
Report of Contributions

https://indico.cern.ch/e/discrete2014
The Pauli Exclusion Principle (PEP) is one of the most fundamental rules of nature and thus a major pillar of modern physics. According to many observations PEP must be extremely well fulfilled. Nevertheless numerous experimental investigations were performed to search for a small PEP violation. The experiment VIP2 at the Gran Sasso underground laboratory is designed to test the Pauli Exclusion Principle for electrons with high sensitivity by searching for forbidden X-ray transitions in copper atoms. VIP2 aims to improve the PEP violation limit obtained with our preceding experiment VIP by orders of magnitude. The experimental method, comparison of different PEP tests based on different assumptions and the developments for VIP2 will be presented.

**Primary author:** Dr MARTON, Johann (Oesterreichische Akademie der Wissenschaften)

**Presenter:** Dr MARTON, Johann (Oesterreichische Akademie der Wissenschaften)

**Session Classification:** Parallel 6b: Foundations of Quantum Theory, Pauli Principle Tests
Solitons, soliton vortices and PT-symmetry in spin-orbit coupled Bose-Einstein condensates.

Tuesday, 2 December 2014 17:00 (35 minutes)

Spin-orbit coupled Bose-Einstein condensates (SO-BECs), which in the meanfield approximation are governed by two linearly coupled Gross-Pitaevskii equations, allow for the existence of many types of localized nonlinear excitations: fundamental and multipole solitons, soliton half-vortices, etc. In the first part of the talk, such excitations will be considered in the presence of so-called Zeeman lattice (i.e. periodic potential which is pi-shifted in both components). I will discuss classification of the solutions with respect to the parity, time, pseudo-charge, and lattice symmetries. In the second part of the talk, a homogeneous SO-BEC will be considered in the presence of mechanisms of loading and loosing atoms. Spontaneous PT-symmetry breaking scenarios, as well as nonlinear modes in such SO-BECs will be described.

Primary author: Prof. KONOTOP, Vladimir (Universidade de Lisboa)

Co-authors: Dr ZEZYULIN, Dmitry (Universidade de Lisboa); Prof. KARTASHOV, Yaroslav (ICFO-Institut de Ciencies Fotoniques, Spain)

Presenter: Prof. KONOTOP, Vladimir (Universidade de Lisboa)

Session Classification: Parallel 3: PT symmetric quantum theory
Gauge Theories for Baryon and Lepton Numbers with Lepto-Baryons

Tuesday, 2 December 2014 18:00 (30 minutes)

I present extensions of the Standard Model, where the global symmetries baryon and lepton number are gauged and subsequently spontaneously broken. These theories are consistent with collider bounds and cosmology, and have intriguing consequences due to the requirement of anomaly cancellation: lepto-baryon fields that have to be introduced can be a dark matter candidate and/or generate neutrino masses. I discuss symmetric and asymmetric dark matter, the generation of neutrino masses, as well as collider signatures in these extensions.

Primary author:  DUERR, Michael (MPIK Heidelberg)
Presenter:  DUERR, Michael (MPIK Heidelberg)
Session Classification:  Parallel 1: g-2 & discrete symmetries (T, C, P), flavour, accidental symmetries
Whispers from the collapse of the w.f: spontaneously emitted radiation

Wednesday, 3 December 2014 17:10 (35 minutes)

The “measurement problem” in quantum mechanics continues to remain a problem which needs an explanation.

A possible solution to this problem is the modification of the Schrodinger equation within the so-called dynamical reduction models. The dynamical reduction models were put forward alternatively to the “standard” quantum mechanics’ Schrodinger equation, followed by a “alla von Neumann” collapse of the wave-function, implementing a (nonrelativistic) dynamical reduction/collapse models, by adding a non-linear and stochastic terms to the Schrodinger equation. Considering the relevance of this conceptually new model(s), it is of utmost importance to study its experimental consequences, where the predictions are diverging from the standard equations, and to perform dedicated experiments to check it.

We discuss various ideas to find experimental signatures for the collapse of the wave function within the dynamical reduction models, starting with the measurement of the spontaneously emitted X rays predicted in the framework the new theory – whispers of the collapse – which is the most promising method to put the strongest limits of the collapse model parameter lambda.

Primary author:  CURCEANU, Catalina (LNF-INFN)

Presenter:  CURCEANU, Catalina (LNF-INFN)

Session Classification:  Parallel 6: Foundations of Quantum Theory, 50 years Bell’s Inequalities
Neutrino masses from SUSY breaking in radiative seesaw models

Friday, 5 December 2014 15:00 (30 minutes)

Radiatively generated neutrino masses ($m_{\nu}$) are proportional to supersymmetry (SUSY) breaking, as a result of the SUSY non-renormalisation theorem. In this work, we investigate the space of SUSY radiative seesaw models with regard to their dependence on SUSY breaking ($\cancel{SUSY}$). In addition to contributions from sources of $nSUSY$ that are involved in electroweak symmetry breaking ($\cancel{EWS}$), sources that are unrelated to EWSB ($\cancel{EWS_{SB}}$). We point out that recent literature overlooks pure-$nSUSY_{EWS}$ contributions. We show that there exist realistic radiative seesaw models in which the leading order contribution to $m_{\nu}$ is proportional to $nSUSY_{EWS}$. To our knowledge no model with such a feature exists in the literature. We give a complete description of the simplest model-topologies and their leading dependence on $nSUSY$. We show that in one-loop realisations $LLHH$ operators are suppressed by at least $M_{soft}/M^3$ or $M_{soft}^2/M^3$. We construct a model example based on a one-loop type-II seesaw. An interesting aspect of these models lies in the fact that the scale of soft-$nSUSY$ effects generating the leading order $m_{\nu}$ can be quite small without conflicting with lower limits on the mass of new particles.

Primary author: FIGUEIREDO, Antonio (CFTP / IST - U. Lisbon)
Presenter: FIGUEIREDO, Antonio (CFTP / IST - U. Lisbon)
Session Classification: Parallel 7: Supersymmetry, Supergravity, Strings, Branes
Discrete symmetries and models of flavour mixing

Wednesday, 3 December 2014 11:45 (45 minutes)

In this talk we shall give an overview of the role of discrete symmetries, including both CP and family symmetry, in constructing unified models of quark and lepton (including especially neutrino) masses and mixing. Various different approaches to model building will be described, denoted as direct, semi-direct and indirect, and the pros and cons of each approach discussed. Particular examples based on Delta(6n^2) will be discussed and an A to Z of Flavour with Pati-Salam will be presented.

Primary author: Prof. KING, Stephen (University of Southampton)
Presenter: Prof. KING, Stephen (University of Southampton)
Session Classification: PLENARY 2
Extra dimensions with flavor.

Tuesday, 2 December 2014 18:35 (30 minutes)

The use of discrete symmetries to explain fermion masses and mixings has been a popular and profitable tool in particle physics. Some of the most interesting features shown in both the quark and lepton sectors, specially with regards to their mixing patterns, strongly hint at the presence of some underlying “flavor” symmetry. On the other hand, the puzzling wide spread in the mass spectrum of fundamental particles, specially when neutrinos are included in the discussion, cannot so clearly nor directly be associated to a symmetry. Instead, several mechanisms have been concocted that, most of the time in collaboration with flavor symmetries, try to explain such observed richness. In this talk we will discuss how some simple and economical models with cyclic symmetry, that reproduce all mixing angles, when constructed in extra dimensions, can also lead to a reproduction of the fermion mass spectrum through the process of localization.

**Primary author:** ARANDA, Alfredo (Universidad de Colima)

**Presenter:** ARANDA, Alfredo (Universidad de Colima)

**Session Classification:** Parallel 1: $g$-2 & discrete symmetries (T, C, P), flavour, accidental symmetries
CKM and PMNS Mixing Matrices from Discrete Subgroups of SU(2)

Wednesday, 3 December 2014 18:50 (30 minutes)

I have the only first principles derivation of the PMNS and CKM matrices within the realm of the Standard Model lagrangian. The mixings originate from the generators of three discrete (i.e., finite) binary rotational subgroups of the EW local gauge group SU(2) x U(1) for three lepton families in $\mathbb{R}^3$ and four related discrete binary rotation subgroups for four quark families in $\mathbb{R}^4$. For each group two of its three generators match the Pauli generators for SU(2), but the different third generators must act together in a linear superposition to match the third Pauli generator. The results dictate the angles for the PMNS and CKM4 matrices. The CKM matrix can be extracted from CKM4 and assuming unitarity. Consequently, one can predict three lepton families and four quark families. However, a sterile neutrino cannot be eliminated. If the two new quarks in the predicted fourth quark family exist, the SM lagrangian may be an excellent approximation all the way down to the Planck scale. In addition, putting the fourth quark family mass values in the Jarlskog expression increases the CPV by more than $10^{13}$, thereby providing a possible explanation of the BAU. The mathematical details are in the online peer reviewed paper at http://www.ptep-online.com/index_files/2014/PP-38-03.PDF

Primary author: POTTER, Franklin (S)
Presenter: POTTER, Franklin (S)
Session Classification: Parallel 1: Discrete symmetries (T, C, P), flavour, accidental symmetries
Track Classification: T, C, P, CP symmetries
Testing the Weak Equivalence Principle with antimatter at CERN

Friday, 5 December 2014 16:59 (30 minutes)

The AEgIS collaboration is planning to measure the gravitational acceleration of antihydrogen, the simplest atom consisting entirely of antimatter, with a precision of 1% as a first achievement. The experiment, based at the Antiproton Decelerator of CERN, provides important information for the development of a quantum theory of gravity.

The experimental setup consists of a nested penning trap and a Stark accelerator, which are used to form and accelerate a pulsed beam of antihydrogen atoms towards a gravity free-fall detector. In this region the beam passes through a moiré deflectometer, which allows the measurement of its vertical displacement, due to the gravitational force, by means of a hybrid position and time sensitive detector (less than 10 um spatial resolution, and 50 ns time resolution), registering the impact point of the anti-atoms and their time of flight.

Recently, a proof of principle study of the AEgIS detection system has been successfully conducted using a miniature copy of the moiré deflectometer coupled to an emulsion film detector. The displacement of the moiré pattern of an antiproton beam due to an electromagnetic field was measured, confirming the detection principle for the gravity measurement in the AEgIS experiment.

The talk will discuss the theoretical background, present the latest developments of the experimental setup and outline the AEgIS plans to achieve the above-mentioned precision.

Primary author: Dr KIMURA, Mitsuhiro (Universitaet Bern (CH))
Presenter: Dr KIMURA, Mitsuhiro (Universitaet Bern (CH))
Session Classification: Parallel 13: Antimatter Experiments
Convoluted Solutions in Supergravity

Wednesday, 3 December 2014 14:30 (30 minutes)

Inspired by the convoluted solutions for two intersecting M2 branes in eleven-dimensional supergravity, in which one brane in the system is completely localized along the overall and relative transverse coordinates while the other brane in the system is localized only along the overall transverse coordinates, we construct two classes of exact solutions to Einstein-Maxwell theory in six and higher dimensions. We show that the membrane configuration preserves four supersymmetries and upon dimensional reduction, the solutions provide intersecting configurations of three D-branes in type IIA supergravity. Moreover, we show that the metric functions in six and higher dimensions can be written as convolution-like integrals of two special functions. The solutions are regular everywhere and show a bolt structure on a single point in any dimensionality. Also, we find the exact nonstationary solutions to the Einstein-Maxwell theory with positive cosmological constant. We show that the cosmological solutions are expanding patches in asymptotically de Sitter spacetime.

Primary author:  GHEZELBASH, Masoud (University of saskatchewan)

Presenter:  GHEZELBASH, Masoud (University of saskatchewan)

Session Classification:  Parallel 7: Supersymmetry, Supergravity, Strings and Branes
Predicting Lepton Mixing Parameters including Majorana Phases from $\Delta(6n^2)$ Flavour Symmetry and Generalised CP

Tuesday, 2 December 2014 19:05 (30 minutes)

An important class of flavour groups that are subgroups of U(3) and that predict experimentally viable lepton mixing parameters including Majorana phases, is the Delta($6n^2$) series. The most well-known member is Delta(24)=S_4. I present results of several extensive studies of lepton mixing predictions obtained in models with a Delta($6n^2$) flavour group that preserve either the full Klein symmetry or a $Z_2$ subgroup for neutrinos and can include a generalised CP symmetry. Predictions include mixing angles and Dirac CP phase generally; and if invariance under a generalised CP symmetry is included, also Majorana phases. For this, the interplay of flavour group and generalised CP symmetry has to be studied carefully. Furthermore, I present results for neutrinoless double-beta decay.

Primary author: Mr NEDER, Thomas (University of Southampton)
Presenter: Mr NEDER, Thomas (University of Southampton)
Session Classification: Parallel 1: g-2 & discrete symmetries (T, C, P), flavour, accidental symmetries
Exploring neutrino physics at LHC via R-parity violating SUSY

Friday, 5 December 2014 15:30 (30 minutes)

$R$-parity violating supersymmetric models (RPV SUSY) are becoming increasingly more appealing than its $R$-parity conserving counterpart in view of the hitherto non-observation of SUSY signals at the LHC. In this talk, RPV scenarios where neutrino masses are naturally generated will be discussed, namely RPV through bilinear terms (bRPV) and the “$\mu$-from-$\nu$” supersymmetric standard model (\muSSM). The latter is characterised by a rich Higgs sector that easily accommodates a 125-GeV Higgs boson. The phenomenology of such models at the LHC is reviewed, giving emphasis on final states with displaced objects, and relevant results obtained by LHC experiments are presented. The implications for dark matter for these theoretical proposals is also addressed.

Primary author: Dr MITSOU, Vasiliki (IFIC Valencia (ES))
Presenter: Dr MITSOU, Vasiliki (IFIC Valencia (ES))
Session Classification: Parallel 7: Supersymmetry, Supergravity, Strings, Branes
Variational Study of SU(3) Gauge Theory by Stationary Variance

Wednesday, 3 December 2014 17:10 (35 minutes)

The principle of stationary variance is advocated as a viable variational approach to gauge theories where the simple Gaussian Effective Potential (GEP) is known to be useless. The method can be regarded as a second-order extension of the GEP and seems to be suited for describing the strong coupling limit of non-Abelian gauge theories. The single variational parameter of the GEP is replaced by trial unknown two-point functions, with infinite variational parameters to be optimized by the solution of a set of integral equations. The stationary conditions can be easily derived by the self-energy, without having to write the effective potential, making use of a general relation between self-energy and functional derivatives that has been proven to any order. By that method, the low-energy limit of pure Yang-Mills $SU(3)$ gauge theory has been studied in Feynman gauge. In terms of standard irreducible graphs, the stationary equations are written as a set of coupled non-linear integral equations for the gluon and ghost propagators. A physically sensible solution is found for any strength of the coupling. The gluon propagator is finite in the infrared, with a dynamical mass that decreases as a power at high energies. At variance with some recent findings in Feynman gauge, the ghost dressing function does not vanish in the infrared limit and a decoupling scenario emerges as recently reported for the Landau gauge.

INTRODUCTION

There is a growing consensus on the utility of variational methods as analytical tools for a deeper understanding of the infrared (IR) limit of non-Abelian gauge theories. The IR slavery of these theories makes the standard perturbation theory useless below some energy scale, and our theoretical knowledge of the IR limit relies on lattice simulation and on non-perturbative techniques like functional renormalization group and Dyson-Schwinger equations. Variational methods have been developed\cite{1-7} as a complement to these analytical approaches and quite recently the method of stationary variance\cite{8, 9} has been advocated as a powerful second order extension of the Gaussian Effective Potential (GEP)\cite{10–13}. The GEP is a genuine variational method and has been successfully applied to many physical problems in field theory, from scalar and electroweak theories\cite{14–20} to superconductivity\cite{21–23} and antiferromagnetism\cite{24}, but turns out to be useless for gauge inter-
Actually, since the GEP only contains first order terms, it is not suited for describing the minimal coupling of gauge theories that has no first-order effects. Several methods have been explored for including fermions [20] and higher order corrections [25,26], sometimes spoiling the genuine variational character of the method.

By a formal higher order extension of the GEP [27] the method of stationary variance has been developed as a genuine variational method that keeps in due account second order effects and seems to be suited to deal with the minimal coupling of gauge theories. While the method has been shown to be viable for the simple Abelian case of QED [28], its full potentialities have not been explored yet. As a non-perturbative tool that can deal with fermions in gauge theories, the method seems to be very useful for exploring the IR limit of QCD, and its natural application field is the non-Abelian SU(3) gauge theory [29].

**YANG-MILLS SU(3) BY STATIONARY VARIANCE**

A full study of QCD by the method of stationary variance is still far away. As a first step, in Ref. [29] we explored the solution of the stationary equations for pure Yang-Mills SU(3) theory. While the method is a genuine variational tool that does not require any small parameter, the technique is based on standard Feynman rules of perturbation theory. The single variational parameter of the GEP is replaced by trial unknown two-point functions, with infinite variational parameters to be optimized by the solution of a set of integral equations, the stationary equations. However, these equations can be easily derived by the self-energy, without having to write the effective potential, making use of a general relation between self-energy and functional derivatives that has been proven to any order [27].

For pure Yang-Mills theory the method of stationary variance provides a set of non-linear coupled integral equations whose solutions are the propagators for gluons and ghosts. Therefore the work has a double motivation: the technical aim of showing that the method is viable and a solution does exist (which was not obvious nor proven in general), and the physical interest on the gluon propagator in the IR limit, where its properties seem to be related to the important issue of confinement.

On the technical side, having shown that a sensible untrivial solution does exist is a major achievement that opens the way to a broader study of QCD by the same method. Inclusion of quarks would be straightforward as some fermions, the ghosts, are already present in the simple Yang-Mills theory, and they already seem to play well their role of canceling the unphysical degrees of freedom.

Other important technical issues are gauge invariance, renormalization and the choice of a physical scale. The method is not gauge invariant, and no effort has been made to restore gauge invariance at this first stage. While there are several ways to attempt it [1,30], in this first step a fixed gauge has been used,
namely the Feynman gauge where the calculation is easier. In this gauge, the properties of the solution are explored in order to see if any unphysical feature emerges for the propagator and the polarization function. Actually the polarization function is found approximately transverse up to a constant mass shift due to the dynamical mass generation. As far as the solution satisfies, even approximately, the constraints imposed by gauge invariance, the method is acceptable on the physical ground. On the other hand the gluon propagator is not a physical observable and is known to be a gauge-dependent quantity. Of course, since the solution depends on the gauge, the choice of working in Feynman gauge could be non-optimal, and the method could be improved by exploring other gauge choices, like Landau gauge. Besides being easier, working in Feynman gauge is also interesting from the physical point of view, as there are very few data available on the gluon propagator in this gauge.

Since lattice simulations are the most natural benchmark for any variational calculation in the IR limit, the regulating scheme is borrowed from lattice simulation, with an energy cutoff and a bare coupling that depends on it. Renormalization Group (RG) invariance requires that the physical observables are left invariant by a change of the cutoff that is followed by the corresponding change of the bare coupling. Then, renormalized physical quantities can be defined that do not depend on the cutoff. The only free parameter of the theory is the energy scale, that must be fixed by a comparison with the experimental data or lattice simulations. No other fit parameter has been introduced in the method, especially mass counterterms that are forbidden by the gauge invariance of the Lagrangian.

On the physical side, the properties of the gluon propagator in Feynman gauge are basically unexplored. In Coulomb gauge[2–5, 7] and in Landau gauge[6, 31–38] there has been an intense theoretical work in the last years. In Landau gauge theoretical and lattice data are generally explained in terms of a decoupling regime, with a finite ghost dressing function and a finite massive gluon propagator. The more recent findings confirm the original prediction[39] of a dynamical mass generation for the gluon. In Feynman gauge we do not expect a very different scenario. A finite ghost propagator has been recently proposed[40], but there are no lattice data available that could confirm it. That makes the study of the Feynman gauge more interesting.

As discussed in Ref.[29], in the present work no important differences are found with respect to the Landau gauge. A decoupling scenario emerges, with very flat ghost dressing functions, flatter than expected, and a ghost propagator that diverges in the IR limit where the ghost behaves like a free zero-mass particle. A finite gluon propagator is found in the IR limit, with a dynamical mass that saturates at about 0.5-0.8 GeV and decreases as a power in the high energy limit. Unfortunately the quantitative predictions are biased by an approximate estimate of the energy scale due to the lack of lattice data in Feynman gauge. Any quantitative estimate of the gluon mass requires that an accurate energy scale should be fixed first. We can only say that a qualitative agreement is found with other predictions in Feynman gauge.
CONCLUDING REMARKS

In summary, one of the major achievements of the present work is the proof that a physically consistent solution does exist for the coupled set of non-linear integral equations that arise from the condition of stationary variance. Since pure Yang-Mills theory already contains fermions (the ghosts), inclusion of quarks in the formalism is straightforward, and would open the way to a broader study of QCD by the same technique.

The method can be improved in many ways. We did not bother about gauge invariance in this first approach, but the properties of the polarization function, namely the correct cancellations of the unphysical degrees of freedom by the ghosts, show that the constraints of gauge invariance can be satisfied, at least approximately, by the variational solution.

While some attempts could be made for enforcing gauge invariance[1,30], a physically motivated choice for the gauge would probably improve the approximation. Landau gauge would be a good candidate, as it would enforce the transversality in the polarization function from the beginning.

Another interesting further development would come from the extension of the formalism to the general case of a finite external background field. For a scalar theory that kind of approach allows a consistent definition of approximate vertex functions by the functional derivative of the effective action. For the GEP these functions can be shown to be the sum of an infinite set of bubble graphs[16]. A similar approach would give a more consistent approximation for the gluon propagator in the present variational framework.

Eventually, the inclusion of quarks would lead to a direct comparison with the low energy phenomenology of QCD.

REFERENCES


Primary author: SIRINGO, Fabio (Università degli Studi di Catania)

Presenter: SIRINGO, Fabio (Università degli Studi di Catania)

Session Classification: Parallel 5: Strongly coupled gauge theories
Adding CP to Flavour Symmetries

Wednesday, 3 December 2014 14:30 (30 minutes)

Topics on adding CP to flavour symmetries.

**Primary author:** DE MEDEIROS VARZIELAS, Ivo (University of Southampton)

**Presenter:** DE MEDEIROS VARZIELAS, Ivo (University of Southampton)

**Session Classification:** Parallel 1: Discrete symmetries (T, C, P), flavour, accidental symmetries
Phenomenology of scenarios with flavor and CP symmetries

Tuesday, 2 December 2014 17:30 (30 minutes)

I discuss a scenario for leptons with a flavor and a CP symmetry. If these symmetries are broken in a particular way, lepton mixing angles as well as the Dirac and the Majorana phases can be predicted in terms of quantities determined by the symmetries of the theory and only one continuous parameter. I present results for a large class of flavor and CP symmetries. Furthermore, I study leptogenesis and neutrinoless double beta decay in such a scenario.

Primary author:  HAGEDORN, Claudia (Excellence Cluster 'Universe', TU Munich)
Presenter:  HAGEDORN, Claudia (Excellence Cluster 'Universe', TU Munich)
Session Classification:  Parallel 1: g-2 & discrete symmetries (T, C, P), flavour, accidental symmetries
Study of CP asymmetry in B0 - antiB0 mixing using inclusive dilepton samples in BaBar

Thursday, 4 December 2014 14:30 (35 minutes)

The asymmetry between same sign inclusive dilepton samples l+ l+ and l- l- from semileptonic B decays in Upsilon(4S) -> B0 antiB0 events allows us to compare B mixing probabilities P(antiB0 -> B0) and P(B0 -> antiB0), and therefore to test the T and CP invariance. We present the measurement of CP asymmetry in inclusive dilepton samples with the full BaBar dataset near Upsilon(4S) resonance, corresponding to 471 million B-antiB pairs.

Primary authors: ANULLI, Fabio (Università e INFN, Roma I (IT)); GARZIA, Isabella (INFN)

Presenter: GARZIA, Isabella (INFN)

Session Classification: Parallel 4: Experiments-discrete-symmetries
Study of CP violation effects in the charmless hadronic decay $B \rightarrow K_s \pi^+ \pi^0$

*Thursday, 4 December 2014 18:05 (25 minutes)*

We report a Dalitz plot analysis of the charmless hadronic decays of charged B mesons to the final state $K_s \pi^+ \pi^0$ using the full BaBar dataset of 471 million BBbar events collected at the Upsilon(4S) resonance. We observe an excess of signal events and measure the branching fractions and CP asymmetries, for the different resonant decay modes and inclusively.

**Primary authors:** ANULLI, Fabio (Universita e INFN, Roma I (IT)); Dr LATHAM, Thomas Edward (University of Warwick (GB))

**Presenter:** Dr LATHAM, Thomas Edward (University of Warwick (GB))

**Session Classification:** Parallel 4: Experiments-discrete-symmetries
In $b \to s$ gamma transitions, the standard model predicts that $B_0$ (anti-$B_0$) decays are related predominantly to the presence of right (left) handed photons in the final state. Therefore, the mixing-induced CP asymmetry in $B \to f_{CP}$ decays, where $f_{CP}$ is a CP eigenstate, is expected to be small. This prediction may be altered by new-physics (NP) processes in which opposite helicity photons are involved. Independently, decays to $K\pi\pi\gamma$ can display an interesting hadronic structure: they have contributions from several kaonic resonances decaying to $K\pi\pi$. The decays of these resonances themselves exhibits a resonant structure, with contributions from $K^*\pi$, $K\rho$ and a ($K\pi$) S-wave. In the present analysis, we extract information about the $K\pi\pi$ resonant structure by means of an amplitude analysis of the $K\pi\pi$ and $K\pi$ invariant mass distributions in $B^+ \to K^{+}\pi^{-}\pi^{+} \gamma$ decays. The results are used, assuming isospin symmetry, to extract the mixing-induced CP parameters of the process $B_0 \to K_{0S} \rho_0 \gamma$ from the time-independent analysis of $B_0 \to K_{0S}\pi^+\pi^-$ gamma.

**Primary authors:** PILLONI, Alessandro (Sapienza U.); ANULLI, Fabio (Universita e INFN, Roma I (IT))

**Presenter:** PILLONI, Alessandro (Sapienza U.)

**Session Classification:** Parallel 4: Experiments-discrete-symmetries
Direct searches for New Physics particles at BABAR

*Tuesday, 2 December 2014 17:30 (25 minutes)*

We report on the latest searches for low mass states predicted in several New Physics models performed with the data collected by the BABAR detector. These include:
- searches for the so-called dark photons in $e^+e^-$ annihilations ($e^+e^- \rightarrow \gamma A', A' \rightarrow e^+e^-, \mu^+\mu^-$), and for long-lived particles motivated by recent astrophysical observations;
- searches for non-standard $\pi^0$-like particle production in $e^+e^- \rightarrow \tau^+\tau^-$ events;
- and searches for a low mass CP-odd Higgs boson predicted in non-minimal supersymmetric extensions of the Standard Model.

**Primary authors:** ANULLI, Fabio (Universita e INFN, Roma I (IT)); EIGEN, Gerald (University of Bergen (NO))

**Presenter:** EIGEN, Gerald (University of Bergen (NO))

**Session Classification:** Parallel 4: Experiments-discrete-symmetries
Theoretical status of $B \to K(\ast)mumu$ and New Physics.

*Thursday, 4 December 2014 15:30 (35 minutes)*

**Primary author:** Prof. JOAQUIM, Matias (Universitat Autonoma Barcelona)

**Presenter:** Prof. JOAQUIM, Matias (Universitat Autonoma Barcelona)

**Session Classification:** Parallel 1: Discrete symmetries (T, C, P), flavour, accidental symmetries
Order and Anarchy hand in hand in 5D SO(10)

Thursday, 4 December 2014 15:00 (30 minutes)

A mechanism to generate flavour hierarchy via 5D wave-function localization is revisited in the context of SO(10) grand unified theory. In an extra-dimension compactified on an orbifold, fermions (living in the same 16 representation of SO(10)) result having exponential zero-modes profiles. The breaking of SO(10) down to SU(5) \times U(1)_X provides the key parameter that distinguishes the profiles of the different SU(5) components inside the same 16 representation. Utilizing suitable scalar fields, a predictive model for fermion masses and mixing is constructed and shown to be viable with the current data through a detailed numerical analysis.

All the Yukawa couplings in the model are anarchical and of order unity, while the hierarchies among different fermions result only from zero-mode profiles. The naturalness of anarchical Yukawa couplings is studied, showing a preference for a normal ordered neutrino spectrum; predictions for various observables in the lepton sector are also derived. The scalar field content of the model is also suitable to solve the doublet-triplet splitting problem through the “missing partner” mechanism.

Primary authors: VICINO, Denise (INFN University of Padova); FERUGLIO, Ferruccio (Dipartimento di Fisica Galileo Galilei); PATEL, Ketan (Physical Research Laboratory)

Presenter: VICINO, Denise (INFN University of Padova)

Session Classification: Parallel 1: Discrete symmetries (T, C, P), flavour, accidental symmetries
We describe a new type of discrete symmetry that relates heterotic-string models. It is based on the spectral flow operator which is normally acting within a general $calN = (2, 2)$ model. We use this operator to construct a map between $calN = (2, 0)$ models. The landscape of $calN = (2, 0)$ models is of particular interest among all heterotic-string models for two important reasons:

1. $N = 1$ spacetime SUSY requires $(2, 0)$ superconformal invariance and
2. models with the minimal $SO(10)$ unification structure, which is well motivated by the Standard Model of particle physics data, are of this type.

This idea was inspired by a new discrete symmetry in the space of fermionic $Z_2 \times Z_2$ heterotic-string models that exchanges the spinors and vectors of the $SO(10)$ GUT group, dubbed spinor-vector duality. We will describe how to generalize this to arbitrary internal Rational Conformal Field Theories (RCFTs).

**Primary authors:** FARAGGI, Alon (U); GEPNER, Doron (Department of Particle Physics); ATHANASOPoulos, Panos

**Presenter:** ATHANASOPoulos, Panos

**Session Classification:** Parallel 14: Discrete Symmetries in Strings and in GUT theories
Flavour Effects in Resonant Leptogenesis from Semi-classical and Kadanoff-Baym Approaches

*Friday, 5 December 2014 17:00 (25 minutes)*

Flavour effects play an important role in the statistical evolution of particle number densities in several particle physics phenomena. We present a fully flavour-covariant formalism for transport phenomena, in order to consistently capture all flavour effects in the system. We explicitly study a Resonant Leptogenesis (RL) scenario, and show that flavour covariance requires one to consider generically off-diagonal number densities, rank-4 rate tensors in flavour space, and non-trivial generalization of the discrete symmetries $C$, $P$ and $T$.

The flavour-covariant transport equations, obtained in our semi-classical framework, describe the effect of three relevant physical phenomena: coherent heavy-neutrino oscillations, quantum decoherence in the charged-lepton sector, and the standard resonant $CP$ violation due to heavy-neutrino mixing. We show quantitatively that the final asymmetry is enhanced by up to an order of magnitude, for electroweak-scale heavy neutrinos, as compared to that obtained from flavour-diagonal or partially flavour off-diagonal equations.

A full field-theoretical treatment in the weakly-resonant regime, based on the so-called Kadanoff-Baym (KB) equations, confirms that heavy-neutrino oscillations and mixing are two *distinct* phenomena, and reproduces the results obtained in our semi-classical framework. Finally, we show that the quasi-particle ansätze, often employed in KB approaches to RL, discard the phenomenon of mixing, capturing only oscillations and leading to an underestimate of the final asymmetry by a factor of order 2.

**Primary authors:** PILAFTSIS, Apostolos (University of Manchester (GB)); DEV, Bhupal (University of Manchester); TERESI, Daniele (University of Manchester); Dr MILLINGTON, Peter (Technische Universität München (TUM))

**Presenter:** TERESI, Daniele (University of Manchester)

**Session Classification:** Parallel 8: Early universe Physics (Inflation, Lepto(Baryo)genesis)
Recent astrophysical observations are consistent with the existence of a secluded dark gauge sector weakly interacting with the Standard Model. The mass of the mediator, the so called dark photon, or U boson, is predicted to be at the GeV scale. Possible extensions of the minimal model lead to the introduction of a dark Higgs boson which, analogously to its Standard Model counterpart, breaks the gauge symmetry.

These new particles can be observed as sharp resonances in the invariant mass distribution of charged lepton or pion pairs in reactions of the type $e^+e^- \rightarrow l(\pi^+)l(\pi^-)\gamma$, in pseudoscalar meson decays or in associate production with a dark Higgs scalar.

KLOE searched for U boson production in phi meson dalitz decays and in $e^+e^- \rightarrow \mu^+\mu^-\gamma$ reaction, while preliminary results are available for electron positron final state and for the higgstrahlung channel.

No evidence of the process was found and tight upper limits were set to the relevant parameters.

**Primary author:** Dr BOSSI, fabio (INFN)

**Co-author:** Dr GRAZIANI, enrico (INFN)

**Presenter:** Dr GRAZIANI, enrico (INFN)

**Session Classification:** Parallel 4: Experiments-discrete-symmetries
Predictions for the Dirac Phase in the Neutrino Mixing Matrix

Using the fact that the neutrino mixing matrix $U = U_e^T U_\nu$, where $U_e$ and $U_\nu$ result from the diagonalisation of the charged lepton and neutrino mass matrices, and assuming 3-neutrino mixing, we consider a number of forms of $U_\nu$ associated with a variety of flavour symmetries: i) tri-bimaximal (TBM) and ii) bimaximal (BM) forms, the forms corresponding iii) to the conservation of the lepton charge $L' = L_e - L_\mu - L_\tau$ (LC), iv) to golden ratio type A (GRA) mixing, v) golden ratio type B (GRB) mixing, and vi) to hexagonal (HG) mixing. In this approach to neutrino mixing one obtains exact predictions for the Dirac phase $\delta$ in the neutrino mixing matrix if the matrix $U_e$ has a minimal form in terms of angles and phases it contains that can provide the requisite corrections to $U_\nu$ so that the reactor, atmospheric and solar neutrino mixing angles $\theta_{13}$, $\theta_{23}$ and $\theta_{12}$ have values compatible with the current data. The predictions for $\delta$ depend on the angles $\theta_{13}$, $\theta_{23}$ and $\theta_{12}$ and have also simple “leading order” and “next-to-leading order” approximate forms. We compare the exact predictions for $\delta$ with those obtained in the “leading order” approximation.

We investigate also the variation of the predictions of $\delta$ with the variation of the values of the neutrino mixing angles $\theta_{13}$, $\theta_{23}$ and $\theta_{12}$ in their $3\sigma$ experimentally allowed ranges.

Finally, we discuss other forms for the matrices $U_e$ and $U_\nu$ which allow us to derive exact predictions for the CP violation phase $\delta$. A measurement of $\cos \delta$ can allow to discriminate between the different forms of $U_e$ and $U_\nu$ considered in our study.

Primary authors: Mr TITOV, Arsenii (SISSA); Mr GIRARDI, Ivan (SISSA); Prof. PETCOV, Serguey (SISSA)

Presenter: Mr GIRARDI, Ivan (SISSA)

Session Classification: Parallel 2: Neutrinos mass and mixing, implications for astroparticle physics, dark matter searches
Aiming to discover neutrinoless double beta decay from $^{130}$Te, the CUORE experiment continues to make progress at Laboratori Nazionali del Gran Sasso (LNGS). CUORE-0, a 1/19 mass replica of CUORE, is a 52 bolometer array that continues to take data providing validation for the methods and strategies undertaken for CUORE. We will present the latest results from CUORE-0 and milestones achieved by the ongoing commissioning of CUORE. Furthermore, we will summarize R&D with bolometers for future generation double-beta decay experiments.

Primary author: HICKERSON, Kevin (UCLA)
Presenter: HICKERSON, Kevin (UCLA)
Session Classification: Parallel 10: LHC and dark matter experiments
Inflation in supergravity from massive vector multiplets

Friday, 5 December 2014 18:00 (30 minutes)

In a supergravity framework we present single field inflationary models built from massive vector multiplets. This property is due to an underlying stueckelberg mechanism where the second scalar partner of the inflaton is eaten by the massive vector. This mechanism can be used to built Starobinsky as well as chaotic models of inflation.

Primary author:  FARAKOS, Fotis
Presenter:  FARAKOS, Fotis
Session Classification:  Parallel 8: Early universe Physics (Inflation, Lepto(Baryo)genesis)
We discuss some recent applications of PT symmetry to fundamental physics. We show that the recognition (Bender and Mannheim) that fourth-order derivative theories are PT symmetric theories rather than Hermitian ones enables one to show that such theories are ghost free and unitary. This then permits the fourth-order derivative conformal gravity theory to be a consistent quantum theory of gravity. We show that the conformal gravity theory provides for a universal departure from Newtonian gravity on large distance scales, which enables us to universally fit (Mannheim and O’Brien) the galactic rotation curves of 141 galaxies without the need for any dark matter, and without the 282 free parameters (two per galactic halo) present in standard dark matter fits to the same set of galaxies. Finally we show that through the use of generalized geometric connections that are PT symmetric we are able to metricate the fundamental forces, to thus both complete and generalize Weyl’s original attempt to provide a geometric origin to electromagnetism based on utilizing and extending to gravity the underlying conformal structure that electromagnetism possesses.

Phenomenology of Light Sterile Neutrinos

Wednesday, 3 December 2014 15:00 (30 minutes)

I review the experimental indications in favor of short-baseline neutrino oscillations. I discuss their interpretation in the framework of neutrino mixing schemes with one or more sterile neutrinos which have masses around the eV scale. Taking into account also cosmological constraints, I present arguments in favor of 3+1 neutrino mixing with one sterile neutrino at the eV scale. I discuss the implications for neutrinoless double-beta decay and cosmology.

Primary author: GIUNTI, Carlo (INFN)
Co-author: LAVEDER, Marco (Dipartimento di Fisica Galilei Galilei)
Presenter: LAVEDER, Marco (Dipartimento di Fisica Galilei Galilei)
Session Classification: Parallel 2: Neutrinos mass and mixing, implications for astroparticle physics, dark matter searches
A first measurement of T asymmetries that are not also CP asymmetries has been recently achieved by the BaBar collaboration. We analyze the measured asymmetries in the presence of direct CP violation, CPT violation, wrong strangeness decays and wrong sign semileptonic decays. We introduce parameters that have well-defined transformation properties under CP, T and CPT, and identify contributions to the measured asymmetries that are T conserving. We explain why, in order that the measured asymmetries would be purely odd under time-reversal, there is no need to assume the absence of direct CP violation. Instead, one needs to assume (i) the absence of CPT violation in strangeness changing decays, and (ii) the absence of wrong sign decays.

**Primary author:** EFRATI, Aielet (W)

**Presenter:** EFRATI, Aielet (W)

**Session Classification:** Parallel 1: Discrete symmetries (T, C, P), flavour, accidental symmetries
The density of states approach for the simulation of finite density quantum field theories

Thursday, 4 December 2014 14:30 (35 minutes)

Finite density quantum field theories have evaded first principle Monte-Carlo simulations due to the notorious sign-problem. The partition function of such theories appears as the Fourier transform of the generalised density-of-states, which is the probability distribution of the imaginary part of the action. With the advent of Wang-Landau type simulation techniques and recent advances [1], the density-of-states can be calculated over many hundreds of orders of magnitude. Current research addresses the question whether the achieved precision is high enough to reliably extract the finite density partition function, which is exponentially suppressed with the volume. In my talk, I review the state-of-play for the high precision calculations of the density-of-states as well as the recent progress for obtaining reliable results from highly oscillating integrals. I will review recent progress for $Z_3$ and $\phi^4$ quantum field theories for which results can be obtained from the simulation of the dual theory, which appears to free of a sign problem.


**Primary author:** LANGFELD, Kurt (Plymouth University)

**Co-authors:** RAGO, Antonio (Plymouth University); LUCINI, Biagio (Swansea University); BONGIOVANNI, Lorenzo (Swansea University); PELLEGRINI, Roberto (University of Edinburgh)

**Presenter:** LANGFELD, Kurt (Plymouth University)

**Session Classification:** Parallel 5: Strongly coupled gauge theories
Prospects for K+ -> pi+ nu nu observation at CERN in NA62

Thursday, 4 December 2014 16:35 (30 minutes)

The rare decays K+ -> pi+ nu nu are excellent processes to make tests of new physics at the highest scale complementary to LHC thanks to their theoretically cleaness.

The NA62 experiment at CERN SPS aims to collect of the order of 100 events in two years of data taking, keeping the background at the level of 10%.

Part of the experimental apparatus has been commissioned during a technical run in 2012. The physics prospects and the status of the experiment will be reviewed in light of the first physics run in October-December 2014.

Primary authors: LAZZERONI, Cristina (University of Birmingham (GB)); HAHN, Ferdinand (CERN)

Presenter: HAHN, Ferdinand (CERN)

Session Classification: Parallel 4: Experiments-discrete-symmetries
Precision tests of the Standard Model with kaon decays at CERN

Thursday, 4 December 2014 18:55 (25 minutes)

Recent results and prospects for precision tests of the Standard Model in kaon decay in flight experiments at CERN are presented. A measurement of the ratio of leptonic decay rates of the charged kaon at a 0.4\% precision constrains the parameter space of new physics models with extended Higgs sector, a fourth generation of quarks and leptons or sterile neutrinos.

Searches for heavy neutrino mass states and the dark photon in the \(\sim 100 \text{ MeV} / c^2\) mass range based on samples collected in 2003-2007 are in progress and prospects will be discussed. The NA62 experiment starting in 2014 will search for a range of lepton number and lepton flavour violating decays of the charged kaon and the neutral pion at improved sensitivities down to \(10^{-12}\), which will probe new physics scenarios involving heavy Majorana neutrinos or R-parity violating SUSY.

Primary authors: LAZZERONI, Cristina (University of Birmingham (GB)); MASSRI, Karim (University of Birmingham (GB))

Presenter: MASSRI, Karim (University of Birmingham (GB))

Session Classification: Parallel 4: Experiments-discrete-symmetries
ChiPT tests at NA48 and NA62 experiments at CERN

Thursday, 4 December 2014 15:05 (30 minutes)

New final results from an analysis of about 400 $K^+ \rightarrow \pi^+ \gamma \gamma$ rare decay candidates collected by the NA48/2 and NA62 experiments at CERN during low intensity runs with minimum bias trigger configurations are presented. The results include a model-independent decay rate measurement and fits to Chiral Perturbation Theory (ChPT) description. The data support the ChPT prediction for a cusp in the di-photon invariant mass spectrum at the two pion threshold.

Primary authors: Lazzeroni, Cristina (University of Birmingham (GB)); Lenti, Massimo (Università e INFN (IT))

Presenter: Lenti, Massimo (Università e INFN (IT))

Session Classification: Parallel 4: Experiments-discrete-symmetries
Recent results from the OPERA experiment at the CNGS beam

Friday, 5 December 2014 17:00 (30 minutes)

The OPERA experiment at the Gran Sasso underground laboratory is searching for \( \nu_{\mu} \rightarrow \nu_{\tau} \) oscillations in appearance mode in the CNGS neutrino beam. Four \( \nu_{\tau} \) candidate events have been found so far, using a sub-sample of data from the 2008-2012 runs. Given the number of analysed events and the low background, \( \nu_{\mu} \rightarrow \nu_{\tau} \) oscillations are established with a significance of 4.2 sigma. In the talk the data analysis will be discussed, with emphasis on the background constraints obtained by using dedicated data-driven control samples. We will also present an analysis of the present tau neutrino and electron neutrino sample in the framework of the 3+1 sterile model. The analysis of the muon charge ratio in the cosmic ray sample will be also covered.

Primary author: Dr LONGHIN, Andrea (on behalf of the OPERA Coll.) (INFN Laboratori Nazionali di Frascati)

Presenter: Dr LONGHIN, Andrea (on behalf of the OPERA Coll.) (INFN Laboratori Nazionali di Frascati)

Session Classification: Parallel 12: Neutrino Experiments
Lorentz symmetry breaking: phenomenology and constraints

Friday, 5 December 2014 11:45 (45 minutes)

In this talk I shall review several motivations for considering departures from exact Lorentz invariance and the different theoretical frameworks adopted to describe these departures. Among these, I shall focus on an effective field theory approach and discuss the phenomenology and constraints of Lorentz symmetry breaking in the Standard Model as well as in Gravity. In particular I will focus on current constraints on UV breaking inspired by quantum gravity scenarios and briefly discuss the open issues and future perspectives for this field of research.

Primary author: LIBERATI, Stefano (SISSA)
Presenter: LIBERATI, Stefano (SISSA)
Session Classification: PLENARY 4
The Yang-Mills vacuum wave-functional thirty-five years later

Wednesday, 3 December 2014 14:30 (35 minutes)

Beside anniversaries of the important discoveries celebrated at this workshop, there is another worth to mention: The first paper attempting direct calculation of the Yang-Mills vacuum wave-functional was published in 1979 [J. Greensite, Nucl. Phys. B158 (1979) 469]. I will review some recent results of the determination of the vacuum wave-functional in Monte Carlo simulations of SU(2) lattice gauge theory.

Primary author: OLEJNIK, Stefan (Institute of Physics, Slovak Acad. Sci., Bratislava)
Presenter: OLEJNIK, Stefan (Institute of Physics, Slovak Acad. Sci., Bratislava)
Session Classification: Parallel 5: Strongly Coupled gauge Theories
Recent results from ALICE and future prospects

Thursday, 4 December 2014 17:30 (30 minutes)

During the first LHC run the ALICE experiment collected data from pp, p-Pb and Pb-Pb collision systems. A selection of recent results will be presented, including those which focus on characterisation of the deconfined system formed in heavy-ion collisions. The future prospects for Run 2 and for the upgrade of ALICE beyond that will also be discussed.

Primary author: BARNBY, Lee (University of Birmingham (GB))
Presenter: BARNBY, Lee (University of Birmingham (GB))
Session Classification: Parallel 10: LHC and dark matter experiments
The GERDA Experiment for the Search of Neutrinoless Double Beta Decay

Friday, 5 December 2014 17:30 (30 minutes)

\textit{Gerda} is designed to search for the neutrinoless double beta (0νββ) decay, a lepton number violating process. It employs bare high-purity germanium diodes enriched to 86\% in 76 Ge directly immersed in liquid argon. Phase-I operated till May 2013 with a mean background of 1·10^{-2}\text{cts/(keV·kg·yr)} near the Q-value. GERDA sets a new lower limit of $T_{1/2} > 2.1 \times 10^{25}$ yr (90\% C.L.) strongly disfavouring the long-standing claim of signal observation. For Phase-II, exploring half-lives up to $1.5 \times 10^{26}$ yr, additional 20 kg of broad-energy Ge detectors will be installed in late 2014. An order of magnitude lower background will be achieved with an active liquid Ar veto and pulse shape analysis. The liquid Ar veto is a hybrid system of wavelength shifting fibres read out by silicon photomultipliers on the one hand and wavelength shifting reflector foils with (vacuum) PMTs on the other hand.

Primary author: WALTER, Manuel (University of Zurich)

Presenter: WALTER, Manuel (University of Zurich)

Session Classification: Parallel 12: Neutrino Experiments
Tests of Lorentz and CPT invariance with neutrinos and photons

Wednesday, 3 December 2014 15:00 (30 minutes)

Lorentz symmetry is a cornerstone of modern physics. As the spacetime symmetry of special relativity, Lorentz invariance is a basic component of the standard model of particle physics and general relativity, which to date constitute our most successful descriptions of nature. Deviations from exact symmetry would radically change our view of the universe and current experiments allow us to test the validity of this assumption. In this talk, I will describe how we can use neutrinos and photons to search for deviations from exact Lorentz and CPT invariance.

Primary author:  DIAZ, Jorge S.
Presenter:       DIAZ, Jorge S.
Session Classification:  Parallel 1: Discrete symmetries (T, C, P), flavour, accidental symmetries
Rare decays at LHCb

Thursday, 4 December 2014 15:35 (30 minutes)

LHCb is a forward spectrometer covering a unique rapidity range at the LHC and with excellent capability to detect decays of heavy flavour mesons. LHCb has recorded an integrated luminosity of 3 fb⁻¹ of proton-proton collisions during 2011 and 2012. Recent results from the LHCb in rare decays of beauty and charm mesons are shown.

Primary author: SOOMRO, Fatima (Ecole Polytechnique Federale de Lausanne (CH))
Presenter: SOOMRO, Fatima (Ecole Polytechnique Federale de Lausanne (CH))
Session Classification: Parallel 4: Experiments–discrete–symmetries
Thermal Duality and Gravitational Collapse

Thermal duality is a relationship between the behaviour of heterotic string models of the E(8)xE(8) or SO(32) types at inversely related temperatures, a variant of T duality in the Euclidean regime. This duality would have consequences for the nature of the Hagedon transition in these string models. We propose that the vacuum admits a family of deformations in situations where there are closed surfaces of constant area but high radial acceleration (a ‘string regularized’ version of a Penrose trapped surface), such as would be formed in situations of extreme gravitational collapse. This would allow a radical resolution of the ‘firewall paradox’ by allowing quantum effects to significantly modify the spacetime geometry around a collapsed object. A ‘string bremsstrahlung’ process would convert the kinetic energy of infalling matter in extreme gravitational collapse to form a region of the deformed vacuum, which would be equivalent to forming a high temperature string phase. A notable feature of this scenario is that the spectrum of final states would respect time reversal (T) symmetry, unlike conventional black holes. This process might have observable consequences for charged particles falling into a rotating collapsed object by producing high energy particles via a variant of the Penrose process.

Primary author: HEWITT, Mike (Canterbury Christ Church University)
Presenter: HEWITT, Mike (Canterbury Christ Church University)
Session Classification: Parallel 7: Supersymmetry, Supergravity, Strings and Branes
Quantum Entanglement between the two neutral mesons produced in meson factories has allowed the first direct observation of Time-Reversal-Violation in the time evolution of the B neutral meson system between the two decays. The exceptional meson transitions are directly connected to semileptonic and CP-eigenstate decay channels. The possibility of extending the observable asymmetries to more decay channels confronts the problem of the “orthogonality condition”, which can be stated with this tongue-twister: Given a decay channel $f$, which is the decay channel $f'$ such that the meson state not going to $f'$ is orthogonal to the meson state not going to $f$? We propose an alternative T-Violation Asymmetry in the meson factories which allows its opening to any pair of decay channels.
New Measurements of the $\pi^+ \to e^+ \nu_e$ Branching Ratio

Tuesday, 2 December 2014 15:15 (30 minutes)

Study of rare decays is an important approach to search for new physics beyond the Standard Model. The branching ratio of charged pion decays, $R = \Gamma(\pi^+ \to e^+ \nu_e(\gamma))/\Gamma(\pi^+ \to \mu^+ \nu_\mu(\gamma))$ is one of the most precisely calculated processes involving quarks with $R_{SM} = (1.2352 \pm 0.0001) \times 10^{-4}$. Precise measurement of $R$ provides one of the most stringent tests of the hypothesis of electron-muon universality in weak interactions. The current experimental values of the branching ratio are $R_{EXP} = (1.2265 \pm 0.0034(stat) \pm 0.0044(syst)) \times 10^{-4}$ (TRIUMF, 1992) and $R_{EXP} = (1.3346 \pm 0.0035(stat) \pm 0.0036(syst)) \times 10^{-4}$ (PSI, 1993), which indicate that there is a room for improvement by two orders of magnitude in precision. The goal of PIENU experiment at TRIUMF is to improve the accuracy of the branching ratio measurement by a factor of 5, to $< 0.1\%$. This precision allows potential access to new physics up to the mass scale of 1000 TeV for pseudoscalar interactions. Examples of the new physics probed include R-parity violating SUSY, heavy neutrino mixing, excited gauge bosons, leptoquarks, compositeness, and the effects of charged Higgs bosons.

The PIENU experiment collected about $4.5 \times 10^3 \pi^+ \to e^+ \nu_e$ events, which corresponds to about 30 times higher statistics than in the previous TRIUMF experiment. The time and energy of decay positrons from decays of pions at rest were measured in a spectrometer employing plastic scintillators, tracking detectors, and NaI(Tl) and pure CsI crystals. The branching ratio is obtained from the ratio of the positron yields from $\pi^+ \to e^+ \nu_e$ decays ($E_e = 69.8$ MeV) and $\pi^+ \to \mu^+ \nu_\mu$ decays followed by $\mu^+ \to e^+ \nu_e \overline{\nu_\mu}$ decays ($\pi^+ \to \mu^+ \to e^+$, $E_e = 0.5$ to 52.8 MeV). Two energy regions, above and below the $\pi^+ \to \mu^+ \to e^+$ distribution were used to determine the time spectra of decay positrons. Data in the two regions are fitted simultaneously to extract the branching ratio to which corrections are applied. The most important corrections resulting in systematic uncertainties include the $\pi^+ \to e^+ \nu_e$ low energy distribution in the calorimeter due to shower leakage and the difference of positron acceptances between $\pi^+ \to e^+ \nu_e$ and $\pi^+ \to \mu^+ \to e^+$ events. The current analysis corresponds to approximately 10% of the statistics of the full data. Results will be presented.
Vancouver, B.C. V6T 2A3, Canada); MISCHE, Richard (TRIUMF, 4004 Wesbrook Mall, Vancouver, B.C. V6T 2A3, Canada); CUEN-ROCHIN, Saul (University of British Columbia, Vancouver, B.C. V6T 1Z1, Canada); CHEN, Shaomin (Tsinghua University, Beijing, 100084, China); NUMAO, Toshio (TRIUMF, 4004 Wesbrook Mall, Vancouver, B.C. V6T 2A3, Canada); SULLIVAN, Tristan (University of British Columbia, Vancouver, B.C. V6T 1Z1, Canada); IGARASHI, Youichi (KEK, 1-1 Oho, Tsukuba-shi, Ibaraki, 305-0801, Japan); KETTELL, steve (Brookhaven National Laboratory, Upton, NY 11973-5000, USA)

**Presenter:** ITO, Shintaro (Osaka University, Toyonaka, Osaka, 560-0043, Japan)

**Session Classification:** Parallel 4: Experiments-discrete-symmetries
Neutrino mass hierarchy determination with PINGU

Tuesday, 2 December 2014 18:10 (30 minutes)

This work is being performed in collaboration with E. Lisi (INFN, Bari, Italy) and F. Capozzi (U. of Bari, Italy). The proposed PINGU experiment (Precision IceCube Next Generation Upgrade) will study low energy atmospheric neutrinos and it will allow to probe the neutrino mass hierarchy, after 3-5 years of data taking. It will also be sensitive to the theta_23 octant and it will help to resolve some degeneracies between neutrino oscillation parameters. We study the robustness of PINGU predictions with respect to a large variety of systematic uncertainties, including energy and angle resolution systematic errors and spectrum shape uncertainties, and we quantitatively determine the impact of such uncertainties on the hierarchy discrimination.

Primary author: MARRONE, Antonio (Univ. of Bari)

Presenter: MARRONE, Antonio (Univ. of Bari)

Session Classification: Parallel 2: Neutrino mass and mixing, implications for astroparticle physics, dark matter searches
Lepton number violation in non-standard Higgs sectors

Thursday, 4 December 2014 16:35 (30 minutes)

We consider the phenomenology of extended Higgs sectors that allow the neutrino masses to be Majorana. This means that the extra scalars do violate lepton number. For that purpose, we classify them using an effective field theory approach. Then, using appropriate current ATLAS and CMS analyses we set the first bounds on lepton number violation in the scalar sector. We also describe how to measure the quantum numbers of the corresponding scalar fields if they were detected in a second phase of the LHC running.

Primary authors: Prof. DEL AGUILA, Francisco (University of Granada (ES)); Dr CHALA, Mikael (DESY)

Presenter: Dr CHALA, Mikael (DESY)

Session Classification: Parallel 9: Higgs Physics @ LHC, discrete symmetries @LHC, new facilities
Discrete Abelian Gauge Symmetries and Axions

Friday, 5 December 2014 18:00 (30 minutes)

As recently observed, discrete Abelian symmetries can remain as remnants in the low-energy effective action of string compactifications with massive U(1) symmetries. As I will discuss in this talk, the Peccei-Quinn symmetry arises naturally in this way in D-brane models with the QCD axion as an open string excitation and several other (invisible) axions from both the open and closed string sectors.

**Primary author:** HONECKER, Gabriele (Johannes Gutenberg University Mainz)

**Presenter:** HONECKER, Gabriele (Johannes Gutenberg University Mainz)

**Session Classification:** Parallel 7: Supersymmetry, Supergravity, Strings, Branes
Foldy-Wouthuysen transformation for a non-Hermitian Hamiltonian

Tuesday, 2 December 2014 18:50 (30 minutes)

I will show the consistency of a non-Hermitian Lagrangian describing free fermions, and perform the Foldy-Wouthuysen transformation in order to map the Hamiltonian on a Hermitian one.

Primary author:  ALEXANDRE, Jean (King’s College London)
Co-author:  BENDER, Carl (W)
Presenter:  ALEXANDRE, Jean (King’s College London)
Session Classification:  Parallel 3: PT symmetric quantum theory
Anomaly-free chiral fermion sets and gauge coupling unification

Wednesday, 3 December 2014 18:45 (30 minutes)

We look for minimal chiral sets of fermions beyond the Standard Model that are anomaly-free and, simultaneously, vector-like particles with respect to color SU(3) and electromagnetic U(1). We then study whether the addition of such particles to the Standard Model particle content allows for the unification of gauge couplings at a high energy scale, above $5.0 \times 10^{15}$ GeV so as to be safely consistent with proton decay bounds. The possibility to have unification at the string scale is also considered. Inspired in grand unified theories, we also search for minimal chiral fermion sets that belong to SU(5) multiplets, restricted to representations up to dimension 50. It is shown that, in various cases, it is possible to achieve gauge unification provided that some of the extra fermions decouple at relatively high intermediate scales.

Primary authors: SIMÕES, Catarina (IFPA, University of Liège); Dr EMMANUEL-COSTA, David (CFTP, Instituto Superior Técnico); CEBOLA, Luís (CFTP, Instituto Superior Técnico); Dr GONZÁLEZ FELIPE, Ricardo (Instituto Superior de Engenharia de Lisboa and CFTP, Instituto Superior Técnico)

Presenter: SIMÕES, Catarina (IFPA, University of Liège)

Session Classification: Parallel 14: Discrete Symmetries in Strings and in GUT theories
Two invisible axion models with a non-minimal flavor structure

Wednesday, 3 December 2014 18:20 (30 minutes)

In this talk I will present two invisible axion model implementations. The first one consists in an ultraviolet completion of the so-called aligned two-Higgs-doublet model that solves the strong CP problem. I will show that, for certain decoupling scenarios, mixing effects among the scalar fields allow for the possibility to obtain a rich scalar sector at the weak scale.

The second model implementation is given by a class of invisible axion models with Flavour Changing Neutral Currents at tree-level controlled by the fermion mixing matrices. In this model, the PQ symmetry is constructed as a horizontal symmetry which provides a solution to the Strong CP problem and gives rise to a rich phenomenology. The presence of Flavour Changing Axion Interaction and the possibility to avoid the domain wall problem stand as the main features of this class of models.

Right-handed neutrinos are also introduced to account for the smallness of active neutrinos masses via a Type I see-saw mechanism that relates the PQ symmetry breaking and the see-saw scales. Experimental limits on the axion couplings will also be discussed.

Primary authors: CELIS, Alejandro (IFIC CSIC-Universitat de Valencia); SERODIO, Hugo (Korea Advanced Institute of Science and Technology, Department of Physics); FUENTES-MARTÍN, Javier (IFIC University of Valencia-CSIC)

Presenter: FUENTES-MARTÍN, Javier (IFIC University of Valencia-CSIC)

Session Classification: Parallel 1: Discrete symmetries (T, C, P), flavour, accidental symmetries
Hadron properties using Dyson-Schwinger and Bethe-Salpeter equations

Thursday, 4 December 2014 15:05 (35 minutes)

The combination of Dyson-Schwinger and Bethe-Salpeter equations allows, in principle, for an ab-initio continuum-QCD study of hadrons and their properties. Glueballs, mesons, baryons, etc. are all treated in a unified framework. Moreover it has the advantage that that it gives access to all momentum regimes and all quark masses, connecting the deep infrared to perturbative QCD and light- and heavy-quark physics.

The major downside is, however, the necessity of truncating both Dyson-Schwinger and Bethe-Salpeter equations to make the problem tractable. However, guided by symmetries such as Poincare invariance, chiral symmetry, etc. one can define a systematic procedure to successively incorporate interaction terms in the calculations. The purpose of the presentation is to discuss this procedure as well as to illustrate it with some selected results.

Primary author: Dr SANCHIS ALEPUZ, Héliois (Justus-Liebig University Giessen)

Co-author: Dr WILLIAMS, Richard (Justus-Liebig University Giessen)

Presenter: Dr SANCHIS ALEPUZ, Héliois (Justus-Liebig University Giessen)

Session Classification: Parallel 5: Strongly coupled gauge theories
Recent BaBar results

Tuesday, 2 December 2014 17:00 (30 minutes)

We present a selection of recent results obtained by using the data collected with the BaBar detector at the PEP-II e+e- B-factory, with particular emphasis on measurements probing the discrete symmetries in beauty and charm decays. These include the measurements of partial decay rates and CP asymmetries of the inclusive decays $B \rightarrow X_s l^+ l^-$ and $B \rightarrow X_s \gamma$; searches for lepton number violation in several $B^+ \rightarrow X^- l^+ l^+$ decays (where $l = e, \mu$ and $X^-$ is a charged hadron); and studies of semi-leptonic decays to measure the sides of the Unitarity Triangle.

Primary authors: ANULLI, Fabio (Università e INFN, Roma I (IT)); EIGEN, Gerald (University of Bergen (NO))

Presenter: EIGEN, Gerald (University of Bergen (NO))

Session Classification: Parallel 4: Experiments-discrete-symmetries
Natural Standard Model Alignment in the Two Higgs Doublet Model

Thursday, 4 December 2014 15:30 (30 minutes)

In order to satisfy the current LHC Higgs data, which require the couplings of the observed 125 GeV Higgs boson to be close to the Standard Model (SM) expectations, any extended Higgs sector must lead to the so-called SM 'alignment limit'. In the context of the Two Higgs Doublet Model (2HDM), this alignment is often associated with either decoupling of the heavy Higgs sector or accidental cancellations in the 2HDM potential. In this talk, we present a symmetry justification for 'natural' alignment without decoupling or fine-tuning. We show that there exist only three different symmetry realizations which could lead to a natural alignment. We discuss some phenomenological implications of the Maximally-Symmetric 2HDM and propose new collider signals for the heavy Higgs sector, which could be searched for during the Run-II phase of the LHC.

Primary author: DEV, Bhupal (University of Manchester)

Co-author: PILAFTSIS, Apostolos (University of Manchester (GB))

Presenter: DEV, Bhupal (University of Manchester)

Session Classification: Parallel 9: Higgs physics @ LHC, discrete symmetries @ LHC, new facilities
Gravitino condensation, supersymmetry breaking and inflation

Friday, 5 December 2014 18:30 (30 minutes)

Supersymmetry is a well motivated theoretical paradigm, which, if it exists, must be broken at low energies. As such, understanding the origin of this breaking is key in order to make contact with known phenomenology.

To this end we detail a non-pertubative breaking mechanism for local supersymmetry in gravitino condensation, an approach which we demonstrate also provides a UV motivated, phenomenologically viable inflationary mechanism at no added cost.

We present results establishing contact between this scenario and known phenomenology, and discuss future avenues for research.

Primary author: HOUSTON, Nick (KCL)
Presenter: HOUSTON, Nick (KCL)
Session Classification: Parallel 8: Early universe Physics (Inflation, Lepto(Baryo)genesis)
Tree level Baryogenesis through Leptogenesis from Kalb-Ramond Torsion Background

Friday, 5 December 2014 17:25 (30 minutes)

We consider a model of an expanding Universe in string theory that yields CPT violation for fermions, in the sense of different dispersion relations for fermions and antifermions. These are induced by a cosmological background with constant torsion provided by the Kalb–Ramond anti-symmetric tensor field (axion) of the string gravitational multiplet. This effect induces different densities of neutrinos and antineutrinos while in chemical equilibrium, offering new scenarios for leptogenesis and baryogenesis even in the absence of CP violation. Leptogenesis effects are visible at tree level and are discussed.

Primary author: SARKAR, sarben (King’s College London)

Co-authors: DE CESARE, Marco (King’s College London); Prof. MAVROMATOS, Nikolaos (King’s College London)

Presenter: SARKAR, sarben (King’s College London)

Session Classification: Parallel 8: Early universe Physics (Inflation, Lepto(Baryo)genesis)
Negative-Frequency Modes in Quantum Field Theory

Wednesday, 3 December 2014 15:40 (30 minutes)

We illustrate a number of interesting features of a nominal departure from standard quantum field theory, constructed so as to permit momentum eigenstates of both positive and negative energy. Postulating an additional discrete symmetry of the free field theory under the interchange of positive- and negative-frequency modes, we show that one can obtain tree-level source-to-source amplitudes that are manifestly causal, whilst being consistent with the standard S-matrix results. In addition, we highlight intriguing possibilities for both the naturalness and cosmological constant problems. Finally, we draw attention to potential issues with perturbative unitarity and Bloch-Nordsieck cancellation, commenting on a possible solution provided by resonance phenomena and the breakdown of naive perturbation theory. As a non-trivial example, we recover the Peskin-Takeuchi parametrization of the oblique corrections of the standard electroweak theory.

Primary authors: FORSHAW, Jeffrey (University of Manchester); Dr MILLINGTON, Peter (Technische Universität München (TUM)); Dr DICKINSON, Robert (Univeristy of Manchester)

Presenter: Dr MILLINGTON, Peter (Technische Universität München (TUM))

Session Classification: Parallel 5: Strongly Coupled gauge Theories
SUMMARY OF THE LATEST RESULTS AND FUTURE PROSPECTS FROM THE T2K EXPERIMENT

Friday, 5 December 2014 16:30 (30 minutes)

The T2K long-baseline experiment is located in Japan and is designed to study oscillations of muon neutrinos. T2K receives a beam of muon neutrinos peaked at 0.6 GeV that are produced at J-PARC accelerator complex by converting a beam of 30-GeV protons hitting a graphite target. Upon travelling 295 km, neutrinos are detected by the Super-Kamiokande water Cherenkov detector. Located at 280 m from the target, the near detector complex (ND280) provides information about un-oscillated neutrino flux, direction and interaction cross-sections. The T2K experiment observed electron neutrino appearance at Super-K with the significance of 7.3σ and measured the associated oscillation parameter θ13 for both normal and inverted mass hierarchies. In addition, by looking at muon neutrino disappearance T2K provided improved measurements of the θ23 and Δm232 parameters. The results of these measurements are presented as well as a brief summary of the neutrino cross section measurements. Future prospects of the T2K experiment are discussed.

Primary author:  Dr PETROV, Yevgeniy (University of British Columbia, for the T2K collaboration)

Presenter:  Dr PETROV, Yevgeniy (University of British Columbia, for the T2K collaboration)

Session Classification:  Parallel 12: Neutrino Experiments
On the origin of neutrino oscillations through Lorentz violation

Tuesday, 2 December 2014 19:10 (30 minutes)

We propose Lorentz invariance violating models to study the possibility of dynamical generation of neutrino masses and oscillations. We show that such models are consistent with both Majorana and Dirac neutrinos and that the only observable effects are the dynamical generation of neutrino masses and oscillations.

Primary author: LEITE, Julio
Presenter: LEITE, Julio
Session Classification: Parallel 2: Neutrino mass and mixing, implications for astroparticle physics, dark matter searches
We consider the evolution operator of a quantum system described by a time-dependent Hamiltonian that is invariant under time reversal. As an illustration we examine the three-neutrino oscillations in a medium with a density profile which is symmetrical about the midpoint of the neutrino trajectory. The evolution operator is written as the product of factors corresponding to effective two-neutrino problems for a low and a high energy regime and each factor determined by means of the Magnus approximation up to second order. Oscillation probabilities calculated in this manner for the case of atmospheric neutrinos traversing Earth show good agreement with numerical calculations.

**Primary author:** Dr D’OLIVO, Juan Carlos (Depto. de Física Teórica, Universidad de Valencia)

**Presenter:** Dr D’OLIVO, Juan Carlos (Depto. de Física Teórica, Universidad de Valencia)

**Session Classification:** Parallel 2: Neutrinos mass and mixing, implications for astroparticle physics, dark matter searches
Numerical results for gauge theories near the conformal window

Thursday, 4 December 2014 17:10 (35 minutes)

A novel strong interaction beyond the standard model could provide a dynamical explanation of electroweak symmetry breaking. Experimental results strongly constrain properties of models that realise this mechanism. Whether these constraints are obeyed by any strongly interacting quantum field theory is a non-perturbative problem that needs to be addressed by first-principle calculations. Monte Carlo simulations of lattice regularised gauge theories is a powerful tool that enables us to address this question. Recently various lattice investigations have appeared that have studied candidate models of strongly interacting dynamics beyond the standard model. After a brief review of the main methods and of some recent results, we focus on the analysis of SU(2) gauge theory with one adjoint Dirac fermion flavour, which is shown to have a near-conformal behaviour with an anomalous dimension of order one. The implications of our findings are also discussed.

Primary author: LUCINI, Biagio (Swansea University)
Presenter: LUCINI, Biagio (Swansea University)
Session Classification: Parallel 5: Strongly coupled gauge theories
Although additional low scale U(1)s have been discussed extensively in SUSY GUTs and superstring models, having a viable light, extra U(1) in worldsheet heterotic string constructions has proven to be a challenge. Here, we present the construction of heterotic string models using the free fermionic formulation and focus on how viable U(1)s may arise. We motivate an example as an appealing proposition to explain the suppression of proton decay mediating operators, induced in supersymmetric models. The additional symmetry forbids the undesired operators, and therefore must be light to accommodate proton lifetime constraints. We discuss and contrast two classes of superstring models with a desirable additional U(1): those with charges embedded in E6 and those without embedding. We show that the gauge coupling data at the electroweak scale necessitate that the Z’ charges are embeddable in E6 but that anomaly free U(1) combinations require no such embedding. We present a recipe of how enhancement may circumvent this conundrum and construct a standardlike model with desirable properties.

Primary author: MEHTA, Viraf (Ruprecht-Karls Universität Heidelberg)

Co-authors: FARAGGI, Alon (U); ATHANASOPOULOS, Panos

Presenter: MEHTA, Viraf (Ruprecht-Karls Universität Heidelberg)

Session Classification: Parallel 7: Supersymmetry, Supergravity, Strings, Branes
Non-minimally flavour violating dark matter

Wednesday, 3 December 2014 15:30 (30 minutes)

Flavour symmetries provide an appealing mechanism to stabilize the dark matter particle. I present a simple model of quark flavoured dark matter that goes beyond the framework of minimal flavour violation. I discuss the phenomenological implications for direct and indirect dark matter detection experiments, high energy collider searches as well as flavour violating precision data.

Primary author: BLANKE, Monika (CERN)
Presenter: BLANKE, Monika (CERN)
Session Classification: Parallel 1: Discrete symmetries (T, C, P), flavour, accidental symmetries
Effects of divergent ghost loops on the Green’s functions of QCD

Thursday, 4 December 2014 17:50 (35 minutes)

I discuss certain characteristic features encoded in some of the fundamental QCD Green’s functions, whose origin can be traced back to the (Landau gauge) nonperturbative masslessness of the ghost field. Specifically, the ghost loops that contribute to these Green’s functions display infrared divergences, akin to those encountered in the perturbative treatment, in contradistinction to the gluonic loops, whose perturbative divergences are tamed by the dynamical generation of an effective gluon mass. In d=4, the aforementioned divergences are logarithmic, thus causing a relatively mild impact, whereas in d=3 they are linear, giving rise to enhanced effects. In the case of the gluon propagator, these effects do not interfere with its finiteness, but make its first derivative diverge at the origin, and introduce a maximum in the region of infrared momenta. The three-gluon vertex is also affected, and the induced divergent behavior is clearly exposed in certain special kinematic configurations, usually considered in lattice simulations; the sign of the corresponding divergence is unambiguously determined. The picture that emerges is finally compared to the available lattice data.

Primary author: BINOSI, Daniele (ECT* Fondazione Bruno Kessler)
Presenter: BINOSI, Daniele (ECT* Fondazione Bruno Kessler)
Session Classification: Parallel 5: Strongly coupled gauge theories
Universality of radiative corrections to gauge couplings for strings with spontaneously broken supersymmetry

I will present recent work on computing radiative corrections to non-abelian gauge couplings in four-dimensional heterotic vacua with spontaneously broken supersymmetry. They may be considered as K3 surfaces with additional Scherk-Schwarz fluxes responsible for the spontaneous $N=4 \rightarrow N=0$ breaking. Remarkably, although the gauge thresholds are no longer BPS protected and receive contributions also from the excitations of the RNS sector, we find that their difference is still BPS saturated and exhibits a universal behaviour. Contrary to the case of unbroken supersymmetry, the non-abelian gauge thresholds develop infrared logarithmic singularities due to charged BPS-like states originating from the twisted RNS sector becoming massless at special points of the classical moduli space.

Primary author: FLORAKIS, Ioannis (CERN)
Presenter: FLORAKIS, Ioannis (CERN)
Session Classification: Parallel 7: Supersymmetry, Supergravity, Strings, Branes
Laser spectroscopy of metastable antiprotonic and pionic helium atoms

Friday, 5 December 2014 18:34 (30 minutes)

The ASACUSA collaboration at CERN carries out two-photon laser spectroscopy of metastable antiprotonic helium atoms, which are three-body systems composed of a helium nucleus, an antiproton, and an electron. By measuring the transition frequencies of this atom and comparing the results with three-body QED calculations, the antiproton-to-electron mass ratio was determined to a precision of 1.4 parts per billion. We also describe the PiHe collaboration, which aims to measure the transition frequencies of pionic helium atoms using the 590-MeV ring cyclotron of the Paul Scherrer Institute.

Primary author: HORI, Masaki (Max-Planck Institute of Quantum Optics (DE))
Presenter: HORI, Masaki (Max-Planck Institute of Quantum Optics (DE))
Session Classification: Parallel 13: Antimatter Experiments
Non-supersymmetric heterotic model building

We investigate orbifold and smooth Calabi-Yau compactifications of the non-supersymmetric heterotic SO(16)×SO(16) string. We focus on such Calabi-Yau backgrounds in order to recycle commonly employed techniques, like index theorems and cohomology theory, to determine both the fermionic and bosonic 4D spectra. We argue that the N=0 theory never leads to tachyons on smooth Calabi-Yaus in the large volume approximation. As twisted tachyons may arise on certain singular orbifolds, we conjecture that such tachyonic states are lifted in the full blow-up. We perform model searches on selected orbifold geometries. In particular, we construct an explicit example of a Standard Model-like theory with three generations and a single Higgs field.

Primary author: Dr GROOT NIBBELINK, Stefan (urn:Google)
Presenter: Dr GROOT NIBBELINK, Stefan (urn:Google)
Session Classification: Parallel 7: Supersymmetry, Supergravity, Strings, Branes
TIME-REVERSAL, LOOP-ANTILOOP SYMMETRY AND THE BESSEL EQUATION

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The Bessel equation is shown to be equivalent, under suitable transformations, to a system of two damped/amplified parametric oscillator equations, which have been used in the study of inflationary models of the Universe, thermal field theories and Chern-Simons gauge theories. The breakdown of loop-antiloop symmetry due to group contraction manifests itself as breaking of time-reversal symmetry. The relation between some infinite dimensional loop-algebras, such as the Virasoro-like algebra, and the Euclidean algebras e(2) and e(3) is also discussed.

**Primary author:** VITIELLO, Giuseppe (University of Salerno, Italy)

**Presenter:** VITIELLO, Giuseppe (University of Salerno, Italy)

**Session Classification:** Parallel 1: Discrete symmetries (T, C, P), flavour, accidental symmetries
Discrete Symmetries in F-theory Model Building

Wednesday, 3 December 2014 17:10 (30 minutes)

F-theory is known to admit a number of discrete symmetries, such as $A_4$, $D_4$ and $Z_N$ symmetries. An introduction to the methods involved will be provided, with a view to discussing current work in the field.

Primary author: MEADOWCROFT, Andrew (University of Southampton)
Presenter: MEADOWCROFT, Andrew (University of Southampton)
Session Classification: Parallel 14: Discrete Symmetries in Strings and in GUT theories
Phenomenology of discrete symmetries

Friday, 5 December 2014 18:30 (25 minutes)

Discrete symmetries play a crucial role in physics beyond the Standard Model. Focusing on supersymmetric models which aim at explaining the family structure of quarks and leptons, I first discuss how Abelian discrete symmetries such as e.g. R-parity can emerge from an underlying U(1) family symmetry. Non-Abelian discrete family symmetries are motivated by the observation of large and very peculiar mixing angles in the neutrino sector. I review their implementation in supersymmetric models and briefly comment on the implications arising from the measurement of a non-zero reactor neutrino mixing angle.

Primary author: LUHN, Christoph (University of Siegen)
Presenter: LUHN, Christoph (University of Siegen)
Session Classification: Parallel 7: Supersymmetry, Supergravity, Strings, Branes
Mass insertion parameters from an SU(5) \times S_4 \times U(1) family symmetry model.

Wednesday, 3 December 2014 18:15 (30 minutes)

The aim of this work is to provide an explanation for the masses and mixings of the Standard Model fermionic content as well as for its supersymmetric extensions, using an $S_4 \times U(1)$ family symmetry in an SU(5) background. The results are given in terms of mass insertion parameters and are compared to the latest experimental limits.

**Primary author:** DIMOU, Maria (Southampton University)

**Co-authors:** LUHN, Christoph (University of Siegen); HAGEDORN, Claudia (Excellence Cluster 'Universe', TU Munich); KING, Stephen (Department of Physics (SHEP))

**Presenter:** DIMOU, Maria (Southampton University)

**Session Classification:** Parallel 14: Discrete Symmetries in Strings and in GUT theories
A new method for computing the quark-gluon vertex

*Wednesday, 3 December 2014 15:05 (35 minutes)*

In this talk we present a new method for determining the nonperturbative quark-gluon vertex, which constitutes a crucial ingredient for a variety of theoretical and phenomenological studies. This new method relies heavily on the exact all-order relation connecting the conventional quark-gluon vertex with the corresponding vertex of the background field method, which is Abelian-like. The longitudinal part of this latter quantity is fixed using the standard gauge technique, whereas the transverse is estimated with the help of the so-called transverse Ward identities. This method allows the approximate determination of the nonperturbative behavior of all twelve form factors comprising the quark-gluon vertex, for arbitrary values of the momenta. Numerical results will be presented for the form factors in three special kinematical configurations (soft gluon and quark symmetric limit, zero quark momentum) and compared with the corresponding lattice data.

**Primary author:** AGUILAR, Arlene Cristina (University of Campinas)

**Presenter:** AGUILAR, Arlene Cristina (University of Campinas)

**Session Classification:** Parallel 5: Strongly Coupled gauge Theories
This work presents prospects for conducting a novel direct test of time-reversal symmetry at the KLOE-2 experiment. Quantum entanglement of neutral K meson pairs uniquely available at KLOE-2 allows to probe the T symmetry directly and independently of CP violation. This is achieved by a comparison of probabilities for a transition and its inverse obtained through exchange of initial and final states. Such transitions between flavor and CP-definite states of the neutral kaons are only connected by the T conjugation which ensures the CP-independence of the test. While a similar measurement was performed by the BaBar experiment with neutral B mesons, the KLOE-2 detector can test T-violation in the neutral kaons system. Such a test requires i.a. reconstruction of the KL → 3π⁰ decay accompanied by KS → π±l∓ν with good timing information. Therefore a new reconstruction method for this process is also presented which is capable of reconstructing the KL → 3π⁰ decay with decay time resolution of O(1τS).

**Primary authors:** GAJOS, Aleksander (Jagiellonian University); DI DOMENICO, Antonio (Università e INFN, Roma I (IT))

**Presenter:** GAJOS, Aleksander (Jagiellonian University)

**Session Classification:** Parallel 1: Discrete symmetries (T, C, P), flavour, accidental symmetries
Study of KS semileptonic decays and CPT tests with the KLOE detector

Thursday, 4 December 2014 18:30 (25 minutes)

Study of semileptonic decays of neutral kaons allows to perform a test of discrete symmetries, as well as basic principles of the Standard Model. In this presentation a general review on dependency between charge asymmetry constructed for semileptonic decays of short- and long-lived kaons and CPT symmetry is given.

The current status of determination of charge asymmetry for short-lived kaon, obtained by registering of about 1.7 billion KSKL meson pairs collected at DAΦNE with the KLOE detector is also reviewed.

Primary authors: DI DOMENICO, Antonio (Universita e INFN, Roma I (IT)); KAMINSKA, Daria

Presenter: KAMINSKA, Daria

Session Classification: Parallel 4: Experiments-discrete-symmetries
Neutrino Oscillations and Dark Matter in IceCube

Tuesday, 2 December 2014 17:00 (30 minutes)

The IceCube detector is the world’s largest neutrino observatory, a 1 km$^3$ array of photomultipliers buried in the ice at the geographic South Pole. With the addition of the DeepCore in-fill, IceCube is sensitive to physics down the the ~10 GeV range. Current studies of neutrino oscillations and dark matter in DeepCore will be discussed. Also I will discuss the proposed in-fill extension, PINGU, with potential to probe low mass dark matter, further constrain neutrino oscillation parameters and determine the neutrino mass hierarchy.

Primary author: DAY, Melanie (IceCube)
Presenter: DAY, Melanie (IceCube)
Session Classification: Parallel 2: Neutrino mass and mixing, implications for astroparticle physics, dark matter searches
Dynamical generation of fermion mixing

Tuesday, 2 December 2014 15:20 (35 minutes)

We present a dynamical mechanism à la Nambu-Jona-Lasinio for the generation of masses and mixing for two interacting fermion fields. The analysis is carried out in a framework in which mass generation is achieved via inequivalent representations, and that we generalize to the case of two generations. The method allows a clear identification of the vacuum structure for each physical phase, confirming previous results about the distinct physical nature of the vacuum for fields with definite mass and fields with definite flavor.

Primary author: BLASONE, Massimo (Università di Salerno)
Presenter: BLASONE, Massimo (Università di Salerno)
Session Classification: Parallel 2: Neutrinos mass and mixing, implications for astroparticle physics, dark matter searches
Neutrino Astrophysics: recent advances and open issues

Tuesday, 2 December 2014 14:45 (35 minutes)

Neutrinos of astrophysical origin are messengers produced in stars, in explosive phenomena like core-collapse supernovae, in the accretion disks around black holes, or in the Earth’s atmosphere. Their fluxes and spectra encode information on the environments that produce them. Such fluxes are modified in characteristic ways when neutrinos traverse a medium, also depending on key unknown neutrino properties. We will summarize recent advances in this domain, the open questions and their importance for observations.

Primary author:  Dr VOLPE, CRISTINA (ASTROPARTICULE ET COSMOLOGIE (APC))
Presenter:  Dr VOLPE, CRISTINA (ASTROPARTICULE ET COSMOLOGIE (APC))
Session Classification:  Parallel 2: Neutrinos mass and mixing, implications for astroparticle physics, dark matter searches
Measurements of CP violation at Belle

Friday, 5 December 2014 15:35 (30 minutes)

We present some of the recent measurements of CP violation in B decays based on the full data sample containing 772 million B meson pairs collected at the Υ(4S) resonance using the Belle detector at the KEKB asymmetric-energy $e^+e^-$ collider. In particular, we present measurements of time-dependent CP violation parameters in $B^0 \to \eta' K^0$, $B^0 \to \omega K^0_S$ and $B^0 \to K^0_S \eta \gamma$ decays. In the Standard Model these decays only proceed through the $b \to s$ quark transition penguin diagrams and are as such very sensitive to new CP violating phases carried by potential new heavy particles in the loops. In addition we also present measurement of direct CP violation in $B^0 \to \eta' K^{*0}$, and measurement of branching fraction of $B^0 \to \pi^0 \pi^0$ decay. The latter result plays an important role in determinations of $\phi_2$ angle of the unitarity triangle.

Primary author: SANTELJ, Luka (KEK, Japan)
Presenter: SANTELJ, Luka (KEK, Japan)
Session Classification: Parallel 4: Experiments-discrete-symmetries
Exotica and discreteness in the classification of string spectra

Friday, 5 December 2014 18:55 (25 minutes)

I discuss the existence of discrete symmetries in the landscape of free fermionic heterotic–string vacua that were discovered via their classification by SO(10) GUT models and its subgroups such as the Pati-Salam, Flipped SU(5) and Standard-Like models. The classification is carried out by fixing a set of basis vectors and varying the GSO projection coefficients entering the one-loop partition function. The analysis of the models is facilitated by deriving algebraic expressions for the GSO projections that enable a computerised analysis of the entire string spectrum and the scanning of large spaces of vacua. The analysis reveals discrete symmetries like the spinor-vector duality observed at the SO(10) level and the existence of exophobic Pati-Salam vacua. Contrary to the Pati–Salam case the classification shows that there are no exophobic flipped SU(5) vacua with an odd number of generations. It is observed that the standard-like models are substantially more constrained.

Primary author:  SONMEZ, Hasan (University Of Liverpool)
Presenter:  SONMEZ, Hasan (University Of Liverpool)
Session Classification:  Parallel 7: Supersymmetry, Supergravity, Strings, Branes
[Re]constructing Finite Flavour Groups: Horizontal Symmetry Scans from the Bottom-Up

Wednesday, 3 December 2014 17:10 (30 minutes)

We present a novel procedure for identifying discrete, leptonic flavour symmetries, given a class of unitary mixing matrices. By creating explicit 3D representations for generators of residual symmetries in both the charged lepton and neutrino sector, we reconstruct large(r) non-abelian flavour groups using the GAP language for computational finite algebra. We use experimental data to construct only those generators that yield acceptable (or preferable) mixing patterns. Such an approach is advantageous because it 1) can reproduce known groups from other ‘top-down’ scans while elucidating their origins from residuals, 2) find new previously unconsidered groups, and 3) serve as a powerful model building tool for theorists wishing to explore exotic flavour scenarios. We test our procedure on a generalization of the canonical tri-bimaximal (TBM) form and discuss further work that is ongoing.

Primary author: TALBERT, Jim (University of Oxford)

Presenter: TALBERT, Jim (University of Oxford)

Session Classification: Parallel 1: Discrete symmetries (T, C, P), flavour, accidental symmetries
Symmetry-improved 2PI Approach to the Infrared Divergences of the Standard Model Effective Potential

Thursday, 4 December 2014 16:35 (35 minutes)

The 3-loop Standard Model (SM) effective potential suffers from infrared (IR) divergences due to the Goldstone bosons. These IR problems start at lower loop-orders for the derivatives of the potential. We study these issues by means of the recently developed symmetry-improved CJT effective action. Our formalism, as opposed to other existing approaches, is particularly appropriate for studying this problem, since the thresholds of the particles are correctly described within quantum loops. By considering the Higgs and top-quark sectors of the SM we show that, in agreement with other recent approaches, the IR divergences are actually absent, being an artifact of perturbation theory. Moreover, we give preliminary quantitative comparisons with the existing treatments, which are based on partial resummations of perturbation-theory contributions. These IR issues can potentially have an important quantitative impact on the stability analyses of the SM effective potential extrapolated at very high energies, since this is known to be particularly sensitive to the matching conditions at the electroweak scale.

**Primary authors:** PILAFTSIS, Apostolos (University of Manchester (GB)); TERESI, Daniele (University of Manchester)

**Presenter:** TERESI, Daniele (University of Manchester)

**Session Classification:** Parallel 5: Strongly coupled gauge theories
Recent results, status and prospects for the BESIII experiment

Friday, 5 December 2014 14:30 (35 minutes)

We report the measurement of the asymmetry $A_{CP}$ of the branching fractions of $D^0 \to K^- \pi^+$ in the CP-odd and CP-even eigenstates using a data sample of 2.92 fb$^{-1}$ collected with the BESIII detector at the center-of-mass energy $\sqrt{s} = 3.773$ GeV.

With the measured $A_{CP}$ the strong phase difference $\delta_{K\pi}$ between the doubly Cabibbo-suppressed process $D^0 \to K^- \pi^+$ and the Cabibbo-favored process $D^0 \to K^- \pi^+$ is extracted.

Using world-average values of external parameters, we obtain the most precise measurement of $\delta_{K\pi}$ to date: $\cos \delta_{K\pi} = 1.02 \pm 0.11 \pm 0.06 \pm 0.01$.

The first and second uncertainties are statistical and systematic, respectively, while the third arises from external input.

Based on the same data sample a preliminary results of the parameter $y_{CP}$ in $D^0 - \bar{D}^0$ oscillation is obtained.

Finally, a summary of the recent results from charmonium spectroscopy is reported.

The high statistics accumulated at the $Y(4260)$ and $Y(4360)$ energies help us to understand the nature and the proprieties of the XYZ states.

Primary author: GARZIA, Isabella (INFN)

Presenter: GARZIA, Isabella (INFN)

Session Classification: Parallel 4: Experiments-discrete-symmetries
Discrete Flavor Symmetries and Origin of CP Violation

Wednesday, 3 December 2014 17:45 (35 minutes)

We discuss the origin of CP violation in settings with a discrete (flavor) symmetry G. We show that physical CP transformations always have to be class-inverting automorphisms of G. This allows us to categorize finite groups into three types: (i) Groups that do not exhibit such an automorphism and, therefore, in generic settings, explicitly violate CP. In settings based on such groups, CP violation can have pure group-theoretic origin and can be related to the complexity of some Clebsch-Gordan coefficients. (ii) Groups for which one can find a CP basis in which all the Clebsch-Gordan coefficients are real. For such groups, imposing CP invariance restricts the phases of coupling coefficients. (iii) Groups that do not admit real Clebsch-Gordan coefficients but possess a class-inverting automorphism that can be used to define a proper (generalized) CP transformation. For such groups, imposing CP invariance can lead to an additional symmetry that forbids certain couplings. We make use of the so-called twisted Frobenius-Schur indicator to distinguish between the three types of discrete groups. We present one explicit example for each type of group, thereby illustrating the CP properties of models based on them. We also show that certain operations that have been dubbed generalized CP transformations in the recent literature do not lead to physical CP conservation.

Primary authors: TRAUTNER, Andreas (TU Muenchen); MAHANTHAPPA, Kalyana (University of Colorado); FALLBACHER, Maximilian (TUM); RATZ, Michael (Technische Universitaet Muenchen); CHEN, Mu-Chun (University of California at Irvine)

Presenter: CHEN, Mu-Chun (University of California at Irvine)

Session Classification: Parallel 1: Discrete symmetries (T, C, P), flavour, accidental symmetries
TeV Scale Lepton number Violation and Baryogenesis

Thursday, 4 December 2014 09:00 (45 minutes)

I will discuss the possibility that physics of neutrino mass is a TeV scale phenomenon which can be probed at the LHC via the searches for right handed W-bosons and the heavy right handed neutrinos and other low energy experiments. The same TeV scale model also leads to successful leptogenesis as a way to understand the origin of matter in the universe. Thus, the Large Hadron Collider can provide information not only on supersymmetry, extra space dimensions as well as the nature of dark matter but also on the physics behind the neutrino masses and the mechanism behind the origin of matter.

Primary author: MOHAPATRA, Rabindra (University of Maryland, College Park)
Presenter: MOHAPATRA, Rabindra (University of Maryland, College Park)
Session Classification: PLENARY 3
Higgs-Dilaton Cosmology: Universality vs. Criticality

Thursday, 4 December 2014 17:35 (30 minutes)

The Higgs-Dilaton model is able to produce an early inflationary expansion followed by a dark energy dominated era responsible for the late time acceleration of the Universe. At tree-level, the model predicts a small tensor-to-scalar ratio, a tiny negative running of the spectral tilt and a non-trivial consistency relation between the spectral tilt of scalar perturbations and the dark energy equation of state. We will reconsider the validity of these predictions in the presence of radiative corrections and their connection to low energy Higgs and top masses.

Primary authors:  Dr RUBIO, Javier (EPFL); Prof. MIKHAIL, Shaposhnikov (EPFL)

Presenter:  Dr RUBIO, Javier (EPFL)

Session Classification:  Parallel 9: Higgs Physics @ LHC, discrete symmetries @LHC, new facilities
Hunting for New Physics with vector-like quarks

Thursday, 4 December 2014 14:30 (30 minutes)

Extending the Standard Model through the inclusion of additional vector-like quarks provides a rich playground for New Physics searches both in the Flavour sector and at the LHC. A detailed analysis of present constraints and future prospects with special emphasis on potential deviations from the Standard Model expectations in selected observables is presented.

Primary author: Dr NEBOT GÓMEZ, Miguel (CFTP - Lisbon)

Presenter: Dr NEBOT GÓMEZ, Miguel (CFTP - Lisbon)

Session Classification: Parallel 1: Discrete symmetries (T, C, P), flavour, accidental symmetries
The Fermilab Muon g-2 Experiment

Tuesday, 2 December 2014 17:00 (30 minutes)

The Fermilab Muon g-2 experiment, E989, is presently being constructed and is seeking to measure the anomalous magnetic moment of the muon to a precision of 0.14ppm: a factor of four better than the previous Brookhaven measurement which has a long-standing discrepancy with respect to the SM prediction of approximately 3.5 standard deviations. I will review the status of the Fermilab experiment and describe how the reduction in the experimental uncertainty will be achieved.

Primary author:  LANCaster, Mark (University College London (UK))

Presenter:  LANCaster, Mark (University College London (UK))

Session Classification:  Parallel 1: g-2 & discrete symmetries (T, C, P), flavour, accidental symmetries
A 3d effective lattice theory for Yang-Mills and QCD thermodynamics

Wednesday, 3 December 2014 16:35 (35 minutes)

QCD thermodynamics is crucial for the physics of the early universe, heavy ion collisions and compact stars. However, predictions by lattice simulations are very costly or, in the case of finite baryon density, even impossible because of a sign problem. Starting from Yang-Mills theory, it is shown how to use strong coupling methods to construct a 3d effective theory which accurately reproduces the deconfinement phase transition. The generalisation to QCD, which is valid for heavy quarks, has only a mild sign problem in the case of finite density and can be simulated efficiently.

Primary author: PHILIPSEN, Owe (Goethe-University Frankfurt)
Presenter: PHILIPSEN, Owe (Goethe-University Frankfurt)
Session Classification: Parallel 5: Strongly coupled gauge theories
Sequestered de Sitter String Scenarios

We present soft supersymmetry breaking terms in type IIB de Sitter string vacua after moduli stabilisation. We focus on models in which the Standard Model is sequestered from the supersymmetry breaking sources and the spectrum of soft-terms is hierarchically smaller than the gravitino mass.

Primary author: Dr KRIPPENDORF, Sven (University of Oxford)
Presenter: Dr KRIPPENDORF, Sven (University of Oxford)
Session Classification: Parallel 7: Supersymmetry, Supergravity, Strings and Branes
DSE-inspired model for the Pion GPD

*Wednesday, 3 December 2014 17:45 (35 minutes)*

We sketch an approach to a computation of the pion’s valence dressed-quark GPD based upon a Rainbow-Ladder truncation of the QCD Dyson-Schwinger equations. In particular, our starting point is the appropriate recasting of the computed GPD as the well-known double distribution ansatz, which automatically fulfils all the constraints required by the observing of discrete and Lorentz symmetries.

**Primary author:** RODRIGUEZ QUINTERO, José (University of Huelva)

**Co-authors:** MEZRAI, Cedric; ROBERTS, Craig (Argonne National Laboratory); MOUTARDE, Hervé (Ifu, CEA-Saclay)

**Presenter:** RODRIGUEZ QUINTERO, José (University of Huelva)

**Session Classification:** Parallel 5: Strongly coupled gauge theories
On the flavor composition of the high-energy neutrinos in IceCube

Tuesday, 2 December 2014 17:30 (35 minutes)

The IceCube experiment has recently released 3 years of data of the first ever detected high-energy (> 30 TeV) neutrinos, which are consistent with an extraterrestrial origin. In this talk, I will discuss the compatibility of the observed track-to-shower ratio with possible combinations of neutrino flavors and its implications.

Primary author: PALOMARES-RUIZ, Sergio (IFIC-Valencia)

Co-authors: Dr VINCENT, Aaron (IPPP-Durham); Dr MENA, Olga (IFIC-Valencia)

Presenter: PALOMARES-RUIZ, Sergio (IFIC-Valencia)

Session Classification: Parallel 2: Neutrino mass and mixing, implications for astroparticle physics, dark matter searches
Degeneracy on a multiHiggs CP non invariant sector.

The Higgs sector with more than one Higgs doublet may have degeneracy in its physical states. Considering also $CP$ symmetry is not conserved in the Higgs sector, then the neutral Higgs states would not have a defined $CP$ charge, i.e., there is a mixing within scalar and pseudoscalar components of the Higgs doublets. This situation will occur for the cMSSM, i.e., with complex soft couplings, and will be manifest through one-loop corrections. This possibility has consequences on the phenomenology and in the type of expected signatures for the nearly and exact Higgs degeneracy, as for example the line-shape will present very different behaviour than expected for the fermion scattering amplitude via non-$CP$ defined Higgs, $\sigma(f \bar{f} \rightarrow H^\text{nonCP}_i \rightarrow f' \bar{f}')$.

**Primary authors:** Dr MONDRAGON, Alfonso (Universidad Nacional Autonoma de Mexico); Dr HERNANDEZ, Enriqueta (Universidad Nacional Autonoma de Mexico); Dr GOMEZ BOCK, Melina (Universidad de las Americas Puebla); Dr MONDRAGON, Myriam (Universidad Nacional Autonoma de Mexico)

**Presenter:** Dr GOMEZ BOCK, Melina (Universidad de las Americas Puebla)

**Session Classification:** Parallel 9: Higgs Physics @ LHC, discrete symmetries @ LHC, new facilities
The Belle II experiment is now being constructed at the KEK laboratory in Japan. This project represents a substantial upgrade to both the Belle detector and the KEKB accelerator. The Belle II experiment will record 50\,ab$^{-1}$ of data, a factor of 50 more than that recorded by the Belle experiment. This large data set, combined with the low backgrounds and high trigger efficiencies characteristic of an $e^+e^-$ experiment, should provide unprecedented sensitivity to new physics signatures in $B$ and $D$ meson decays, and in $\tau$ lepton decays. The experiment is scheduled to begin taking data in 2016. This talk will review the capabilities of the experiment, the expected sensitivity to new physics, and the current status of detector construction.

**Primary author:** Dr YAMAOKA, Jared (Pacific Northwest National Lab)

**Presenter:** Dr YAMAOKA, Jared (Pacific Northwest National Lab)

**Session Classification:** Parallel 4: Experiments-discrete-symmetries
Progress towards in-beam hyperfine spectroscopy of antihydrogen

Antihydrogen is the simplest atom consisting purely of antimatter. Its matter counterpart, hydrogen, is one of the best studied atomic systems in physics. Thus comparing the spectra of hydrogen and antihydrogen offers some of the most sensitive tests of matter-antimatter symmetry. The ASACUSA collaboration is pursuing an experiment to measure the ground-state hyperfine splitting of antihydrogen in a polarized beam [1,2], a quantity which was measured in hydrogen in a beam to a relative precision of $4 \times 10^{-8}$ [3] and in a maser to better than $10^{-12}$ [5,6].

After recently reporting the first observation of a beam of antihydrogen atoms 2.7 m downstream of the formation region in a field-free environment [4], the atomic resonance beam apparatus to perform a hyperfine measurement was completed. During the shutdown of CERN, a source of cold polarized hydrogen atoms was built and experiments were performed to characterize the apparatus with a hydrogen beam of similar properties as compared to the expected antihydrogen beam. Scans of the hyperfine structure of hydrogen showing encouraging results for the achievable precision for a measurement with antihydrogen will be reported.


Primary author: WIDMANN, Eberhard (Austrian Academy of Sciences (AT))

Presenter: WIDMANN, Eberhard (Austrian Academy of Sciences (AT))

Session Classification: Parallel 13: Antimatter Experiments
SuperCDMS: Results on low mass WIMPs and future perspectives

*Thursday, 4 December 2014 16:35 (30 minutes)*

The SuperCDMS experiment attempts to detect WIMP dark matter particles through their elastic scattering off Ge nuclei. The simultaneous measurement of the energy deposited in ionization and phonons allows for an excellent discrimination of nuclear recoils (expected from WIMP interactions) versus electron recoils (due to background events). The current experimental setup features new detectors (iZiPs) which are instrumented on both sides with interleaved ionization and phonon sensors and allow to separate surface and bulk events, thereby eliminating the main source of background of the previous CDMS II phase. Using this full background rejection capability, and operating at a very low analysis threshold ($1.6 - 10\,\text{keV}_{\text{nr}}$) we have carried out a search for low-mass WIMPs. An exposure of 577 kg days was analysed for WIMPs with mass below 30 GeV, with the signal region blinded. An upper bound was extracted on the WIMP-nucleon scattering cross-section, which probes new parameter space for WIMP masses below 6 GeV and is in tension with the dark matter interpretation of previous experimental results.

**Primary author:** CERDENO, David G. (University of Durham)

**Presenter:** CERDENO, David G. (University of Durham)

**Session Classification:** Parallel 10: LHC and dark matter experiments
Particle Physics and Cosmology from Almost-Commutative Manifolds

Saturday, 6 December 2014 09:50 (45 minutes)

I will review almost-commutative manifolds, a light version of noncommutative geometry, proposed by Connes in order to explain the Standard Model of electroweak and strong interactions and eventually unify the Standard Model with Einstein’s geometrical theory of gravity. I will briefly discuss the spectral action principle and the choice of the algebra. After a short presentation of the phenomenological successes of the model, I will address cosmological issues by considering the gravitational sector of the theory.

Primary author: Prof. SAKELLARIADOU, Mairi (King’s College London)
Presenter: Prof. SAKELLARIADOU, Mairi (King’s College London)
Session Classification: PLENARY 5
Measurements of exclusive and inclusive $b \rightarrow X_s \, l^+ \, l^-$ and $b \rightarrow s \, \gamma$ radiative decays at Belle

Recent measurements of exclusive and inclusive $b \rightarrow X_s \, l^+ \, l^-$ and $b \rightarrow s \, \gamma$ decays are reported from Belle.

Primary author: Dr YAMAOKA, Jared (Pacific Northwest National Lab)
Presenter: Dr YAMAOKA, Jared (Pacific Northwest National Lab)
Session Classification: Parallel 4: Experiments-discrete-symmetries
I present a progress report on the direct search for dark matter axions with ADMX upgraded with low noise RF SQUID amplifiers and cryogenics. Axions are a well motivated candidate to explain the discrepancy between the observed baryonic matter density and that inferred from precision measurements of the microwave background anisotropy, gravitational lensing, and the dynamics of spiral galaxies. As a pseudo-Goldstone boson associated with spontaneous breaking of the PQ symmetry, axions gain further credibility from the Higgs discovery. The ADMX experiment utilises a cryogenic tuneable electromagnetic resonator immersed in a static magnetic field to search for axions at micro electron volt scales. The axion field undergoes Primakov conversion into microwave photons when the frequency of a TM resonance of the cavity corresponds to the energy per axion. Background originates from the physical cavity temperature added to the effective noise temperature of the receiver electronics. By reducing the temperature of the axion receiver, we aim for an improved rate of search of the allowed window of axion masses.

Primary author: DAW, Edward (The University of Sheffield)
Presenter: DAW, Edward (The University of Sheffield)
Session Classification: Parallel 10: LHC and dark matter experiments
Towards precision measurements with trapped Antihydrogen

Friday, 5 December 2014 17:29 (30 minutes)

Precise low-energy measurements of antimatter and subsequent comparison with equivalent matter measurements offer an experimental approach to address the question of why the Universe appears to be largely composed of matter. The observed abundance of matter relative to antimatter is not adequately explained by our present theories which would suggest that largely equal quantities should have been present from the beginning. Antihydrogen, as the antimatter equivalent of hydrogen, allows a unique opportunity to make precise comparison with matter spectra to test CPT and Lorentz invariance as well as to make direct tests of antimatter gravitation. Measured quantities in the anti-atomic system are expected to be exactly the same as the supremely well-measured and calculated values for the atomic system, therefore any slight deviation would shed light on the problem of baryon asymmetry.

The ALPHA collaboration at CERN was the first group to demonstrate trapping of antihydrogen and make preliminary measurements on this exotic bound state. We have demonstrated the first resonant quantum interaction with a pure antimatter system by driving and detecting magnetic resonance transitions between hyperfine states in trapped antihydrogen atoms [1], the first application of a method for measuring the gravitational mass of trapped antihydrogen [2], and made initial precision measurements of the antihydrogen charge anomaly [3]. These measurements are significant milestones towards sensitive tests of CPT and antimatter gravitation. ALPHA is commissioning a major upgrade to improve these measurements and begin investigating optical transitions in antihydrogen.


Primary author: BERTSCHE, William Alan (University of Manchester (GB))
Presenter: BERTSCHE, William Alan (University of Manchester (GB))
Session Classification: Parallel 13: Antimatter Experiments
We search for the decay $B_s \to \gamma \gamma$ and measure the branching fraction for $B_s \to \phi \gamma$ using $121.4\text{fb}^{-1}$ of data collected at the $\Upsilon(5S)$ resonance with the Belle detector at the KEKB asymmetric energy B-factory located at the High Energy Accelerator Research Organization (KEK), Japan. These are flavor changing neutral current processes involving the transition of a $b$ to $s$ quark which are extremely sensitive to new physics beyond the Standard Model. We measure the branching fraction of $B_s \to \phi \gamma$ to be $(3.6 \pm 0.5(\text{stat.}) \pm 0.3(\text{syst.}) \pm 0.6(f_s)) \times 10^{-5}$, which is in a good agreement with the theoretical predictions as well as a recent measurement from LHCb. We observe no statistically significant signal for the $B_s \to \gamma \gamma$ decay and set an upper limit at $3.1 \times 10^{-6}$ at 90% C.L. Recent results on these decays will be presented in this talk.

**Primary authors:** Dr BHUYAN, Bipul (IIT Guwahati); Ms DUTTA, Deepanwita (IIT Guwahati)

**Presenter:** Ms DUTTA, Deepanwita (IIT Guwahati)

**Session Classification:** Parallel 4: Experiments-discrete-symmetries
The Cherenkov Telescope Array: status and science goals for fundamental physics

*Friday, 5 December 2014 15:30 (30 minutes)*

The Cherenkov Telescope Array (CTA) is a worldwide project aiming at building the next ground-based gamma-ray observatory with a sensitivity ten times better than current experiments like H.E.S.S., MAGIC and VERITAS. CTA will be composed of several tens of telescopes with two-to-three different sizes distributed on two sites located in the Northern and Southern Hemispheres. CTA will also have a much wider energy lever arm and improved angular resolution. Important steps for the CTA project are currently underway: the decision about the site locations and the shaping of the key science projects. The science program will be presented with specific emphasis on the plans for indirect searches for dark matter.

**Primary author:** MOULIN, Emmanuel (CEA)

**Presenter:** MOULIN, Emmanuel (CEA)

**Session Classification:** Parallel 11: Astroparticle Physics Experiments
PT-Symmetric $\phi^3$ and $\phi^4$ theories: properties and intriguing results.

The renormalization group properties of a PT-symmetric $\phi^3$ theory are discussed and compared to the corresponding properties of the conventional theory. In $d=6$ dimensions, the theory turns out to be energetically stable, perturbatively renormalizable, and trivial (the conventional one being asymptotically free and unstable). Moreover, in $d = 6 - \epsilon$ dimensions, the theory has a non-trivial fixed point. The critical behaviour around this point is discussed. Finally, it is shown that, due to its stability properties, the PT-symmetric theory has a predictive power higher than the conventional one. As for the PT-symmetric $\phi^4$ theory, the $d = 0$ dimension case is studied. Unexpected and intriguing results arise.

**Primary author:** Prof. BRANCHINA, Vincenzo (University of Catania)

**Presenter:** Prof. BRANCHINA, Vincenzo (University of Catania)

**Session Classification:** Parallel 3: PT symmetric quantum theory
Despite the absence of experimental evidence, weak scale supersymmetry remains one of the best motivated and studied Standard Model extensions. This talk summarises recent ATLAS and CMS results for searches for supersymmetric (SUSY) particles. Weak and strong production in both R-Parity conserving and R-Parity violating SUSY scenarios are considered. The searches involved final states including jets, missing transverse momentum, light leptons, taus or photons, as well as long-lived particle signatures.

Primary author: RAMMENSEE, Michael Christian (CERN)
Presenter: RAMMENSEE, Michael Christian (CERN)
Session Classification: Parallel 7: Supersymmetry, Supergravity, Strings, Branes
Non-SUSY BSM Searches: Recent Results from ATLAS & CMS

Thursday, 4 December 2014 18:35 (30 minutes)

The Standard Model of particle physics is a sensational success, especially since the discovery the 125 GeV Higgs boson. However, there are still numerous unanswered questions... Why is the Higgs so light? Do the interactions couplings unify and how can gravity be included? Why three fermion generations? What is dark matter?

Theories Beyond the Standard Model (BSM), such as Grand Unified Theories, Extra Dimensions or Technicolour are trying to answer these questions.

In this talk, we will focus on the most recent results obtained by the ATLAS and CMS experiments at the LHC for BSM searches, excluding Higgs and supersymmetry searches. New results in Dark matter, heavy narrow bosons, new heavy quarks and 3rd generation lepto-quarks will be presented. A brief summary of the perspectives at 14 TeV and at HL-LHC will be shown.

Primary author: MALEK, Fairouz (LPSC-Grenoble , CNRS-IN2P3 (FR))
Presenter: MALEK, Fairouz (LPSC-Grenoble , CNRS-IN2P3 (FR))
Session Classification: Parallel 10: LHC and dark matter experiments
We present an overview of recent results in Higgs boson physics obtained with the ATLAS and CMS experiments at the Large Hadron Collider (LHC) located at CERN, Geneva. The focus is on measurements of the properties of the recently discovered Higgs boson with a mass of about 125 GeV. We will then present a brief selection of results in searches for Higgs bosons beyond the Standard Model. We will close by discussing prospects of future Higgs boson measurements and searches at the LHC.

**Primary author:** FLECHL, Martin (Austrian Academy of Sciences (AT))

**Presenter:** FLECHL, Martin (Austrian Academy of Sciences (AT))

**Session Classification:** Parallel 9: Higgs physics @ LHC, discrete symmetries @ LHC, new facilities
Recent Results of the AMS-02 Experiment on the ISS

Friday, 5 December 2014 14:30 (30 minutes)

AMS-02 is a general purpose cosmic ray detector operating on the International Space Station since 19 May 2011. Results based on the data collected during the first 2.5 years of the mission include high precision measurements of the proton, helium, electron and positron fluxes, and the boron to carbon ratio in the energy range from ~1GeV/n to ~1TeV/n. The positron fraction is determined in the energy range from 0.5 to 500GeV and its energy spectrum shows an steadily increasing fraction from 10 to 200GeV with no fine structure. Individual electron and positron fluxes require a description beyond a single power-law spectrum.

Primary author: CASAUS, Jorge (Centro de Investigaciones Energ. Medioambientales y Tecn. - (ES))

Presenter: CASAUS, Jorge (Centro de Investigaciones Energ. Medioambientales y Tecn. - (ES))

Session Classification: Parallel 11: Astroparticle Physics Experiments
The NOvA long-baseline neutrino oscillation experiment

Wednesday, 3 December 2014 15:30 (30 minutes)

The recently completed NuMI Off-Axis Nu_e Appearance (NOvA) long-baseline neutrino oscillation experiment, will use an upgraded NuMI neutrino source at Fermilab in conjunction with a 300-ton near-detector and a 14-kton far-detector to explore the neutrino sector. NOvA uses a fully active, finely segmented detector design that offers superb event identification capability, allowing precision measurements of electron (anti-)neutrino appearance and muon (anti-)neutrino disappearance. Through these NOvA will provide constraints on theta_13, theta_23, the atmospheric mass splitting, the neutrino mass hierarchy, and the CP-violating phase. This talk reviews NOvA’s uniquely broad physics scope, including sensitivity updates, presents some early measures of the detector performance and discusses the experiment’s construction and operation timeline.

Primary author: TAMSETT, Matthew (University of Sussex)

Presenter: TAMSETT, Matthew (University of Sussex)

Session Classification: Parallel 2: Neutrinos mass and mixing, implications for astroparticle physics, dark matter searches
Quantum Field Theory of Magnetic Monopoles

Thursday, 4 December 2014 15:40 (35 minutes)

In spite of a vast amount research over several decades, the behaviour of magnetic monopoles in quantum field theory is still poorly understood. Quantum field theory formulation of elementary magnetic monopoles is plagued by lack of manifest locality and Lorentz invariance, which makes calculations very cumbersome. Solitonic ‘t Hooft-Polyakov monopoles avoid this problem, but even in their case calculating genuine quantum effects is difficult, and very few results exist. Even basic observables such as the pair production rate of monopoles in particle collisions cannot currently be calculated. I will describe a non-perturbative lattice field theory approach to this problem, and present results for both ‘t Hooft-Polyakov and elementary magnetic monopoles.

Primary author: Prof. RAJANTIE, Arttu (Imperial College Sci., Tech. & Med. (GB))
Presenter: Prof. RAJANTIE, Arttu (Imperial College Sci., Tech. & Med. (GB))
Session Classification: Parallel 5: Strongly coupled gauge theories
B-physics with ATLAS and CMS

Thursday, 4 December 2014 17:30 (30 minutes)

The large production rates of heavy flavoured particles at the LHC provide excellent opportunities to test the standard model and probe for new physics effects. A review of selected recent measurements by ATLAS and CMS based on LHC Run I data is presented, along with prospects for coming LHC runs.

Primary author: VIEGAS GUERREIRO LEONARDO, Nuno (Purdue University (US))
Presenter: VIEGAS GUERREIRO LEONARDO, Nuno (Purdue University (US))
Session Classification: Parallel 4: Experiments–discrete–symmetries
Electroweak vacuum stability, Higgs and top masses, and new physics

Thursday, 4 December 2014 18:10 (25 minutes)

According to the usual analysis, if the Standard Model (SM) is valid up to the Planck scale $M_P$, the stability condition of the electroweak (EW) vacuum (stable, metastable or unstable) mainly depends on the Higgs and top masses, $M_H$ and $M_t$. The analysis is performed by considering SM interactions only, as it is argued that new physics at $M_P$, although present, has no impact on it, and the results are presented with the help of a stability diagram in the $(M_H, M_t)$ plane. For the current experimental values of $M_H$ and $M_t$, in particular, the EW vacuum turns out to be metastable, with a lifetime much longer than the age of the universe. I this talk I present some recent work showing that new physics can have a great impact on the stability phase diagram, a result that has quite interesting phenomenological consequences. Candidates for beyond SM physics can be “tested” against this stability analysis. Moreover, contrary to some recent claims, higher precision measurements of the top and Higgs masses cannot provide any definite indication on whether we live in a stable or metastable universe, the answer to this question strongly depends on new physics. Finally, these results cast serious doubts on the Higgs inflation scenario, the latter being highly based on a crucial fine tuning of the EW vacuum stability condition.

Primary author: BRANCHINA, Vincenzo (University of Catania)

Presenter: BRANCHINA, Vincenzo (University of Catania)

Session Classification: Parallel 9: Higgs Physics @ LHC, discrete symmetries @LHC, new facilities

Track Classification: Higgs Physics at LHC and Beyond
The origin of discrete symmetries in F-theory models and their role in particle physics

Wednesday, 3 December 2014 16:35 (35 minutes)

We discuss the origin of discrete symmetries in F-theory models. Motivated by the neutrino sector, we focus on non-abelian discrete family symmetries associated to monodromies. We combine them with SU(5) GUT and examine their low energy implications.

Primary author: Prof. LEONTARIS, George (Ioannina University)
Presenter: Prof. LEONTARIS, George (Ioannina University)
Session Classification: Parallel 14: Discrete Symmetries in Strings and in GUT theories
Tests of Discrete Symmetries in K systems

Wednesday, 3 December 2014 11:00 (45 minutes)

The status of present experiments and future projects with kaons is reviewed, focusing on prospects for discrete symmetries tests.

Primary author: Prof. DI DOMENICO, Antonio (Universita Sapienza e INFN, Roma I (IT))
Presenter: Prof. DI DOMENICO, Antonio (Universita Sapienza e INFN, Roma I (IT))
Session Classification: PLENARY 2
Track Classification: T, C, P, CP symmetries
Results from the Pierre Auger Observatory

Friday, 5 December 2014 15:00 (30 minutes)

We will present highlights from the Pierre Auger Observatory. We will also present the current status and plans for upgrades of the Observatory. We will mention briefly the programme of the Observatory to search for new, exotic physics.

Primary author: Dr NELLEN, Lukas (I. DE CIENCIAS NUCLEARES, UNAM)
Co-author: PIERRE AUGER COLLABORATION
Presenter: Dr NELLEN, Lukas (I. DE CIENCIAS NUCLEARES, UNAM)
Session Classification: Parallel 11: Astroparticle Physics Experiments
Status and prospects for the Mu2e experiment at Fermilab

Tuesday, 2 December 2014 14:45 (30 minutes)

The Mu2e Experiment at Fermilab will search for coherent, neutrino-less conversion of muons into electrons in the field of a nucleus with a sensitivity improvement of a factor of 10,000 over existing limits. Such a lepton flavor-violating reaction probes new physics at a scale inaccessible with direct searches at either present or planned high energy colliders. The experiment both complements and extends the current search for muon decay to electron+gamma at MEG and searches for new physics at the LHC. We will present the physics motivation for Mu2e, the design of the muon beamline and the detector, and the current status of the experiment.

Primary authors: GLENZINSKI, Douglas (Fermi National Accelerator Laboratory (FNAL)); CORCORAN, Marjorie (Rutgers University)

Presenter: Dr TASSIELLI, Giovanni F. (INFN Lecce / Università del Salento)

Session Classification: Parallel 4: Experiments-discrete-symmetries

Track Classification: Accidental symmetries (B, L conservation)
PT-symmetric quantum theory

Tuesday, 2 December 2014 12:00 (45 minutes)

The average quantum physicist on the street would say that a quantum-mechanical Hamiltonian must be Dirac Hermitian (invariant under combined matrix transposition and complex conjugation) in order to guarantee that the energy eigenvalues are real and that time evolution is unitary. However, the Hamiltonian $H = p^2 + ix^3$, which is obviously not Dirac Hermitian, has a positive real discrete spectrum and generates unitary time evolution, and thus it defines a fully consistent and physical quantum theory!

Evidently, the axiom of Dirac Hermiticity is too restrictive. While $H = p^2 + ix^3$ is not Dirac Hermitian, it is PT symmetric; that is, invariant under combined parity P (space reflection) and time reversal T. The quantum mechanics defined by a PT-symmetric Hamiltonian is a complex generalization of ordinary quantum mechanics. When quantum mechanics is extended into the complex domain, new kinds of theories having strange and remarkable properties emerge. In the past few years, some of these properties have been verified in laboratory experiments. A particularly interesting PT-symmetric Hamiltonian is $H = p^2 - x^4$, which contains an upside-down potential. We will discuss this potential in detail, and explain in intuitive as well as in rigorous terms why the energy levels of this potential are real, positive, and discrete.

Applications of PT-symmetry in quantum field theory will be discussed.

Primary author: Prof. BENDER, Carl (Washington University in St Louis)
Presenter: Prof. BENDER, Carl (Washington University in St Louis)
Session Classification: PLENARY 1
Quantum mechanical models, conservation laws and a discrete action principle

It has been shown that the dynamics of discrete (integer-valued) Hamiltonian cellular automata can only be defined consistently, if it is linear in analogy to the linearity of unitary evolution in quantum mechanics. This suggests to look for an invertible map between such automata and continuous quantum mechanical models. Based on sampling theory, such a map can indeed be constructed and leads to quantum mechanical models which incorporate a fundamental scale. The admissible observables, the one-to-one correspondence of the respective conservation laws, and the existence of solutions of the modified dispersion relation for stationary states are discussed.

References:


Primary author: ELZE, Hans-Thomas (Universita di Pisa)
Presenter: ELZE, Hans-Thomas (Universita di Pisa)
Session Classification: Parallel 6b: Foundations of Quantum Theory, Pauli Principle Tests
How effective is the Standard Model effective field theory?

*Thursday, 4 December 2014 15:00 (30 minutes)*

The discovery of the Higgs boson closes the last remaining degree of freedom in the space of Standard Model physics, thus allowing unprecedented model-independent sensitivity to BSM physics. We may use this sensitivity by formally treating the Standard Model the way it has always been thought of: as an effective field theory supplemented by higher-dimensional operators. This approach parametrizes all possible ways decoupled new physics may enter in experimental observables. In this talk we place limits on a complete basis of dimension-6 operators from electroweak precision tests at LEP, as well as triple-gauge couplings and Higgs measurements at the Tevatron and LHC.

**Primary author:** YOU, Tevong (King’s College London)

**Co-author:** ELLIS, Jonathan R. (CERN)

**Presenter:** YOU, Tevong (King’s College London)

**Session Classification:** Parallel 9: Higgs physics @ LHC, discrete symmetries @ LHC, new facilities
50 years of Bell’s theorem and Weak Interaction Processes

Wednesday, 3 December 2014 16:35 (35 minutes)

John St. Bell was known and hired as a “particle physicist” when he came up with his work on hidden parameters. The aim of this talk is to discuss whether his theorem can be brought back to those systems that do not build up ordinary matter and light. Indeed, entanglement can be witnessed in decay processes governed by the weak interaction, e.g., in flavour oscillating systems or hyperon systems, BUT: Can an experimentally conclusive test be found proving the existence of correlations that are stronger than those allowed by classical physics?

It is not straightforwardly to apply Bell’s theorem to unstable systems. For neutral entangled K-mesons finally Bell’s theorem could be generalized without spoiling the conclusiveness [1] and allows for an experimental test, however, for the entangled Lambda-Antilambda system such a solution has not yet been found [2].

The findings [1] turned out to be also surprising from the theoretical point of view since a connection between the violation of Bell’s theorem and the tiny violation of the CP symmetry (C..charge conjugation, P...parity) has been found. Herewith, e.g. the security of quantum cryptography protocols gets related to the small difference between a world of matter and antimatter that itself can be attributed to the unsolved problem why we live in a universe dominated by matter.

In the last part of the talk I point out, why weakly decaying systems are a unique laboratory to study foundations of quantum mechanics, e.g. for testing decoherence models or collapse models [3] or for quantum information theoretic tasks [2].


Primary author: HIESMAYR, Beatrix (University of Vienna)

Presenter: HIESMAYR, Beatrix (University of Vienna)

Session Classification: Parallel 6: Foundations of Quantum Theory, 50 years Bell’s Inequalities
Measurement of the neutrino mixing angle $\theta_{13}$ with the Double Chooz detector

Tuesday, 2 December 2014 18:40 (30 minutes)

The $\theta_{13}$ parameter of the PMNS mixing matrix remained unknown until first hints and estimates by both Double Chooz and beam experiments in 2011. The Double Chooz reactor antineutrino experiment aims for a precise measurement of this parameter. Located at the Chooz nuclear power plant in France, it relies on a two identical detector measurement, canceling most of systematic uncertainties related to neutrino flux emission and detection. The near detector, located at a few hundred meters from the two reactor cores, aims to monitor the $\bar{\nu}_e$ flux from the cores. The far detector, located at a distance of about one kilometer from the reactor cores near the expected first maximum of the oscillation, measures an energy dependent deficit in the electron antineutrino spectrum. Different approaches are used to extract $\theta_{13}$: A combined rate and spectral shape analysis as well as a background-model-independent analysis based on reactor power variations. A unique feature of the Double Chooz experiment is, that it was the only one of the currently running $\theta_{13}$ reactor experiments observing a phase with both reactors off. This provides access to the background only measurement, allowing to crosscheck the background modes used in the oscillation analysis. New analysis enhancements resulted in the latest results of the experiment, based on far detector only measurement, published in summer 2014. In total 467.90 live days with 66.5 GW-ton-years of exposure, twice as much data compared to the last publication, the value of $\theta_{13}$ is measured to be $\sin^2 2\theta_{13} = 0.090^{+0.032}_{-0.029}$. Data taking in the near detector is about to start, enabling a significant reduction of both reactor and detector related systematics uncertainties in a near future.

Primary author: FRANKE, Michael

Presenter: FRANKE, Michael

Session Classification: Parallel 2: Neutrino mass and mixing, implications for astroparticle physics, dark matter searches
Welcome address: Mr C. Mottershead, Vice Principal Research & Innovation

Tuesday, 2 December 2014 09:00 (15 minutes)

Session Classification: PLENARY 1
In 2010 the MoEDAL experiment at the Large Hadron Collider (LHC) was unanimously approved by CERN’s Research Board to start data taking in 2015. MoEDAL is a pioneering experiment designed to search for highly ionizing avatars of new physics such as magnetic monopoles or massive (pseudo-)stable charged particles. Its groundbreaking physics program defines over 30 scenarios that yield potentially revolutionary insights into such foundational questions as: are there extra dimensions or new symmetries; what is the mechanism for the generation of mass; does magnetic charge exist; what is the nature of dark matter; and, how did the big-bang develop. MoEDAL’s purpose is to meet such far-reaching challenges at the frontier of the field.

The innovative MoEDAL detector employs unconventional methodologies tuned to the prospect of discovery physics. The largely passive MoEDAL detector, deployed at Point 8 on the LHC ring, has a dual nature. First, it acts like a giant camera, comprised of nuclear track detectors - analyzed off-line by ultra fast scanning microscopes - sensitive only to new physics. Second, it is uniquely able to trap the particle messengers of physics beyond the Standard Model for further study. MoEDAL’s radiation environment is monitored by a state-of-the-art real-time TimePix pixel detector array.

**Primary author:** PINFOLD, James (University of Alberta (CA))

**Presenter:** PINFOLD, James (University of Alberta (CA))

**Session Classification:** PLENARY 5
Closing - Announcement of Next Discrete 2016
Implications of Higgs mediated Flavour Changing Neutral Currents with Minimal Flavour Violation.

Thursday, 4 December 2014 17:05 (30 minutes)

We propose an extension of the hypothesis of Minimal Flavour Violation to two Higgs doublet Models without the assumption of Natural Flavour Conservation in the Higgs sector. The potentially dangerous flavour changing neutral currents are suppressed by small entries of the CKM matrix as a result of a discrete symmetry imposed to the Lagrangian. This discrete symmetry is also extended to the leptonic sector. We analyse the constraints and some of the phenomenological implication of this class of models.

Primary author: REBELO, Margarida Nesbitt (Instituto Superior Tecnico (IST))
Presenter: REBELO, Margarida Nesbitt (Instituto Superior Tecnico (IST))
Session Classification: Parallel 9: Higgs Physics @ LHC, discrete symmetries @LHC, new facilities
S3 and Q6 as flavour symmetries in multi-Higgs models

Thursday, 4 December 2014 19:05 (30 minutes)

We present an overview of the flavour groups S3 and Q6 in models with an extended Higgs sector. We extend the S3 results to SU(5) Grand Unified theories with Q6 as flavour group. We find the generic form of the mass matrices both in the quark and lepton sectors, which are consistent with experimental data. We reproduce, according to current data, the mixing in the CKM matrix. In the leptonic sector, the neutrino mixing angles are also found, in good agreement with experimental data.

Primary author: MONDRAGON, Myriam (urn:Google)
Presenter: MONDRAGON, Myriam (urn:Google)
Session Classification: Parallel 9: Higgs Physics @ LHC, discrete symmetries @LHC, new facilities
WIMPy baryogenesis with sterile neutrinos

Friday, 5 December 2014 16:30 (30 minutes)

We propose a mechanism for baryogenesis from particle decays or annihilations that can work at the TeV scale. Some heavy particles annihilate or decay into a heavy sterile neutrino $N$ (with $M \gtrsim 0.5$–1 TeV) and a "light" one $\nu$ (with $m \ll 100$–GeV), generating an asymmetry among the two helicity degrees of freedom of $\nu$. This asymmetry is partially transferred to Standard Model leptons via fast Yukawa interactions and reprocessed into a baryon asymmetry by the electroweak sphalerons. We illustrate this mechanism in a WIMPy baryogenesis model where the helicity asymmetry is generated in the annihilation of dark matter. This model connects the baryon asymmetry, dark matter, and neutrino masses.

Primary author: Mrs RIUS, Nuria (IFIC, Valencia University-CSIC)

Co-author: Mr RACKER, Juan (IFIC, Valencia University-CSIC)

Presenter: Mrs RIUS, Nuria (IFIC, Valencia University-CSIC)

Session Classification: Parallel 8: Early universe Physics (Inflation, Lepto(Baryo)genesis)

Track Classification: Neutrinos in cosmology and astroparticle physics
Some Open Questions on CP Violation and Flavour

We address some open questions on CP Violation and Flavour, including the nature and scale of New Physics and the origin of CP Violation. In the lepton sector, we conjecture that the observed pattern of leptonic mixing may just reflect a quasi-degeneracy of Majorana Neutrino Masses.

Primary author: BRANCO, Gustavo (Instituto Superior Tecnico)
Presenter: BRANCO, Gustavo (Instituto Superior Tecnico)
Session Classification: PLENARY 2
Track Classification: T, C, P, CP symmetries
History of Electroweak Symmetry Breaking

Thursday, 4 December 2014 12:30 (45 minutes)

In this talk, I will recall the history of the development of the unified electroweak theory, incorporating the symmetry-breaking Higgs mechanism, as I saw it from my standpoint as a member of Abdus Salam’s group at Imperial College. I will start by describing the state of physics in the years after the Second World War, explain how the goal of a unified gauge theory of weak and electromagnetic interactions emerged, the obstacles encountered, in particular the Goldstone theorem, and how they were overcome, followed by a brief account of more recent history, culminating in the historic discovery of the Higgs boson in 2012.

Primary author:  Prof. KIBBLE, Tom W.B. (Imperial College London)
Presenter:  Prof. KIBBLE, Tom W.B. (Imperial College London)
Session Classification:  PLENARY 3
Track Classification:  Higgs Physics at LHC and Beyond
Experimental particle physics in light of results from the LHC

Tuesday, 2 December 2014 10:00 (45 minutes)

I will concentrate on hadron colliders, although I will also discuss (briefly) neutrino physics, e+e- colliders etc

Primary author: VIRDEE, Jim (Imperial College Sci., Tech. & Med. (GB))
Presenter: VIRDEE, Jim (Imperial College Sci., Tech. & Med. (GB))
Session Classification: PLENARY 1

Track Classification: Experimental results from and prospects at LHC and new facilities.
Galileons and their Generalizations

Saturday, 6 December 2014 10:35 (45 minutes)

A new class of effective scalar field theories, with properties potentially interesting for cosmology, have emerged from attempts to modify gravity. I will discuss these “Galileon” field theories, emphasizing how they may be derived from the probe brane construction, and using this to generalize them to their associated curved-background and multi-field incarnations. I will comment on issues of stability, non-renormalization, coupling to gravity, and cosmological applications, and conclude by sketching how such terms can be constructed as Wess-Zumino terms of a particular type.

Primary author: TRODDEN, Mark (University of Pennsylvania)
Presenter: TRODDEN, Mark (University of Pennsylvania)
Session Classification: PLENARY 5
Track Classification: Cosmological aspects of non-commutative space-times
I will review recent observational results in particle astrophysics/cosmology, focussing on new data from Planck and from AMS-02 & IceCube, and discuss how the universe can be used as a laboratory for probing fundamental physics.

**Primary author:** Prof. SARKAR, S (University of Oxford (GB))

**Presenter:** Prof. SARKAR, S (University of Oxford (GB))

**Session Classification:** PLENARY 1
Unraveling the organization of the QCD tapestry

Wednesday, 3 December 2014 12:30 (45 minutes)

I will review recent progress in our understanding of the infrared dynamics of the QCD Green’s functions, derived from the close synergy between lattice simulations and Schwinger-Dyson equations. Particular attention will be devoted to the elaborate nonperturbative mechanisms that endow the fundamental degrees of freedom (quarks and gluons) with dynamical masses.

Primary author: PAPAVASSILIOU, Joannis (University of Valencia)
Presenter: PAPAVASSILIOU, Joannis (University of Valencia)
Session Classification: PLENARY 2
Track Classification: Strongly Coupled Gauge Theories
We are celebrating the 50 anniversary of the discovery of CP-Violation. The direct evidence of separate genuine Time-Reversal-Violating Asymmetries, independent of CP-Violation and CPT-Invariance, came recently in the transitions filtered by time-ordered decays of Entangled Neutral B-mesons. These Symmetry Breakings are understood in the quantum field theory of ElectroWeak Interactions in terms of the particle content. Quantum Mechanics does not preclude the possible Violation of the CPT-Theorem, but it needs a more subtle mechanism.

**Primary author:** BERNABEU, Jose (IFIC)  
**Presenter:** BERNABEU, Jose (IFIC)  
**Session Classification:** PLENARY 5  
**Track Classification:** T, C, P, CP symmetries
Experimental prospects for C, P, T, CP and CPT tests

The prospects for tests of C, P, and CP using triple product asymmetries in quark, charged lepton, and boson decay are discussed, and possibilities of testing CP, T and CPT with entangled pairs of neutral mesons will be reviewed.

Primary author:  BEVAN, Adrian (University of London (GB))
Presenter:  BEVAN, Adrian (University of London (GB))
Session Classification:  PLENARY 1
Summary and prospects of the LHCb Experiment

Friday, 5 December 2014 12:30 (45 minutes)

The physics highlights of the LHCb experiment will be reviewed, based on results from up to 3 fb^-1 of pp-collision data. Measurements of the angles of the unitary triangle will be highlighted, together with limits on new physics from rare b-decays, plus the observation of new baryonic states. Physics prospects for the upcoming Run-2 and the LHCb upgrade will also be summarized.

Primary author: Prof. HARNEW, Neville (University of Oxford (GB))
Presenter: Prof. HARNEW, Neville (University of Oxford (GB))
Session Classification: PLENARY 4

Track Classification: Experimental results from and prospects at LHC and new facilities.
Half a Century with CP Violation

Wednesday, 3 December 2014 09:00 (45 minutes)

The speaker intends to present a “historical” talk on CP violation discussing what have been the most important lessons learned so far and what can be said about the future prospects in this field.

Primary authors:  JARLSKOG, Cecilia (Unknown);  Prof. JARLSKOG, cecilia (lund university)

Presenter:  Prof. JARLSKOG, cecilia (lund university)

Session Classification:  PLENARY 2

Track Classification:  T, C, P, CP symmetries
Discrete Symmetries in String/M theory and Grand Unification

After reviewing the origin of discrete symmetries like B and L and CP in string/M theory we go on to address the origin and fate of such symmetries in phenomenological Grand Unified models which derive from string/M theory. The impact on the nature of dark matter and other phenomenological consequences is discussed.

Primary author: ACHARYA, Bobby Samir (Abdus Salam Int. Cent. Theor. Phys. (IT))
Presenter: ACHARYA, Bobby Samir (Abdus Salam Int. Cent. Theor. Phys. (IT))
Session Classification: PLENARY 4
Track Classification: Supersymmetry/Supergravity/Strings and Branes
Testing Non-minimal Higgs sector at Colldiers

Thursday, 4 December 2014 11:45 (45 minutes)

Testing models with Higgs doublets at LHC will be discussed. I will focus on the Inert Doublet Model, with the exact Z2 symmetry, which offers viable Dark Matter candidates. LHC data together with Planck results on relic density provide very strong constraints on DM mass and its coupling to the Higgs boson. Some results on the potential of ILC in testing such models will be shown as well.

Primary author: Prof. KRAWCZYK, Maria (Institute of Theoretical Physics, Warsaw University)
Presenter: Prof. KRAWCZYK, Maria (Institute of Theoretical Physics, Warsaw University)
Session Classification: PLENARY 3
Track Classification: Higgs Physics at LHC and Beyond
Discrete Glimpses of the Physics Landscape after the Higgs Discovery

Tuesday, 2 December 2014 09:15 (45 minutes)

The discovery of a Higgs boson at the LHC raises (almost) as many questions as it answers. Is it an elementary particle, or composite? Are there other Higgs bosons? Is the vacuum stable? Are there other particles at the TeV scale waiting to be discovered at the LHC or in dark matter experiments? This talk will answer none of these questions.

Primary author: ELLIS, Jonathan R. (CERN)
Presenter: ELLIS, Jonathan R. (CERN)
Session Classification: PLENARY 1
Track Classification: Higgs Physics at LHC and Beyond
Symmetry Improved CJT Effective Potential

Thursday, 4 December 2014 09:45 (45 minutes)

The formalism introduced by Cornwall, Jackiw and Tomboulis (CJT) provides a systematic analytic approach to consistently describing non-perturbative effects in Quantum Thermal Field Theory. One major limitation of the CJT effective action is that its loopwise expansion introduces residual violations of possible global symmetries, thus giving rise to massive Goldstone bosons in the spontaneously broken phase of the theory. In my talk I will present a novel symmetry-improved CJT formalism which consistently encodes global symmetries in a loopwise expansion. Unlike other methods, I will illustrate how the symmetry-improved CJT effective action satisfies a number of important field-theoretic properties, such as the masslessness of the Goldstone boson and the fact that the phase transition is of second order in O(N) theories, already in the Hartree-Fock approximation. After taking the sunset diagrams into account, I show how the symmetry-improved CJT approach properly describes the threshold properties of the massless Goldstone boson and the Higgs particle within quantum loops. Finally, I will briefly outline the derivation of a symmetry-improved CJT effective potential, in which new topologies of infinite class of graphs can be resummed that go well beyond the standard Coleman–Weinberg effective potential. [This presentation is based on my paper with Daniele Teresi, Nucl. Phys. B874 (2013) 594.]

Primary author: PILAFTSIS, Apostolos (University of Manchester (GB))
Co-author: TERESI, Daniele (University of Manchester)
Presenter: PILAFTSIS, Apostolos (University of Manchester (GB))
Session Classification: PLENARY 3
Track Classification: Strongly Coupled Gauge Theories
Status of the quark-gluon plasma and heavy-ion results from the LHC.

I review the status of quark-gluon plasma and heavy ion results from the Large Hadron Collider.

**Primary author:** EVANS, David (University of Birmingham (GB))

**Presenter:** EVANS, David (University of Birmingham (GB))

**Track Classification:** Strongly Coupled Gauge Theories
Neutrinos and Leptogenesis in the Early Universe

Saturday, 6 December 2014 11:50 (45 minutes)

Neutrino mass models can explain the origin of the baryon asymmetry in the Universe, via the leptogenesis mechanism. A review of its main features and of the possible connection between low energy leptonic CP-violation and the one responsible for the baryon asymmetry will be presented.

Primary author: PASCOLI, Silvia (University of Durham (GB))
Presenter: PASCOLI, Silvia (University of Durham (GB))
Session Classification: PLENARY 5
Track Classification: Neutrinos in cosmology and astroparticle physics
Supergravity: status and prospects

Friday, 5 December 2014 09:00 (45 minutes)

I give a review of Supergravity theories with emphasis on recent developments and prospects.

Primary author: DERENDINGER, Jean-Pierre (Universitaet Bern (CH))
Presenter: DERENDINGER, Jean-Pierre (Universitaet Bern (CH))
Session Classification: PLENARY 4
Track Classification: Supersymmetry/Supergravity/Strings and Branes
Adaptation of the Hamilton-Jacobi formalism to quantum mechanics yields a cocycle condition which is invariant under D-dimensional Mobious transformations. The invariance under Mobious transformations can only be implemented consistently if space is compact and implies energy quantisation and undefinability of quantum trajectories. It implies the existence of a fundamental length scale that may be identified with the Planck length. Consistency of phase space duality is a complementary facet of the formalism and may serve as the fundamental physical principle underlying quantum mechanics. Evidence for the compactness of space may exist in the cosmic microwave background radiation.
Axiverse-induced dark radiation problem

Thursday, 4 December 2014 19:05 (30 minutes)

String theory suggests that cosmology is populated by many light pseudoscalar axions (an “Axiverse” scenario). Their presence in early universe give rise to dark radiation, non-standard model contribution to radiation imprinted onto Cosmic Microwave Background (CMB). Due to complexity of string compactification, it is natural to expect number of axions to be several hundreds up to thousands. Although there have been hints of dark radiation from Planck satellite and WMAP experiment, we show in this talk that large number of axions in typical axiverse scenario produces dark radiation much larger than observable value. Motivated by this problem, we study moduli space of compactified manifolds allowing by this constraint. We show that G2 manifold can relax strong dependency between number of axions and dark radiation. In addition, under plausible condition on moduli mass matrix, a compactified manifold with sufficiently large number of axions gives a phenomenologically acceptable value of dark radiation. The application on G2 compactified M-theory is also presented in great detail.

Primary author: PONGKITIVANICHKUL, Chakrit (King's College London)

Presenter: PONGKITIVANICHKUL, Chakrit (King’s College London)

Session Classification: Parallel 10: LHC and dark matter experiments
SO(10) Grand Unification from M-theory on a G2-manifold

We consider Grand Unified Theories based on SO(10) which originate from M-theory on G2-manifolds. In this framework we are naturally led to a novel solution of the doublet-triplet splitting problem involving an extra $16_X, T\bar{6}_X$ vector-like pair by considering discrete symmetries of the extra dimensions and preserving unification. Since Wilson line breaking preserves the rank of the gauge group, the necessary $U(1)$ gauge breaking is generated from extra multiplets. The main prediction of the approach is the existence of light states with the quantum numbers of a $16_X, T\bar{6}_X$ vector-like pair which could show up in future LHC searches.

**Primary author:** CRISPIM ROMAO, Miguel (University of Southampton)

**Presenter:** CRISPIM ROMAO, Miguel (University of Southampton)

**Session Classification:** Parallel 14: Discrete Symmetries in Strings and in GUT theories

**Track Classification:** Supersymmetry/Supergravity/Strings and Branes
At extreme energy densities, hadronic matter undergoes a phase transition into a deconfined system of quarks and gluons, known as a Quark-Gluon Plasma (QGP). Such a state of matter may be formed by colliding ultra-relativistic heavy-ions together, which reproduce the high temperatures and densities thought to have existed about ten microseconds after the Big Bang. Lead ions have been accelerated and collided in the Large Hadron Collider (LHC) at CERN in order to allow experiments to study of the properties of the QGP. Data from proton-proton and proton-lead collisions, where no QGP formation is expected, have also been collected and analysed as a comparison to the lead-lead data.

A brief summary of some of the main results from lead-lead collisions, at the LHC, will be presented together with relevant results from proton-proton and proton-lead collisions.

Primary author: EVANS, David (University of Birmingham (GB))
Presenter: EVANS, David (University of Birmingham (GB))
Session Classification: PLENARY 3