

T 21: BSM Higgs 1 (extended Higgs sectors)

Time: Monday 16:00–18:00

Location: Geb. 30.41: HS 3

T 21.1 Mon 16:00 Geb. 30.41: HS 3

Unraveling Sum Rules in 2HDM - Beyond Standard Model Implications — ●SARA CHOPRA¹, SAURAV BANIA², GUDRID MOORTGART PICK³, and SVEN HEINEMEYER⁴ — ¹Universität Hamburg — ²Universität Hamburg — ³Universität Hamburg — ⁴Consejo Superior de Investigaciones Científicas (CSIC)

In our exploration of particle physics, we comprehensively investigate the profound implications of sum rules within the Two Higgs Doublet Model (2HDM). Beginning with the foundational Standard Model, we derive sum rules to understand particle interactions.

Our focus shifts to the intricacies of 2HDM, meticulously deriving sum rules through examining couplings. We emphasize the behavior of these rules at escalating energy levels, particularly under E2 and E4 dependencies. Crucially, we assess their robustness, specifically scrutinizing unitarity's endurance amidst heightened energies.

This endeavor marks a pivotal step in unraveling 2HDM's behavior at elevated energy levels, offering invaluable insights beyond the Standard Model. Our research not only advances particle physics but also deepens our understanding of sum rules' implications in models beyond the established theoretical framework.

T 21.2 Mon 16:15 Geb. 30.41: HS 3

Search for a light CP-odd Higgs boson with the ATLAS detector — ●MANUEL GUTSCHE, ASMA HADEF, HANNAH JACOBI, TOM KRESSE, CHRISTIAN SCHMIDT, and ARNO STRAESSNER — Technische Universität Dresden

While the Standard Model of particle physics (SM) has proven to be a precisely predictive theory, tensions between experimental observations and theoretical calculations have arisen. One such discrepancy originates from Fermilab's measurement of the muon's anomalous magnetic moment a_μ . The flavour-aligned two-Higgs-doublet model (2HDM) is an extension of the SM that introduces a second Higgs doublet, leading to a rich phenomenology with four additional Higgs bosons. One of these particles is the CP-odd and electrically neutral A -boson whose mass m_A is a free parameter of the theory. If A is assumed to have a low mass of less than m_Z and large couplings to leptons as well as top quarks, the 2HDM could explain the observed deviation in a_μ .

In this talk, the search for an A -boson with a mass between 20 GeV and 110 GeV, produced by gluon fusion and decaying into two τ leptons, is presented. The analysis focuses on the channel with one electron and one muon in the final state, making use of 140.1 fb^{-1} of data recorded by the ATLAS detector at $\sqrt{s} = 13 \text{ TeV}$.

An overview of the analysis strategy is given. Different validation and signal-enriched regions along with the employed fake estimation method are introduced. Details on the most impactful systematic uncertainties as well as the expected limits for the production cross-section and model-dependent coupling parameters are presented.

T 21.3 Mon 16:30 Geb. 30.41: HS 3

Searches for neutral BSM Higgs bosons decaying into tau leptons — ●JACOPO MALVASO — Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, D-22607 Hamburg

The CMS Collaboration has reported in Run 2 two excesses above the background expectation in the search for a Beyond Standard Model Higgs boson decaying into tau leptons, at masses of 0.1 and 1.2 TeV and in the gluon fusion production process.

This talk will present the strategy for a similar search with data collected by the CMS experiment in Run 3. First distributions and comparisons of data and Monte Carlo simulations will be shown for 2022 and 2023 data.

T 21.4 Mon 16:45 Geb. 30.41: HS 3

Exploring a supersymmetric four-Higgs doublet model — ●LUCAS WILLANZHEIMER¹, FRANZISKA LOHNER¹, and GUDRID MOORTGAT-PICK^{1,2} — ¹Universität Hamburg — ²Deutsches Elektronen-Synchrotron DESY

Motivated by recent results from the ATLAS and CMS collaborations which reveal excesses in studies of decays into top quark pairs $t\bar{t}$ and tau leptons $\tau^+\tau^-$ at approximately 400 GeV -phenomena that the minimal supersymmetric standard model (MSSM) cannot explain simultaneously- we explore, in this study, the Higgs sector of a supersymmetric four-Higgs doublet model. Assuming a symmetry in which

each type of matter, including up-type- and down-type-quarks as well as charged leptons, couples exclusively to its 'own' doublet, our aim is to investigate whether such a supersymmetry-type model, with its Yukawa-sector, could embed excesses of such kind.

T 21.5 Mon 17:00 Geb. 30.41: HS 3

First shot of the smoking gun: probing the electroweak phase transition in the 2HDM with novel searches for $A \rightarrow ZH$ in $\ell^+\ell^-t\bar{t}$ and $\nu\nu b\bar{b}$ final states — ●THOMAS BIEKÖTTER¹, SVEN HEINEMEYER², JOSE MIGUEL NO², KATERYNA RADCHENKO³, and GEORG WEIGLEIN³ — ¹ITP, Karlsruhe, Germany — ²IFT, Madrid, Spain — ³DESY, Hamburg, Germany

Recently the ATLAS collaboration has reported the first results of searches for heavy scalar resonances decaying into a Z boson and a lighter new scalar resonance, where the Z boson decays leptonically and the lighter scalar decays into a top-quark pair, giving rise to $\ell^+\ell^-t\bar{t}$ final states. This had previously been identified as a smoking-gun signature at the LHC for a first-order electroweak phase transition (FOEWPT) within the framework of two Higgs doublet models (2HDMs). We analyze the impact of these new searches on the 2HDM parameter space, with emphasis on their capability to probe currently allowed 2HDM regions featuring a strong FOEWPT. Remarkably, the ATLAS search in the $\ell^+\ell^-t\bar{t}$ final state shows a local 2.85σ excess (for masses of about 650 GeV and 450 GeV for the heavy and light resonance) in the 2HDM parameter region that would yield a FOEWPT in the early universe, which could constitute the first experimental hint of baryogenesis at the electroweak scale. We analyze the implications of this excess, and discuss the detectability prospects for the associated gravitational wave signal from the FOEWPT.

T 21.6 Mon 17:15 Geb. 30.41: HS 3

Search for heavy Higgs bosons in the $t\bar{t}Z$ final state at CMS — MATTEO BONANOMI, YANNICK FISCHER, JOHANNES HALLER, ●DANIEL HUNDHAUSEN, CHRISTOPHER MATTHIES, and MATTHIAS SCHRÖDER — Universität Hamburg

All measurements of the properties of the Higgs boson at 125 GeV are compatible with a standard model-like behaviour. However, the observed resonance might well be part of an extended Higgs sector, which is predicted in various scenarios of new physics beyond the standard model. Two Higgs Doublet Models (2HDM) provide a generic description of the phenomenology arising in models with a second Higgs doublet. In this talk, we will present a search for a hypothetical CP-odd heavy Higgs boson A decaying into a CP-even heavy Higgs boson H and a Z boson, with the H boson decaying further into a top quark-antiquark pair ($t\bar{t}$). This decay channel is particularly relevant in the high mass and low $\tan(\beta)$ regime. We will present the strategy and status of the analysis of data collected with the CMS experiment at a centre-of-mass energy of 13 TeV, targeting the fully hadronic $t\bar{t}$ decay.

T 21.7 Mon 17:30 Geb. 30.41: HS 3

Search for Heavy Higgs Bosons in the $t\bar{t}\nu\bar{\nu}$ Final State at CMS — MATTEO BONANOMI, ●LUKAS EBELING, YANNICK FISCHER, JOHANNES HALLER, DANIEL HUNDHAUSEN, and MATTHIAS SCHRÖDER — Institut für Experimentalphysik, Universität Hamburg

Two Higgs Doublet Models extending the Higgs sector of the Standard Model predict additional heavy Higgs states. In this talk, a search for a heavy Higgs boson A decaying into a second heavy Higgs boson H and a Z boson is presented. The search targets the decay of the H boson into a $t\bar{t}$ pair, which is expected to have dominant contributions in the regime of large Higgs boson masses and small $\tan(\beta)$. In the analysis, the all-hadronic final state of the $t\bar{t}$ system and the $\nu\bar{\nu}$ final state of the Z boson decay are explored. Missing transverse momentum is used as a sensitive observable. We will present the status of the analysis using simulated data of the CMS experiment. Furthermore, the results are combined with a similar search in final states with charged leptons and jets.

T 21.8 Mon 17:45 Geb. 30.41: HS 3

Intermediate Charge-Breaking Phases in the 2HDM — MAYUMI AOKI¹, LISA BIERMANN², ●CHRISTOPH BORSCHENSKY², IGOR P. IVANOV³, MARGARETE MÜHLEITNER², and HIROTO SHIBUYA¹ — ¹Institute for Theoretical Physics, Kanazawa University,

Kanazawa, Japan — ²Institute for Theoretical Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany — ³School of Physics and Astronomy, Sun Yat-sen University, Zhuhai, China

The evolution of the early Universe around the electroweak epoch is an ideal testbed for physics beyond the Standard Model and in particular extended scalar sectors. The Universe may have experienced a sequence of phases of exotic nature, one of these being an intermediate phase where the electromagnetic charge is not conserved.

In my talk, intermediate $U(1)_{\text{em}}$ charge-breaking (CB) phases in

the CP-conserving 2-Higgs Doublet Model will be investigated. While previously studied only in the approximation of high temperatures, the possibility for their existence in the one-loop effective potential including thermal corrections is confirmed. I will discuss the relation of CB phases with the (non-)restoration of the electroweak $SU(2) \times U(1)$ symmetry at high temperatures, and the consistency with current collider data. For certain selected benchmark scenarios, the features of a CB phase in the evolution of the vacuum will be examined, such as the occurrence of a first-order phase transition to the CB phase from the neutral one.