FA51: Fisica Astroparticellare

C. S. Fong (Bors.), E. Nardi (Resp.), E. Peinado (Bors.)

Description of the 2012 activity

i. A comprehensive account of the theory of *leptogenesis* has been presented in ref. [1]. We have explained why leptogenesis is an appealing mechanism for baryogenesis. We have presented a comprehensive review of its motivations and of the basic ingredients, and we have described subclasses of effects, like those of lepton flavours, spectator processes, scatterings, finite temperature corrections, the role of the heavier sterile neutrinos and quantum corrections. We have then addressed leptogenesis in supersymmetric scenarios, as well as some other popular variations of the basic leptogenesis framework.

ii. In ref. [2] we have developed the attempt put forth in ref. [3]to explain the fermion mass hierarchy, starting from the assumption that the Yukawa couplings correspond to vacuum expectation values of a spontaneously broken flavour symmetry. The tree level potential for a scalar multiplet of 'Yukawa fields' Y for one type of quarks admits the promising vacuum configuration $\langle Y\rangle \propto \mathrm{diag}(0,0,1)$ that breaks spontaneously $SU(3)_L \times SU(3)_R$ flavour symmetry. We have investigated whether the vanishing entries could be lifted to nonvanishing values by slightly perturbing the potential, thus providing a mechanism to generate the Yukawa hierarchies. For theories where at the lowest order the only massless states are Nambu-Goldstone bosons we have found, as a general result, that the structure of the tree-level vacuum is perturbatively stable against corrections from scalar loops or higher dimensional operators. We have discussed the reasons for this stability, and we have given an explicit illustration in the case of loop corrections by direct computation of the one-loop effective potential. We have shown that a hierarchical configuration $\langle Y\rangle \propto \mathrm{diag}(\epsilon', \epsilon, 1)$ (with ϵ', $\epsilon \ll 1$) can be generated by enlarging the scalar Yukawa sector, and we have presented a simple model in which spontaneous breaking of the flavour symmetry can account for the fermion mass hierarchies.

iii. In ref. [4] We have considered the see-saw mechanism within a non-supersymmetric SO(10) model. By assuming the SO(10) quark-lepton symmetry, and after imposing suitable conditions that ensure that the right-handed (RH) neutrino masses are at most mildly hierarchical (compact RH spectrum) we obtain a surprisingly predictive scenario. The absolute neutrino mass scale, the Dirac and the two Majorana phases of the neutrino mixing matrix remain determined in terms of the set of already measured low energy observables, modulo a discrete ambiguity in the signs of two neutrino mixing angles and of the Dirac phase. The RH neutrinos mass spectrum is also predicted, as well as the size *and sign* of the leptogenesis CP asymmetries. We have computed the cosmological baryon asymmetry generated through leptogenesis, obtaining the correct sign, and a size compatible with observations.

v. The general theory of leptogenesis, with special attention to its most striking phenomenological consequences, and including all the most recent refinements, constituted the main research topic of the group during the past few years and also during 2012. Nevertheless, the group is also active in other lines of research, among which quite notably is the construction of theoretical models for neutrino masses in GUT theories [5], the phenomenology of lepton flavour violation [6], non-Abelian discrete symmetries as a way to explain the quark and lepton mass matrices [7] and supersymmetric R-parity [8].

References

1. **"Leptogenesis in the Universe,"**
   C. S. Fong, E. Nardi and A. Riotto, Adv.High Energy Phys. **2012** 158303 (2012).
2. **"Yukawa hierarchies from spontaneous breaking of the $SU(3)_L \times SU(3)_R$ flavour symmetry?,"** J. R. Espinosa, C. S. Fong and E. Nardi, arXiv:1211.6428, to appear in JHEP.
3. **"Naturally large Yukawa hierarchies,"** E. Nardi, Phys. Rev. D **84**, 036008 (2011).
4. **"Squeezing out predictions with leptogenesis from SO(10),"**
   F. Buccella, D. Falcone, C. S. Fong, E. Nardi and G. Ricciardi, Phys. Rev. D **86**, 035012 (2012).
5. **"Neutrino masses in $SU(5) \times U(1)_F$ with adjoint flavons,"**
   E. Nardi, D. Restrepo and M. Velasquez, Eur. Phys. J. C **72**, 1941 (2012)
6. **"Lepton flavor violation in minimal flavor violation extensions of the seesaw,"**
   E. Nardi, Nucl. Phys. Proc. Suppl. **225-227** (2012) 236.
7. **"Quark-Lepton Mass Relation in a Realistic A4 Extension of the Standard Model,"** S. F. King, S. Morisi, E. Peinado and J. W. F. Valle, arXiv:1301.7065.
8. **"Flavor origin of R-parity,"** S. Morisi, E. Peinado and A. Vicente, arXiv:1212.4145.

Talks at Conferences

1. *"Topics in Leptogenesis".*
   Enrico Nardi, Invited talk at: *"BeNe 2012 - Behind the Neutrino Mass"*,
   September 17-21, 2012; *"Abdus Salam ICTP"* Trieste, Italy.
   [`http://users.ictp.it/ smr2366/talks/Nardi-Bene2012.pdf`].
2. *" Leptogenesis and neutrino masses,"*
   E. Nardi, Invited talk at: *"PPC 2012 - International workshop on Particle Physics and Cosmology,"*, November 5-9, 2012, KIAS, Seoul, Korea.
   [`http://workshop.kias.re.kr/PPC2012/downloads/Nardi-PPC-2012.pdf`].
3. *"Lepton Flavor Violation in minimal Flavor Violation extensions of the see-saw."*
   Enrico Nardi, Invited talk at NOW 2012: *"Neutrino Oscillation Workshop"*,
   9-16 September 2012, Conca Specchiulla (Otranto, Lecce, Italy).
   [`http://www.ba.infn.it/ now/now2012/web-content/TALKS/Saturday15/parallel1/Nardi-NOW2012.pdf`].
4. *"The effective potential for spontaneous breaking of the flavour symmetry."*
   Chee Sheng Fong, Invited talk at: *"Planck 2012",* May 28 - June 1, Warsaw, Poland.
   [`http://planck12.fuw.edu.pl/talks/fong.pdf`].
5. *"Yukawa hierarchies from spontaneous flavor symmetry breaking."*
   Chee Sheng Fong, Invited talk at: *"2nd KIAS phenomenology workshop",* September 10-14, KIAS, Seoul, KOREA.
   [`http://workshop.kias.re.kr/Pheno2/?download=fong_flavor_ssb.pdf`].

Editorial Work

1. Proceedings of the 3^{nd} Young Researchers Workshop *"Physics Challenges In The LHC Era,"* 16^{th} Frascati Spring School 'Bruno Touschek', Frascati, Italy, May 7 & 10, 2012.
   E. Nardi, Editor.
   [`http://www.lnf.infn.it/sis/frascatiseries/Volume55/volume55.pdf`].
2. Proceedings of *"FLASY12: 2^{nd} workshop on flavor symmetries and consequences in accelerators and cosmology",* 30 Jun - 4 Jul 2012. Dortmund, Germany Eds: E. Peinado *et al.*
   [`http://arxiv.org/abs/arXiv:1210.6239`].