

1 Introduction

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References

- [1] F. Wilczek, *Quantum Time Crystals*, *Phys. Rev. Lett.* **109** (2012) 160401, [1202.2539].
- [2] J. Ellis, D. S. Hwang, K. Sakurai and M. Takeuchi, *Disentangling Higgs-Top Couplings in Associated Production*, *JHEP* **04** (2014) 004, [1312.5736].
- [3] R. Zhou and L. Bian, *Gravitational wave and electroweak baryogenesis with two Higgs doublet models*, *Phys. Lett. B* **829** (2022) 137105.
- [4] J. Brod, U. Haisch and J. Zupan, *Constraints on CP-violating Higgs couplings to the third generation*, *JHEP* **11** (2013) 180, [1310.1385].
- [5] F. Boudjema, R. M. Godbole, D. Guadagnoli and K. A. Mohan, *Lab-frame observables for probing the top-Higgs interaction*, *Phys. Rev. D* **92** (2015) 015019, [1501.03157].
- [6] ATLAS, CMS collaboration, G. Aad 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 $\sqrt{s} = 7$ and 8 TeV*, *JHEP* **08** (2016) 045, [1606.02266].
- [7] G. Bhattacharyya, D. Das and P. B. Pal, *Modified Higgs couplings and unitarity violation*, *Phys. Rev. D* **87** (2013) 011702, [1212.4651].
 - [8] J. F. Gunion, B. Grzadkowski and X.-G. He, *Determining the top - anti-top and Z Z couplings of a neutral Higgs boson of arbitrary CP nature at the NLC*, *Phys. Rev. Lett.* **77** (1996) 5172–5175, [hep-ph/9605326].
 - [9] P. S. Bhupal Dev, A. Djouadi, R. M. Godbole, M. M. Muhlleitner and S. D. Rindani, *Determining the CP properties of the Higgs boson*, *Phys. Rev. Lett.* **100** (2008) 051801, [0707.2878].
 - [10] A. Butter et al., *The Machine Learning landscape of top taggers*, *SciPost Phys.* **7** (2019) 014, [1902.09914].
 - [11] K. Kołodziej, *carlomat_4.0, a new version of the general purpose Monte Carlo program*, *Comput. Phys. Commun.* **276** (2022) 108330.
 - [12] G. Corti and M. Karacson, *Radiation environment of the LHCb Calorimeters during LHC Run 1 (2010-2013)*, .
 - [13] A. Angelescu, D. A. Faroughy and O. Sumensari, *Lepton Flavor Violation and Dilepton Tails at the LHC*, *Eur. Phys. J. C* **80** (2020) 641, [2002.05684].
 - [14] B. Coleppa, M. Kumar, S. Kumar and B. Mellado, *Measuring CP nature of top-Higgs couplings at the future Large Hadron electron collider*, *Phys. Lett. B* **770** (2017) 335–341, [1702.03426].
 - [15] ATLAS collaboration, *Search for high-mass resonances in final states with a tau lepton and missing transverse momentum with the ATLAS detector*, .
 - [16] B. Grzadkowski and J. F. Gunion, *Using decay angle correlations to detect CP violation in the neutral Higgs sector*, *Phys. Lett. B* **350** (1995) 218–224, [hep-ph/9501339].
 - [17] F. Demartin, F. Maltoni, K. Mawatari, B. Page and M. Zaro, *Higgs characterisation at NLO in QCD: CP properties of the top-quark Yukawa interaction*, *Eur. Phys. J. C* **74** (2014) 3065, [1407.5089].
 - [18] M. R. Buckley and D. Goncalves, *Boosting the Direct CP Measurement of the Higgs-Top Coupling*, *Phys. Rev. Lett.* **116** (2016) 091801, [1507.07926].

- [19] N. Mileo, K. Kiers, A. Szynekman, D. Crane and E. Gegner, *Pseudoscalar top-Higgs coupling: exploration of CP-odd observables to resolve the sign ambiguity*, *JHEP* **07** (2016) 056, [1603.03632].
- [20] A. V. Gritsan, R. Röntsch, M. Schulze and M. Xiao, *Constraining anomalous Higgs boson couplings to the heavy flavor fermions using matrix element techniques*, *Phys. Rev. D* **94** (2016) 055023, [1606.03107].
- [21] J. Li, Z.-g. Si, L. Wu and J. Yue, *Central-edge asymmetry as a probe of Higgs-top coupling in $t\bar{t}h$ production at the LHC*, *Phys. Lett. B* **779** (2018) 72–76, [1701.00224].
- [22] S. Amor Dos Santos et al., *Probing the CP nature of the Higgs coupling in $t\bar{t}h$ events at the LHC*, *Phys. Rev. D* **96** (2017) 013004, [1704.03565].
- [23] D. Gonçalves, K. Kong and J. H. Kim, *Probing the top-Higgs Yukawa CP structure in dileptonic $t\bar{t}h$ with M_2 -assisted reconstruction*, *JHEP* **06** (2018) 079, [1804.05874].
- [24] C. H. Albright and S. Nandi, *An Explicit $SO(10) \times U(1)$ -F model of the Yukawa interactions*, *Mod. Phys. Lett. A* **11** (1996) 737–748, [hep-ph/9505383].
- [25] S. Fajfer, J. F. Kamenik and B. Melic, *Discerning New Physics in Top-Antitop Production using Top Spin Observables at Hadron Colliders*, *JHEP* **08** (2012) 114, [1205.0264].