Contents

part1 ................................. 1
Lunch break ........................................ 1
Why do we have three Families? – E_7 Surprise ................. 1
Neutrinoless Double Beta Decay Searches: Status and Prospects ................. 1
Radiative neutrino mass models and the flavour anomalies ................. 1
Combined explanations of Flavor Anomalies ......................... 1
Visualisation tools and the B-anomalies ......................... 1
The prospect of Belle II ........................................ 2
Leptonic CP Phase Measurement and Non-Standard Interactions ................. 2
Probing sterile neutrino in meson decays with and without sequential neutrino decay ................. 2
Status of Light Sterile Neutrinos ........................................ 2
Origin of non-standard and general neutrino interactions ......................... 2
Neutrinos as the gate to new physics ........................................ 3
Collider tests of low scale seesaw models ......................... 3
Double Beta Decay and TeV Scale Physics ........................................ 3
Lorentz violation from cosmic photons and neutrinos ......................... 3
Baryogenesis From Flavon Decays ........................................ 3
Direct Detection Prospects for the Cosmic Neutrino Background ......................... 3
Highlights of Recent LHCb Results on Heavy Flavor and CPV ......................... 4
Direct CP violation in charmed meson decays ......................... 4
Charmed baryon weak decays with SU(3) flavor symmetry ......................... 4
CP violation in charm ........................................ 4
Fermion mass ratios from non-renormalizable Yukawa operators in SO(10) ......................... 4
An imprint of SO(10) on the MSSM spectrum ........................................... 5
Lopsided texture compatible with thermal leptogenesis in partially composite Pati–Salam unification .................................................. 5
Antitriplet charmed baryon decays with SU(3) flavor symmetry ...................... 5
Scotogenic Dirac Neutrino Masses and Mixing ........................................... 5
Dark matter stability and Dirac neutrinos using only Standard Model symmetries ........................................................................... 6
Sequentially loop-generated pattern of quark and lepton masses in models with extended symmetries .................................................. 6
Modular Invariance and Neutrino Masses .................................................... 6
Quark and lepton flavors in A4 modular invariance ....................................... 6
Generalised CP Symmetry in Modular-Invariant Models of Flavour ............... 6
Dark matter direct detections in the presence of non-standard neutrino interactions ................................................................. 7
part5 ............................................................................................................. 7
part3 ............................................................................................................. 7
Baryonic B decays ....................................................................................... 7
Three-body charmed baryon Decays with SU(3) flavor symmetry ................... 7
part2 ............................................................................................................. 7
part3 ............................................................................................................. 8
part6 ............................................................................................................. 8
Recent Developments in Neutrino Models .................................................... 8
CP violation from string .............................................................................. 8
Origin of non-Abelian discrete flavour symmetries ....................................... 8
Prospects of charm physics at tau-charm facility ......................................... 8
Effective Field Theory Approach to Lepton Number Violation ...................... 9
Flavor Violating Higgs Couplings .............................................................. 9
The DAMPE mission and its first results ................................................. 9
Status and prospects of CDEX experiments at CJPL .................................. 9
S3 symmetry with extended Higgs sectors: Dark matter and leptogenesis .... 9
Probing dark matter through cosmic-ray anti-nuclei ..................................... 9
Modular $A_5$ Symmetry for Flavour Model Building .................................. 10
Thermodynamics of $f(R)$ Gravity with Disformal Transformation .......................... 16
Asymptotic behaviors of neutrino mixing in dense matter ............................................ 16
Dissecting a derivative $\Delta L = 2$ effective operator: 3-loop neutrino masses and their links to dark matter .......................... 17
Observational Constraints on Secret Neutrino Interactions from Big Bang Nucleosynthesis .......................................................... 17
$N_1+N_2$-leptogenesis in $\Delta(27)$ with a universal texture zero .................................. 18
Lepton Phenomenology from $A_5$ and $CP$ ................................................................. 18
An imprint of $SO(10)$ on the MSSM spectrum ......................................................... 18
Fermion mass ratios from non-renormalizable Yukawa operators in $SO(10)$ ................ 19
Origin of non-Abelian discrete flavour symmetries ..................................................... 19
Lopsided texture compatible with thermal leptogenesis in partially composite Pati–Salam unification .......................................................... 19
Generalized CP and Lepton Mixing .................................................................................. 20
Leptonic Unitarity Triangle, Geometrical Neutrino Oscillation and CP Violation .......... 20
Search for new physics with coherent elastic neutrino-nucleus scattering ...................... 20
Prospects for Supernova Neutrino Detection ................................................................ 20
part5 ............................................................................................................................ 21
part6 ............................................................................................................................ 21
Addressing flavor symmetries of neutrinos at DUNE .................................................... 21
The tri-direct littlest seesaw model with the precision measurement ......................... 21
$N_1+N_2$-leptogenesis in $\Delta(27)$ with a universal texture zero .................................. 21
Asymptotic behaviors of neutrino mixing in dense matter ............................................ 21
Probing heavy neutrino oscillation and associated CP violation at future hadron colliders .................................................................... 22
part6 ............................................................................................................................ 22
Vector-like lepton dark matter, neutrino mass and collider signatures ......................... 22
Dissecting a derivative $\Delta L = 2$ effective operator: 3-loop neutrino masses and their links to dark matter .......................... 22
General $SU(N)$ Scotogenic (non-)Supersymmetric and CFT Models .......................... 22
Observational Constraints on Secret Neutrino Interactions from Big Bang Nucleosynthesis .......................................................... 23
Thermodynamics of $f(R)$ Gravity with Disformal Transformation .......................... 23
Probing heavy neutrino oscillation and associated CP violation at future hadron colliders

\( (g-2)_{\mu} \) Versus Flavor Changing Neutral Currents Induced by the Light (B-L) \( \mu \tau \) Boson

Welcome

Concluding remark
part1

Lunch break

Morning session I / 3

*Why do we have three Families? – E_7 Surprise*

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Afternoon session I / 4

*Neutrinoless Double Beta Decay Searches: Status and Prospects*

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Morning session I / 5

*Radiative neutrino mass models and the flavour anomalies*

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Morning session I / 6

*Combined explanations of Flavor Anomalies.*

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Morning session I / 7

*Visualisation tools and the B-anomalies*
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Morning session II / 8

The prospect of Belle II

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Afternoon session I / 9

Leptonic CP Phase Measurement and Non-Standard Interactions

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Afternoon session II / 10

Probing sterile neutrino in meson decays with and without sequential neutrino decay

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Afternoon session II / 11

Status of Light Sterile Neutrinos

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Morning session I / 12

Origin of non-standard and general neutrino interactions

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Morning session I / 13

Neutrinos as the gate to new physics

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Morning session I / 14

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Morning session I / 15

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Morning session II / 16

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Morning session I / 17

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**Fermion mass ratios from non-renormalizable Yukawa operators in SO(10)**

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Parallel session / 24

**An imprint of SO(10) on the MSSM spectrum**

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Parallel session / 25

**Lopsided texture compatible with thermal leptogenesis in partially composite Pati–Salam unification**

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Parallel session / 26

**Antitriplet charmed baryon decays with SU(3) flavor symmetry**

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Morning session I / 27

**Scotogenic Dirac Neutrino Masses and Mixing**

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**Morning session I / 28**

**Dark matter stability and Dirac neutrinos using only Standard Model symmetries**

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**Morning session I / 29**

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**Morning session II / 30**

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**Morning session II / 31**

**Quark and lepton flavors in A4 modular invariance**

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**Morning session II / 32**

**Generalised CP Symmetry in Modular-Invariant Models of Flavour**

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Morning session II / 33

Dark matter direct detections in the presence of non-standard neutrino interactions

Author: Wei Chao

Afternoon session I / 34

part5

Afternoon session I / 35

part3

Afternoon session I / 36

Baryonic B decays

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Parallel session / 37

Three-body charmed baryon Decays with SU(3) flavor symmetry

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Parallel session / 38

part2
Parallel session / 39

part5

Parallel session / 40

part6

Morning session I / 41

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Morning session I / 42

CP violation from string

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Morning session I / 43

Origin of non-Abelian discrete flavour symmetries

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Morning session II / 44

Prospects of charm physics at tau-charm facility

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Morning session II / 45

Effective Field Theory Approach to Lepton Number Violation

Morning session II / 46

Flavor Violating Higgs Couplings

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Afternoon session I / 47

The DAMPE mission and its first results

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Afternoon session I / 48

Status and prospects of CDEX experiments at CJPL

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Afternoon session I / 49

S3 symmetry with extended Higgs sectors: Dark matter and leptogenesis

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Afternoon session I / 50

Probing dark matter through cosmic-ray anti-nuclei

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Parallel session / 51

Modular $A_5$ Symmetry for Flavour Model Building

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Parallel session / 52

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Parallel session / 53

Lepton Phenomenology from A5 and CP

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Parallel session / 54

Generalized CP with texture zeros and their phenomenology

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Morning session I / 55

From Daya Bay to JUNO: the quest for neutrino mass ordering

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New results from the EXO-200 experiment

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“Zeroing” the minimal seesaw and the 2HDM with Dirac neutrinos

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KeV fermion from a simple 3-portal model

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Flavourful axion phenomenology

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Flavor dependent U(1) gauge symmetry and related phenomenology

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Scalar doublets charged under mu-tau-philic $Z_n$ flavor symmetry

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Parallel session / 68

part3

Parallel session / 69

part4

Morning session I / 70

Haibo Li: Hyperon physics at BESIII

Morning session II / 71

Hyperon decays: The next frontier for CP violation studies(?)

Author: Stephen Lars Olsen

Morning session I / 72

Some recent studies on the neutrino mu-tau reflection symmetry

Author: Zhen-hua Zhao

Morning session II / 73

Recent results and status of PandaX experiments

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Morning session II / 74

Scalar Electroweak Multiplet Dark Matter

Author: Michael Ramsey-Musolf

Morning session I / 75
Searching for Dark Photon Dark Matter with Gravitational Wave Detectors

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Afternoon session II / 76

cLFV on target at GeV scale electron/positron beam experiment

Author: Wei Liao

77

Trimaximal Neutrino Mixing from Modular $A_4$ Invariance with Residual Symmetries

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We construct phenomenologically viable models of lepton masses and mixing based on modular $A_4$ invariance broken to residual symmetries $Z_T^3$ or $Z_{ST}^3$ and $Z_S^2$ respectively in the charged lepton and neutrino sectors. In these models the neutrino mixing matrix is of trimaximal mixing form. In addition to successfully describing the charged lepton masses, neutrino mass-squared differences and the atmospheric and reactor neutrino mixing angles $\theta_{23}$ and $\theta_{13}$, these models predict the values of the lightest neutrino mass (i.e., the absolute neutrino mass scale), of the Dirac and Majorana CP violation (CPV) phases, as well as the existence of specific correlations between i) the values of the solar neutrino mixing angle $\theta_{12}$ and the angle $\theta_{13}$ (which determines $\theta_{12}$), ii) the values of the Dirac CPV phase $\delta$ and of the angles $\theta_{23}$ and $\theta_{13}$, iii) the sum of the neutrino masses and $\theta_{23}$, iv) the neutrinoless double beta decay effective Majorana mass and $\theta_{23}$, and v) between the two Majorana phases.

78

General $SU(N)$ Scotogenic (non-)Supersymmetric and CFT Models

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Generalization of the scotogenic neutrino mass model in the supersymmetric, non-supersymmetric, and CFT framework is presented, where Standard Model gauge group $SU(3)_c \otimes SU(2)_L \otimes U(1)_Y$ is extended by $SU(N)_D$ dark gauge symmetry that stabilizes dark matter with $N \geq 2$. Neutrino masses are generated via dim-5 Weinberg effective operator, $\langle LH \rangle \langle LH \rangle$, therefore the $SU(N)_D$ gauge symmetry can be spontaneously broken as well as unbroken. We also discuss the embedding
of $G_{SM} \otimes SU(N)_D$ gauge group into Grand Unified Theory (GUT) and gauge coupling unification.

79

Addressing flavor symmetries of neutrinos at DUNE.

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Symmetry-based studies have been very successful to explain the observed mixing pattern of neutrinos. Among number of such approaches, mu-tau reflection symmetry, which predicts $\theta_{23} = \pi/4$, $\delta = \pm \pi/2$ together with non-zero $\theta_{13}$, attracts a lot of attention in recent times. In this talk, we will discuss the consequences of such symmetry for DUNE. We aim to talk about DUNE’s potential to measure the precision of $\theta_{23}$ and $\delta$ for the given symmetry. Moreover, the latest results of the global best-fit value of neutrino oscillation data favor non-maximal values of $\theta_{23}$ and $\delta$. In order to understand the realistic leptonic mixing patterns, one can generalize such symmetry. In this context, we will talk about generalized CP symmetries and the capabilities of the DUNE in probing leptonic CP violation within this framework. Finally, we will also discuss the status and prospects of ‘bi-large’ leptonic mixing pattern considering DUNE.

80

Antitriplet charmed baryon decays with SU(3) flavor symmetry

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We study the decays of the antitriplet charmed baryon state ($\Xi_{c0}, \Xi_{c+}, \Lambda_{c+}$) based on the SU(3) flavor symmetry. In particular, after predicting $B(\Xi_{c0} \rightarrow \Xi^{-}\pi^{+}) = (15.7 \pm 0.7) \times 10^{-3}$ and $B(\Xi_{c+} \rightarrow \Xi^{-}\pi^{+}\pi^{0}) = (14.7 \pm 8.4) \times 10^{-3}$, we extract that $B(\Xi_{c0} \rightarrow \Lambda K^{-}\pi^{+}, \Lambda K^{-}\pi^{+}\pi^{0}, \Xi^{0}e^{+}\nu_{e}) = (16.8 \pm 2.3, 0.45 \pm 0.11, 48.7 \pm 17.4) \times 10^{-3}$ and $B(\Xi_{c+} \rightarrow pK_{S}0K_{S}, \Sigma^{+}K^{-}\pi^{+}, \Xi^{0}\pi^{+}\pi^{0}, \Xi^{0}e^{+}\nu_{e}) = (1.3 \pm 0.8, 13.8 \pm 8.0, 33.8 \pm 21.9, 33.8 \pm 22.6) \times 10^{-3}$. We also find that $B(\Xi_{c0} \rightarrow \Xi^{0}\eta, \Xi^{0}\eta') = (1.7 \pm 1.7, 10.8 \pm 6.3, 11.0) \times 10^{-3}$ and $B(\Xi_{c0} \rightarrow \Lambda \eta^{0}, \Lambda \eta^{0}) = (1.6 \pm 0.8, 1.2, 9.4 \pm 6.8, 11.6) \times 10^{-4}$ and $B(\Xi_{c+} \rightarrow \Sigma^{+}\eta, \Sigma^{+}\eta') = (28.4 \pm 6.9, 8.2, 13.2, 11.9, 24.0) \times 10^{-4}$. These $\Xi_{c}$ decays with the branching ratios of $O(10^{-3} - 10^{-4})$ are clearly promising to be observed by the BESIII and LHCb experiments.

81

Three-body charmed baryon Decays with SU(3) flavor symmetry

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We study the three-body anti-triplet $Bc \to BnM M'$ decays with the SU(3) flavor (SU(3)$_f$) symmetry, where $Bc$ denotes the charmed baryon anti-triplet of $(\Xi_c^0, -\Xi_c^+, \Lambda_c^+)$, and $Bn$ and $M(M')$ represent baryon and meson octets, respectively. By considering only the S-wave $MM'$-pair contributions, the decays of $Bc \to BnM M'$ can be decomposed into irreducible forms with 11 parameters under SU(3)$_f$, which are fitted by the 14 existing data, resulting in a reasonable value of $\chi^2$/d.o.f = 2.8 for the fit. Consequently, we find that the triangle sum rule of $A(\Lambda_c^+ \to n{\bar K}^0\pi^+)-A(\Lambda_c^+ \to pK^-\pi^+)-\sqrt{2}A(\Lambda_c^+ \to p{\bar K}^0\pi^0) = 0$ given by the isospin symmetry holds under SU(3)$_f$, where $A$ stands for the decay amplitude. In addition, we predict that $B(\Lambda_c^+ \to n\pi^+{\bar K}^0) = (0.9 \pm 0.8) \times 10^{-2}$, which is (3-4) times smaller than the BESIII observation, indicating the existence of the resonant states. For the to-be-observed $Bc \to BnM M'$ decays, we compute the branching fractions with the SU(3)$_f$ amplitudes to be compared to the BESIII and LHCb measurements in the future.

82

Thermodynamics of f (R) Gravity with Disformal Transformation

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We study thermodynamics in f(R) gravity with the disformal transformation. The transformation applied to the matter Lagrangian has the form of $g_{mn} = A(\phi, X) g_{mn} + B(\phi, X) \partial_m \phi \partial_n \phi$ with the assumption of the Minkowski matter metric $g_{mn} = \eta_{mn}$, where $\phi$ is the disformal scalar and $X$ is the corresponding kinetic term of $\phi$. We verify the generalized first and second laws of thermodynamics in this disformal type of f(R) gravity in the Friedmann-Lemaître-Robertson-Walker (FLRW) universe. In addition, we show that the Hubble parameter contains the disformally induced terms, which define the effectively varying equations of state for matter.

83

Asymptotic behaviors of neutrino mixing in dense matter

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As we all know, it is convenient to define the effective lepton flavor mixing matrix $\tilde{U}$ and neutrino mass-squared differences $\Delta_{ji} \equiv \tilde{m}_{ji}^2 - \tilde{m}_{ai}^2$ (for $i, j = 1, 2, 3$) to describe the phenomena of neutrino mixing and flavor oscillations in a medium. In this talk, I will discuss the asymptotic behaviors of $|\tilde{U}_{\alpha i}|^2$ and $\Delta_{ji}$ (for $\alpha = e, \mu, \tau$ and $i, j = 1, 2, 3$) in very dense matter (namely, allowing the matter parameter $A = 2\sqrt{2} G_F N_e E$ to mathematically approach infinity). The final conclusion is that $\tilde{U}$ contains only a single degree of freedom in this extreme case, with no CP violation in neutrino
oscillations. The key point is to clarify the confusion associated with the parameter redundancy of
\( \theta_{12}, \theta_{13}, \theta_{23} \) and \( \delta \) in the standard parametrization of \( U \).

84

Dissecting a derivative \( \Delta L = 2 \) effective operator: 3-loop neutrino masses and their links to dark matter

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Scenarios with radiatively induced neutrino masses via dark matter interactions link two separate physical phenomena that each requires physics beyond the Standard Model. In addition to having a dark matter candidate, these scenarios provide a natural explanation to the smallness of neutrino masses compared to the electroweak scale. We here investigate the framework where the new physics that breaks lepton number and induces neutrino masses couples only to the charged right-handed leptons in Standard Model. The unique lowest order operator that describes this framework is a dimension \( D = 9 \) lepton number breaking effective derivative operator \( O_9 \). We find that there are only two possible classes of new physics that can emerge in the UV completions of the \( O_9 \) operator that induce neutrino masses at 3-loop level with virtual dark matter particles in the process. We discuss the generic constraints and predictions of the different realizations in each class. In particular we analyze the important interplay between neutrino mixing and neutrinoless double-\( \beta \) decay in order to either rule out models or predict characteristic beyond standard model signals.

85

Observational Constraints on Secret Neutrino Interactions from Big Bang Nucleosynthesis

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We investigate possible interactions between neutrinos and massive scalar bosons via \( g_\phi \bar{\nu} \nu \phi \) (or massive vector bosons via \( g_V \gamma^\mu \gamma^\nu \nu V^\mu \)) and explore the allowed parameter space of the coupling constant \( g_\phi \) (or \( g_V \)) and the scalar (or vector) boson mass \( m_\phi \) (or \( m_V \)) by requiring that these secret neutrino interactions (SNIs) should not spoil the success of Big Bang nucleosynthesis (BBN). Incorporating the SNIs into the evolution of the early Universe in the BBN era, we numerically solve the Boltzmann equations and compare the predictions for the abundances of light elements with observations. It turns out that the constraint on \( g_\phi \) and \( m_\phi \) in the scalar-boson case is rather weak, due to a small number of degrees of freedom. However, in the vector-boson case, the most stringent bound on the coupling \( g_V < 6 \times 10^{-10} \) at 95% confidence level is obtained for \( m_V \approx 1 \) MeV, while the bound becomes much weaker \( g_V < 8 \times 10^{-6} \) for smaller masses \( m_V < 10^{-3} \) MeV. Moreover, we discuss in some detail how the SNIs affect the cosmological evolution and the abundances of the lightest elements.
N₁+N₂-leptogenesis in $\Delta(27)$ with a universal texture zero

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We investigate the possibility of viable leptogenesis in an appealing $\Delta(27)$ model with a universal texture zero. The model accommodates the mass spectrum, mixing and CP phases for both quarks and leptons and allows for grand unification. Flavoured Boltzmann equations for the lepton asymmetries are solved numerically, taking into account both $N₁$ and $N₂$ right-handed neutrino decays. We show that leptogenesis is separately possible in either the $N₁$ and $N₂$ dominated scenarios, with the asymmetry in the electron flavour protected from the $N₁$-washout by the texture zero. The two viable regions of the parameter space are $M₁ \in [10^9, 10^{12}]$, with $M₁/M₂ \in [0.002, 0.1]$, and $M₁ \in [10^9, 10^{10}]$, with $M₁/M₂ < 0.002$ and $M₂$ relatively close to $M₃$, which however is not a natural expectation of the $\Delta(27)$ model. We conclude that the $N₁$-dominated scenario is successful and the most natural option for the model.

Lepton Phenomenology from A5 and CP

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We analyse in detail the phenomenological implications for lepton masses and mixing derived by the breaking of the discrete symmetries $A_5$ and CP into the subgroups $Z₂ \times CP$ in the neutrino sector and $Z₅$ in the charged lepton sector. We derive accurate analytic expressions for the sum of the neutrino masses as well as the effective Majorana masses. The consequences of embedding the flavor symmetry in a supersymmetric framework are also investigated. In particular, a nice complementarity between neutrino and charged-lepton observables is found in this context, with non-trivial relations among them.

An imprint of SO(10) on the MSSM spectrum

Authors: Stefan Antusch$^1$; Christian Hohl$^1$; Vasja Susič$^1$

$^1$ University of Basel
A feature of some SUSY SO(10) models is t-b-tau unification of Yukawa couplings. We present an interesting effect of this unification on the sparticle spectrum of the Minimal Supersymmetric Standard Model. As a consequence, experimentally discovering such a pattern in the MSSM superpartner masses could provide the first hint of SO(10) unification at high energies.

Fermion mass ratios from non-renormalizable Yukawa operators in SO(10)

Authors: Christian Hohl; Stefan Antusch; Vasja Susič

Since the 16 of SO(10) contains all fermions of one generation in the Standard Model, models where one operator dominates each Yukawa entry have the potential to predict the mass ratios between all fermion types. We analyse here a class of non-renormalizable SO(10) Yukawa operators, containing the Higgs field in one of the representations 10, 120 and 126, and with an arbitrary power of the representations 45 and 210 acquiring SM singlet vevs. We discuss how to build predictive models using such operators. Finally we present a simplified example of such models in supersymmetry and show that they already provide some predictions for the MSSM sparticle spectrum.

Origin of non-Abelian discrete flavour symmetries

Author: Ye-Ling Zhou

Non-Abelian discrete symmetries, due to their powerful predictions in flavour mixing, have been widely used in flavour model building. However, there are a few question marks surrounding the use of such symmetries in particle physics. The first and most obvious question is from where do such symmetries originate. I will discuss two different potential origins: 1) extra dimensional space time motivated from string theory, and 2) continuous symmetry breaking. Specifically, I will introduce a gauged SO(3)xU(1) flavour model. It goes through two-step symmetry breaking, SO(3) to A4 and A4 to Z2/Z3. The model is consistent with oscillation data and predicts sum rules of mixing parameters. It further 1) solves the cosmological domain wall problem, a well-known problem for discrete symmetry breaking, and 2) predicts three degenerate gauge bosons and another Z' with specifically cLFV interactions.

Lopsided texture compatible with thermal leptogenesis in partially composite Pati–Salam unification

Author: Masaki J.S. Yang
In this study, we consider a lopsided flavor texture compatible with thermal leptogenesis in partially composite Pati–Salam (PS) unification. The Davidson–Ibarra bound $M_{\nu R 1} \gtrsim 10^9$ GeV for the successful thermal leptogenesis can be recast to the Froggatt–Nielsen (FN) charge of the lopsided texture. We found the FN charge $n_{\nu 1}$ of the lightest right-handed neutrino $\nu_{R 1}$ cannot be larger than an upper bound, $n_{\nu 1} \lesssim 4.5$.

To realize these FN charges in the PS GUT, we utilize the partial compositeness. In this picture, the hierarchies of the Yukawa matrices is a consequence of mixing between massless chiral fermions $f$ and heavy vector fermions $F$. This is induced by the linear mixing terms $\lambda f \bar{f} L F_R$ and $\lambda f' \bar{f}' L F'_R$. If the GUT breaking Higgs contributes these linear mixing the resulting Yukawa interactions can be different between quarks and leptons.

For this purpose, we use the bi-fundamental Higgs $H_R (4,1,2)$ under the PS group $G_{PS} = SU(4)_c \times SU(2)_L \times SU(2)_R$. In order to mediate GUT breaking effect to the Yukawa interactions, exotic fermions $(6,1,1) + (1,2,2)$, that corresponds to 10 representation in $SO(10)$ are introduced. Mixing between heavy composites and exotics induces desirable mass and mixing structures.

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**Generalized CP and Lepton Mixing**

Author: Peng Chen

Co-author: et al

We study the implications of generalized CP transformations acting on the mass matrices of charged leptons and neutrinos respectively in a model–independent way. Generalized $e^{-\mu}$, $e^{-\tau}$ and $\mu^{-\tau}$ symmetries are considered in detail.

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**Afternoon session I / 93**

**Leptonic Unitarity Triangle, Geometrical Neutrino Oscillation and CP Violation**

Author: Hong-Jian He

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**Morning session I / 94**

**Search for new physics with coherent elastic neutrino-nucleus scattering**

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Morning session II / 95

Prospects for Supernova Neutrino Detection

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Parallel session / 96

part5

Parallel session / 97

part6

Parallel session / 98

Addressing flavor symmetries of neutrinos at DUNE.

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Parallel session / 99

The tri-direct littlest seesaw model with the precision measurement

Author: TseChun Wang\textsuperscript{None}

Parallel session / 100

N1+N2-leptogenesis in $\Delta(27)$ with a universal texture zero

Author: Aurora Melis\textsuperscript{None}

Parallel session / 101
Asymptotic behaviors of neutrino mixing in dense matter

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Parallel session / 102

Probing heavy neutrino oscillation and associated CP violation at future hadron colliders

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Parallel session / 103

Vector-like leptonic dark matter, neutrino mass and collider signatures

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Parallel session / 104

Dissecting a derivative $\Delta L = 2$ effective operator: 3-loop neutrino masses and their links to dark matter

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Parallel session / 105

General SU(N) Scotogenic (non-)Supersymmetric and CFT Models

Author: Oleg Popov
Parallel session / 107

Observational Constraints on Secret Neutrino Interactions from Big Bang Nucleosynthesis

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Parallel session / 108

Thermodynamics of f (R) Gravity with Disformal Transformation

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Parallel session / 109

Probing heavy neutrino oscillation and associated CP violation at future hadron colliders

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Heavy neutrinos are essential ingredients of type-I seesaw mechanism, and the heavy neutrino mixing and associated CP phase can be directly probed at future high-energy hadron colliders, by measuring the charge asymmetry in same-sign dilepton signals which is mediated by the heavy $W_R$ boson. The high-energy LHC could probe a non-vanishing CP phase for a $W_R$ mass up to 7.2 TeV, while at future 100 TeV colliders FCC-hh and SPPC the $W_R$ mass could go up to 26 TeV. Mixing angles and CP violation in the heavy neutrino sector are crucial to generate the
observed baryon asymmetry for TeV-scale resonant leptogenesis, thus the same-sign charge asymmetry measurements at colliders can be used to test leptogenesis.

Parallel session / 111

(g-2)_\mu Versus Flavor Changing Neutral Currents Induced by the Light (B-L)_\mu\tau Boson

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Morning session I / 112

Welcome

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Morning session II / 113

Concluding remark

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