of the Higgs and other light scalar fields during inflation can have important cosmological consequences, but because of the infrared problem, they cannot be computed using perturbation theory. A powerful alternative is the stochastic Starobinsky-Yokoyama approach, which is based on the observation that on superhorizon distances the field behaves classically, with a noise term produced by subhorizon quantum modes. It has been mostly used to calculate the one-point probability distribution of the field, but its real power lies in describing the asymptotic long-distance behaviour of correlation functions through a spectral expansion. I demonstrate this by calculating isocurvature constraints for scalar dark matter models and decay rates of metastable vacua. I also show how to extend the stochastic theory beyond the overdamped approximation used by Starobinsky and Yokoyama. The parameters of this effective theory are determined at one-loop order in perturbation theory, and do not suffer from the same infrared problems as a direct perturbative computation of observables. Therefore it provides a powerful and accurate way of computing cosmological observables.

Talks / **99**

Indirect new physics constraints with 1,2 and 3 bosons

Corresponding Authors: ken.mimasu@cern.ch, ken.mimasu@soton.ac.uk

I will discuss the first combined interpretation of multiboson production at colliders in the Standard Model Effective Field Theory framework. We find that triboson measurements contribute significantly towards pinning down possible new interactions. We quantify how, in addition to the precise diboson measurements from the LEP and LHC experiments, they offer complementary and competitive indirect sensitivity to new physics to electroweak precision observables (EWPO), by lifting flat directions in the parameter space and improving the validity of the EFT expansion, even in the directions most strongly constrained by EWPO.

Talks / **100**

Classes of complete dark photon models constrained by Z-Physics

Corresponding Authors: howard.haber@cern.ch, haber@scipp.ucsc.edu

Talks / 101

Bubble nucleation for cosmological phase transitions

Corresponding Author: oliver.gould@nottingham.ac.uk

First-order phase transitions proceed via bubble nucleation. This is true regardless of whether the transition is happening in your kettle or on a cosmological scale in the very early universe. I will give an overview of our present understanding of bubble nucleation within quantum field theory, including both long-standing theoretical questions and recent progress.

Talks / 102

Flavor of a light charged Higgs

Corresponding Author: marta.losada@nyu.edu

Talks / 103

The Fluctuating Spacetime of Dark Matter

Corresponding Author: jeffdror@ufl.edu

Talks / 104

Cosmological tensions

Corresponding Authors: eleonora.divalentino@gmail.com, e.divalentino@sheffield.ac.uk

Talks / 105

Ireland @ CERN

Corresponding Author: ryan@maths.tcd.ie

Talks / 106

Review talk: state-of-the-art of the field

Corresponding Author: john.ellis@cern.ch

Talks / 108

Constraints and probes of dark matter objects

Corresponding Author: djuna.l.croon@durham.ac.uk

Talks / 109

History of DIAS

Corresponding Author: emeehan@dias.ie

Talks / 112

TBA

Author: Helena Garcia Escudero[1]

[1] *UCI*

Corresponding Author: garciaeh@uci.edu

Talks / 115

History of Dunsink