FLASY2019: 8th Workshop on Flavor Symmetries and Consequences in Accelerators and Cosmology

Monday, 22 July 2019 - Saturday, 27 July 2019

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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 $\mathbb{Z}_3^T$ or $\mathbb{Z}_3^{ST}$ and $\mathbb{Z}_2^S$ 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 θ_{23} and θ_{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 θ_{12} and the angle θ_{13} (which determines θ_{12}), ii) the values of the Dirac CPV phase δ and of the angles θ_{23} and θ_{13}, iii) the sum of the neutrino masses and θ_{23}, iv) the neutrinoless double beta decay effective Majorana mass and θ_{23}, and v) between the two Majorana phases.

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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, $\frac{(LH)(LH)}{\Lambda}$, 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.

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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.

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Antitriplet charmed baryon decays with SU(3) flavor symmetry

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We study the decays of the antitriplet charmed baryon state (Ξc0,Ξc+,Λc+) based on the SU(3) flavor symmetry. In particular, after predicting B(Ξc0⟶Ξ-π+)=(15.7±0.7)×10-3 and B(Ξc+⟶Ξ-π+π+)=(14.7±8.4)×10-3, we extract that B(Ξc0⟶ΛK-π+,ΛK+K-,Ξ-e+νe)=(16.8±2.3,0.45±0.11,48.7±17.4)×10-3 and B(Ξc+⟶pKs0Ks0,Σ+K-π+,Ξ0π+π0,Ξ0e+νe)=(1.3±0.8,13.8±8.0,33.8±21.9,33.8-22.6+21.9)×10-3. We also find that B(Ξc0⟶Ξ0η,Ξ0η′)=(1.7-1.7+1.0,8.6-6.3+11.0)×10-3, B(Ξc0⟶Λ0η,Λ0η′)=(1.6-0.8+1.2,9.4-6.8+11.6)×10-4 and B(Ξc+⟶Σ+η,Σ+η′)=(28.4-6.9+8.2,13.2-11.9+24.0)×10-4. These Ξc decays with the branching ratios of O(10-4–10-3) are clearly promising to be observed by the BESIII and LHCb experiments.

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

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We study the three-body anti-triplet Bc→BnMM′ decays with the SU(3) flavor (SU(3)f) symmetry, where
Bc denotes the charmed baryon anti-triplet of (Ξc0,-Ξc+,Λc+), and Bn and M(M′) represent baryon and
meson octets, respectively. By considering only the S-wave MM′-pair contributions, the decays of Bc→BnMM′ 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 χ2/d.o.f = 2.8 for the fit. Consequently, we find that the triangle sum rule of A(Λc+→n{\bar K}0π+) - A(Λc+→pK-π+) - √2A(Λ+c→p{\bar K}0π0) = 0 given by the isospin symmetry holds under SU(3)f, where A stands for the decay amplitude. In addition, we
predict that B(Λ+c→nπ+{\bar K}0) = (0.9 ± 0.8)×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→BnMM′ decays, we compute the branching fractions with the SU(3)f amplitudes to be compared to the BESIII and LHCb measurements in the future.

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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.

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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 $\widetilde{U}$ and neutrino mass-squared differences $\widetilde{\Delta}_{ji} \equiv \widetilde{m}_j^2 - \widetilde{m}_i^2$ (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 $|\widetilde{U}_{\alpha i}|^2$ and $\widetilde{\Delta}_{ji}$ (for $\alpha = e, \mu, \tau$ and $i, j = 1, 2, 3$) in very dense matter (namely, allowing the matter parameter $A = 2\sqrt{2}\, G_{\rm F} N_e E$ to mathematically approach infinity). The final conclusion is that $\widetilde{U}$ 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 $\widetilde{\theta}_{12}$, $\widetilde{\theta}_{13}$, $\widetilde{\theta}_{23}$ and $\widetilde{\delta}$ in the standard parametrization of $\widetilde{U}$.

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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 $\mathcal{O}_9$. We find that there are only two possible classes of new physics that can emerge in the UV completions of the $\mathcal{O}_9$ 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-β decay in order to either rule out models or predict characteristic beyond standard model signals.

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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 $g_\phi \overline{\nu}\nu\phi$ (or massive vector bosons via $g_V \overline{\nu}\gamma^\mu \nu V_\mu$) and explore the allowed parameter space of the coupling constant g_ϕ (or g_V) and the scalar (or vector) boson mass m_ϕ (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_ϕ and m_ϕ 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 $m_V \simeq 1$ MeV, while the bound becomes much weaker $g_V < 8 \times 10^{-6}$ for smaller masses $m_V < 10^{-4}$ MeV. Moreover, we discuss in some detail how the SNIs affect the cosmological evolution and the abundances of the lightest elements.

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N_1+N_2-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 N_1 and N_2 right-handed neutrino decays. We show that leptogenesis is separately possible in either the N_1 and N_2 dominated scenarios, with the asymmetry in the electron flavour protected from the N_1-washout by the texture zero. The two viable regions of the parameter space are $M_1 \in [10^9, 10^{12}]$, with $M_1/M_2 \in [0.002, 0.1]$, and $M_1 \in [10^9, 10^{10}]$, with $M_1/M_2 < 0.002$ and M_2 relatively close to M_3, which however is not a natural expectation of the $\Delta(27)$ model. We conclude that the N_1-dominated scenario is successful and the most natural option for the model.

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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 $Z_2 \times$CP in the neutrino sector and Z_5 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.

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An imprint of SO(10) on the MSSM spectrum

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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.

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

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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 $\overline{\mathbf{126}}$, 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 simplyfied example of such models in supersymmetry and show that they already provide some predictions for the MSSM sparticle spectrum.

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Origin of non-Abelian discrete flavour symmetries

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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.

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

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In this study, we consider a lopsided flavor texture compatible with thermal leptogenesis in partially composite Pati–Salam (PS) unification. The Davidson–Ibarra bound $M_{\nu R1}$ \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 ν_{R1} can not be larger than a 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

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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–μ, e–τ and μ–τ symmetries are considered in detail.

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Leptonic Unitarity Triangle, Geometrical Neutrino Oscillation and CP Violation

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Morning session I / 94

Search for new physics with coherent elastic neutrino-nucleus scattering

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Prospects for Supernova Neutrino Detection

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Addressing flavor symmetries of neutrinos at DUNE.

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The tri-direct littlest seesaw model with the precision measurement

Author: TseChun Wang[None]

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N1+N2-leptogenesis in Δ(27) with a universal texture zero

Author: Aurora Melis[None]

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

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Dissecting a derivative ΔL = 2 effective operator: 3-loop neutrino masses and their links to dark matter

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

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Observational Constraints on Secret Neutrino Interactions from Big Bang Nucleosynthesis

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Thermodynamics of f (R) Gravity with Disformal Transformation

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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.

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

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Welcome

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Morning session II / 113

Concluding remark

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