

TAsP: Theoretical Astroparticle Physics

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Main scientific activities and achievements during the year 2015

Dark matter: The nature of dark matter (DM), and in which way DM particles could interact with ordinary matter, is one of the most compelling questions in particle physics, and is an active topic of research in our group. A general analysis of the possibility that the abundance of DM is dominated by an asymmetry of the same origin of the Cosmological matter/antimatter asymmetry was presented in Ref. [1]. The possibility of automatically stable DM candidates from GUT theories of rank larger than four is certainly very appealing. The possibility of a fermionic DM candidate from the fundamental representation of an $SO(10)$ GUT was first put forth in [2]. DM is allowed to decay if its lifetime remains longer than the age of the Universe. However, this could yield specific astrophysical signatures due to the DM decay products. A scenario of this type has been studied in [3] in relation with the observation of high energy neutrino events at IceCube.

Leptogenesis: The general theory of leptogenesis, with special attention to its most striking phenomenological consequences, and including all the most recent refinements, keeps being one of the main research topic of the group, whose scientific leadership in this field is internationally recognized. In relation with leptogenesis studies, we have confronted $SO(10)$ models with charged fermions and neutrino data, revisiting the issue of the generation of the observed fermion mass spectrum and exploring the possibility of embedding leptogenesis in non-supersymmetric $SO(10)$ GUTs. We have shown that some sets of fundamental parameters (Yukawa couplings and vevs) which are able to fit the charged fermions and neutrino mass/mixing patterns, can automatically yield the correct amount of cosmological baryon asymmetry. New CP-violating decay channels for the heavy singlet neutrinos which are specific of $SO(10)$ models have been identified for the first time [4].

Neutrino physics and flavour physics: Implementing the inverse seesaw mechanism in a $SU(3)_C \times SU(3)_F \times U(1)$ gauge theory implies flavor correlations between charged lepton flavor violating (LFV) decays and the measured neutrino oscillations parameters. The predictions follow from the gauge structure itself without the need for any flavor symmetry. Such tight complementarity renders this scenario testable [5].

Recent LHCb results hint to lepton universality violation in $b \rightarrow s$ transitions at the level of 2.6σ which would also imply LFV B decays. With the assumption that the unitary transformation between weak and mass charged leptons equals the leptonic mixing matrix measured in neutrino oscillation experiments, branching ratios for LFV B meson decays can be predicted. It has been shown that some of these branching ratios correlate in an interesting way with the leptonic CP-violating phase δ characterizing neutrino oscillations [6].

The major achievements of a line of researches that we started a couple of years ago have been resumed [7], in which we describe how the complete pattern of quark Yukawa couplings (quark masses, CKM mixing angles, and the CKM CP violating phase) can be obtained as a consequence breaking spontaneously the $SU(3)_C^3$ quark-flavour symmetry, with no need to introduce hierarchical parameters, since all hierarchies are generated dynamically.

Publications

- 1 Minimal Asymmetric Dark Matter
S. M. Boucenna, M. B. Krauss and E. Nardi (Frascati).
Published in Phys. Lett. B **748**, 191 (2015)
- 2 Dark Matter from the vector of SO(10)
S. M. Boucenna, M. B. Krauss and E. Nardi (Frascati).
Published in Phys. Lett. B **755**, 168 (2016) [arXiv:1511.02524 [hep-ph]]
- 3 Decaying Leptophilic Dark Matter at IceCube
S. M. Boucenna, M. Chianese, G. Mangano, G. Miele, S. Morisi, O. Pisanti and E. Vitagliano.
Published in JCAP **1512**, no. 12, 055 (2015)
- 4 Leptogenesis in SO(10)
C. S. Fong, D. Meloni, A. Meroni and E. Nardi (Frascati).
Published in JHEP **1501**, 111 (2015)
- 5 Predicting charged lepton flavor violation from 3-3-1 gauge symmetry
S. M. Boucenna (Frascati), J. W. F. Valle and A. Vicente.
Published in Phys. Rev. D **92**, no. 5, 053001 (2015)
- 6 Are the B decay anomalies related to neutrino oscillations?
S. M. Boucenna (Frascati), J. W. F. Valle and A. Vicente.
Published in Phys. Lett. B **750**, 367 (2015)
- 7 Quark Yukawa pattern from spontaneous breaking of flavour $SU(3)^3$
E. Nardi (Frascati).
Published in Nucl. Part. Phys. Proc. **267-269**, 69 (2015)
- 8 Small neutrino masses and gauge coupling unification
S. M. Boucenna (Frascati), R. M. Fonseca, F. Gonzalez-Canales and J. W. F. Valle.
Published in Phys. Rev. D **91**, no. 3, 031702 (2015)
- 9 The LHC diphoton resonance from gauge symmetry
S. M. Boucenna (Frascati), S. Morisi and A. Vicente.
arXiv:1512.06878 [hep-ph].