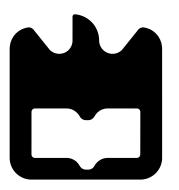
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A Study of possibilities beyond the Standard Model



o júri / the jury

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agradecimentos / acknowledgements

Honestamente acho que isto vai ter que ser escrito antes da entrega

Honestly this will be written in english translated poorly from above :)

Resumo

É impossível debater que o surpreendente sucesso do modelo padrão de física de partículas o faz um dos maiores sucesso da ingenuidade humana, no entanto, apesar de o modelo padrão descrever com grande detalhe todas as partículas observadas e as suas interações e conseguir tratar um grande número de fenomeno físicos onde era esperado encontrar falhas, tudo numa estrutura bem motivada, este é considerado incompleto.

Introduzir motivação para a falha do SM. Introduzir motivação para mais Higgs. Introduzir motivação para o BLSM Introduzir motivação para o 3HDM Tocar nas conclusões??

Abstract

This part will be in English. Translated from above.

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0.4 Labels

A paragraph or text to be added later A mistake or a question that is likely wrong A comment or doubt to ask or check Excess? Probably will cut, waiting for advice

Bibliography

- [1] M. Aaboud *et al.*, "Search for new high-mass phenomena in the dilepton final state using 36 fb⁻¹ of proton-proton collision data at $\sqrt{s} = 13$ TeV with the ATLAS detector," *JHEP*, vol. 10, p. 182, 2017.
- [2] R. N. Mohapatra and R. E. Marshak, "Local B-L Symmetry of Electroweak Interactions, Majorana Neutrinos and Neutron Oscillations," *Phys. Rev. Lett.*, vol. 44, pp. 1316–1319, 1980. [Erratum: Phys. Rev. Lett.44,1643(1980)].
- [3] L. Basso, S. Moretti, and G. M. Pruna, "Constraining the g'_1 coupling in the minimal B-L Model," J. Phys., vol. G39, p. 025004, 2012.
- [4] L. Basso, S. Moretti, and G. M. Pruna, "Theoretical constraints on the couplings of non-exotic minimal Z' bosons," *JHEP*, vol. 08, p. 122, 2011.
- [5] M. Tanabashi et al., "Review of Particle Physics," Phys. Rev., vol. D98, no. 3, p. 030001, 2018.
- [6] M. S. Chanowitz, J. R. Ellis, and M. K. Gaillard, "The Price of Natural Flavor Conservation in Neutral Weak Interactions," Nucl. Phys., vol. B128, pp. 506–536, 1977.
- [7] H. Fritzsch and P. Minkowski, "Unified Interactions of Leptons and Hadrons," Annals Phys., vol. 93, pp. 193–266, 1975.
- [8] H. Georgi and D. V. Nanopoulos, "T Quark Mass in a Superunified Theory," *Phys. Lett.*, vol. 82B, pp. 392–394, 1979.
- [9] H. Georgi and D. V. Nanopoulos, "Ordinary Predictions from Grand Principles: T Quark Mass in O(10)," *Nucl. Phys.*, vol. B155, pp. 52–74, 1979.
- [10] H. Georgi and D. V. Nanopoulos, "Masses and Mixing in Unified Theories," *Nucl. Phys.*, vol. B159, pp. 16–28, 1979.
- [11] Y. Achiman and B. Stech, "Quark Lepton Symmetry and Mass Scales in an E6 Unified Gauge Model," Phys. Lett., vol. 77B, pp. 389–393, 1978.
- [12] F. Gursey, P. Ramond, and P. Sikivie, "A Universal Gauge Theory Model Based on E6," Phys. Lett., vol. 60B, pp. 177–180, 1976.
- [13] F. Gursey and M. Serdaroglu, "E6 GAUGE FIELD THEORY MODEL REVISITED," *Nuovo Cim.*, vol. A65, p. 337, 1981. [,271(1981)].
- [14] T. Yanagida, "Horizontal gauge symmetry and masses of neutrinos," Conf. Proc. vol. C7902131, pp. 95–99, 1979.
- [15] M. Gell-Mann, P. Ramond, and R. Slansky, "Complex Spinors and Unified Theories," Conf. Proc., vol. C790927, pp. 315–321, 1979.

- [16] R. N. Mohapatra and G. Senjanovic, "Neutrino Mass and Spontaneous Parity Nonconservation," Phys. Rev. Lett., vol. 44, p. 912, 1980. [,231(1979)].
- [17] K. Kaneta, Z. Kang, and H.-S. Lee, "Right-handed neutrino dark matter under the B-L gauge interaction," *JHEP*, vol. 02, p. 031, 2017.
- [18] N. Okada and O. Seto, "Higgs portal dark matter in the minimal gauged $U(1)_{B-L}$ model," *Phys. Rev.*, vol. D82, p. 023507, 2010.
- [19] S. Okada, "Z' Portal Dark Matter in the Minimal B-L Model," Adv. High Energy Phys., vol. 2018, p. 5340935, 2018.
- [20] M. Fukugita and T. Yanagida, "Baryogenesis Without Grand Unification," *Phys. Lett.*, vol. B174, pp. 45–47, 1986.
- [21] A. Pilaftsis, "CP violation and baryogenesis due to heavy Majorana neutrinos," *Phys. Rev.*, vol. D56, pp. 5431–5451, 1997.
- [22] A. Pilaftsis and T. E. J. Underwood, "Resonant leptogenesis," *Nucl. Phys.*, vol. B692, pp. 303–345, 2004.
- [23] S. Khalil, "TeV-scale gauged B-L symmetry with inverse seesaw mechanism," Phys. Rev., vol. D82, p. 077702, 2010.
- [24] A. S. Belyaev, J. E. Camargo-Molina, S. F. King, D. J. Miller, A. P. Morais, and P. B. Schaefers, "A to Z of the Muon Anomalous Magnetic Moment in the MSSM with Pati-Salam at the GUT scale," *JHEP*, vol. 06, p. 142, 2016.
- [25] J. A. Grifols and A. Mendez, "Constraints on Supersymmetric Particle Masses From (g-2) μ ," *Phys. Rev.*, vol. D26, p. 1809, 1982.
- [26] J. R. Ellis, J. S. Hagelin, and D. V. Nanopoulos, "Spin 0 Leptons and the Anomalous Magnetic Moment of the Muon," Phys. Lett., vol. 116B, pp. 283–286, 1982.
- [27] D. A. Kosower, L. M. Krauss, and N. Sakai, "Low-Energy Supergravity and the Anomalous Magnetic Moment of the Muon," *Phys. Lett.*, vol. 133B, pp. 305–310, 1983.
- [28] T. C. Yuan, R. L. Arnowitt, A. H. Chamseddine, and P. Nath, "Supersymmetric Electroweak Effects on G-2 (mu)," Z. Phys., vol. C26, p. 407, 1984.
- [29] J. C. Romao, A. Barroso, M. C. Bento, and G. C. Branco, "Flavor Violation in Supersymmetric Theories," Nucl. Phys., vol. B250, pp. 295–311, 1985.
- [30] G.-C. Cho, K. Hagiwara, Y. Matsumoto, and D. Nomura, "The MSSM confronts the precision electroweak data and the muon g-2," *JHEP*, vol. 11, p. 068, 2011.
- [31] N. Okada, S. Raza, and Q. Shafi, "Particle Spectroscopy of Supersymmetric SU(5) in Light of 125 GeV Higgs and Muon g-2 Data," *Phys. Rev.*, vol. D90, no. 1, p. 015020, 2014.
- [32] M. Endo, K. Hamaguchi, T. Kitahara, and T. Yoshinaga, "Probing Bino contribution to muon g-2," *JHEP*, vol. 11, p. 013, 2013.
- [33] I. Gogoladze, F. Nasir, Q. Shafi, and C. S. Un, "Nonuniversal Gaugino Masses and Muon g-2," *Phys. Rev.*, vol. D90, no. 3, p. 035008, 2014.
- [34] F. Wang, W. Wang, and J. M. Yang, "Reconcile muon g-2 anomaly with LHC data in SUGRA with generalized gravity mediation," JHEP, vol. 06, p. 079, 2015.
- [35] A. Czarnecki and W. J. Marciano, "The Muon anomalous magnetic moment: A Harbinger for 'new physics'," *Phys. Rev.*, vol. D64, p. 013014, 2001.

- [36] S. Khalil and C. S. Un, "Muon Anomalous Magnetic Moment in SUSY B-L Model with Inverse Seesaw," Phys. Lett., vol. B763, pp. 164–168, 2016.
- [37] J.-L. Yang, T.-F. Feng, Y.-L. Yan, W. Li, S.-M. Zhao, and H.-B. Zhang, "Lepton-flavor violation and two loop electroweak corrections to $(g-2)_{\mu}$ in the B-L symmetric SSM," *Phys. Rev.*, vol. D99, no. 1, p. 015002, 2019.
- [38] R. Costa, A. P. Morais, M. O. P. Sampaio, and R. Santos, "Two-loop stability of a complex singlet extended Standard Model," *Phys. Rev.*, vol. D92, p. 025024, 2015.
- [39] P. Bechtle, O. Brein, S. Heinemeyer, O. Stål, T. Stefaniak, G. Weiglein, and K. E. Williams, "HiggsBounds 4: Improved Tests of Extended Higgs Sectors against Exclusion Bounds from LEP, the Tevatron and the LHC," Eur. Phys. J., vol. C74, no. 3, p. 2693, 2014.
- [40] P. Bechtle, S. Heinemeyer, O. Stål, T. Stefaniak, and G. Weiglein, "HiggsSignals: Confronting arbitrary Higgs sectors with measurements at the Tevatron and the LHC," Eur. Phys. J., vol. C74, no. 2, p. 2711, 2014.
- [41] P. Z. Skands *et al.*, "SUSY Les Houches accord: Interfacing SUSY spectrum calculators, decay packages, and event generators," *JHEP*, vol. 07, p. 036, 2004.
- [42] J. Alwall, R. Frederix, S. Frixione, V. Hirschi, F. Maltoni, O. Mattelaer, H. S. Shao, T. Stelzer, P. Torrielli, and M. Zaro, "The automated computation of tree-level and next-to-leading order differential cross sections, and their matching to parton shower simulations," *JHEP*, vol. 07, p. 079, 2014.
- [43] A. Freitas, J. Lykken, S. Kell, and S. Westhoff, "Testing the Muon g-2 Anomaly at the LHC," *JHEP*, vol. 05, p. 145, 2014. [Erratum: JHEP09,155(2014)].
- [44] S. M. Barr and A. Zee, "Electric Dipole Moment of the Electron and of the Neutron," Phys. Rev. Lett., vol. 65, pp. 21–24, 1990. [Erratum: Phys. Rev. Lett.65,2920(1990)].
- [45] V. Ilisie, "New Barr-Zee contributions to $(\mathbf{g} \mathbf{2})$ in two-Higgs-doublet models," *JHEP*, vol. 04, p. 077, 2015.
- [46] T.-F. Feng and X.-Y. Yang, "Renormalization and two loop electroweak corrections to lepton anomalous dipole moments in the standard model and beyond (I): Heavy fermion contributions," *Nucl. Phys.*, vol. B814, pp. 101–141, 2009.
- [47] G. Aad, T. Abajyan, B. Abbott, J. Abdallah, S. Abdel Khalek, A. Abdelalim, O. Abdinov, R. Aben, B. Abi, M. Abolins, and et al., "Observation of a new particle in the search for the standard model higgs boson with the atlas detector at the lhc," *Physics Letters B*, vol. 716, p. 1–29, Sep 2012.
- [48] S. Chatrchyan, V. Khachatryan, A. M. Sirunyan, A. Tumasyan, W. Adam, E. Aguilo, T. Bergauer, M. Dragicevic, J. Erö, C. Fabjan, et al., "Observation of a new boson at a mass of 125 gev with the cms experiment at the lhc," Physics Letters B, vol. 716, no. 1, pp. 30–61, 2012.
- [49] C. Collaborations et al., "Combined measurement of the higgs boson mass in pp collisions at

 $sqrt \ \{s\} = 7 and 8 tev with the atlas and cms experiments, ''ar Xiv preprintar Xiv: 1503.07589, 2015. A square of the square$

[50] C. Collaborations et al., "Measurements of the higgs boson production and decay rates and constraints on its couplings from a combined atlas and cms analysis of the lhc pp collision data at

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 $sqrt \{s\} = 7$ and 8 tev, "arXivpreprintarXiv: 1606.02266, 2016.