# T 72: BSM Higgs 3 (extended Higgs sectors)

Time: Wednesday 16:00–17:45 Location: Geb. 30.41: HS 3

T 72.1 Wed 16:00 Geb. 30.41: HS 3

**Domain Walls in the N2HDM: Exploring Vacuum Trapping and Scalar Potential Evolution** — •Rohan Gupta[1], Gudrid Moortgat-Pick[1,2], and Mohamed Younes Sassi[1,2] — [1]Universität Hamburg, Germany — [2]DESY, Hamburg, Germany

In various Beyond the Standard Model (BSM) theories, the scalar sector is extended with additional scalar doublets and singlets. Consequently, the scalar potential of the theory becomes significantly more intricate than that of the Standard Model and leads to the possibility of having new phenomena such as Vacuum Trapping, where the vacuum expectation values (VEV) of the doublet scalar fields remain zero, despite the non-zero VEVs at the global minimum of the theory. The universe is then trapped in the symmetric phase and electroweak symmetry breaking does not occur, rendering the parameter points, that exhibit this phenomenon, as unphysical. This study specifically explores the occurrence of vacuum trapping in the N2HDM, an extension of the Standard Model's scalar sector that includes an additional doublet and a singlet scalar. Due to the breaking of a discrete symmetry related to the singlet, this model leads to the formation of domain walls in the early universe. We discuss the possibility of preventing vacuum trapping, particularly in cases where tunneling to the electroweak vacuum occurs within the domain wall structure.

T 72.2 Wed 16:15 Geb. 30.41: HS 3

**Electroweak symmetry restoration in the N2HDM via domain walls** — •Mohamed Younes Sassi and Gudrid Moortgat-Pick — II. Institut für Theoretische Physik, Hamburg, Germany

Domain walls are a type of topological defects that can arise in the early universe after the spontaneous breaking of a discrete symmetry. This occurs in several beyond Standard Model theories with an extended Higgs sector such as the Next-to-Two-Higgs-Doublet model (N2HDM). In this talk I will discuss the domain wall solution related to the singlet scalar of the N2HDM as well as demonstrate the possibility of restoring the electroweak symmetry in the vicinity of the domain wall. Such symmetry restoration can have profound implications on the early universe cosmology as the sphaleron rate inside the domain wall would, in principle, be unsuppressed compared with the rate outside the wall.

T 72.3 Wed 16:30 Geb. 30.41: HS 3

**Precision Calculations of Effective Potentials and Electroweak Phase Transitions in the Early Universe** — Thomas Biekötter[1], •Andrii Dashko[2], Maximilian Löschner[2], and Georg Weiglein[2,3] — [1]Institute for Theoretical Physics, Karlsruhe Institute of Technology, Wolfgang-Gaede-Str. 1, 76131 Karlsruhe, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany — [3]II. Institut für Theoretische Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

We present a detailed study of the precision calculations of higher-order contributions to effective potential with the application of three-dimensional effective field theories (3D EFTs). Our work focuses on the thermodynamic quantification and description of electroweak phase transitions in the early Universe for the complex singlet extended Standard Model (cxSM). In particular, we address the issue of gauge and scale dependences associated with the effective potential, which can lead to ambiguities when calculating thermodynamical quantities from the effective potential. To overcome this issue, we employ the high temperature 3D EFT framework, which provides a robust approach for consistently taking into account the relevant contributions in physical predictions. In addition, we study the ambiguities in commonly used renormalization schemes of the effective potential. The phenomenological implications of our results are discussed.

T 72.4 Wed 16:45 Geb. 30.41: HS 3

**Phenomenology of inflation inspired two Higgs doublet models with extensions** — •Hannah Bürgel and Gudrid Moortgat-Pick — Universität Hamburg, Deutschland

In my master thesis I study the phenomenology of inflation inspired (i.e. via inclusion of a non-minimal coupling to gravity) two Higgs doublet models with extensions particularly the two Higgs doublet model with singlet. For this purpose, an inflation term is inserted in the potential. I investigate the effects on the parameter space including masses and mixing angles under several theoretical and experimental constrains and compare them to collider results.

T 72.5 Wed 17:00 Geb. 30.41: HS 3

**In search for heavy and light scalars with the Higgs boson in the hadronic final state with the ATLAS experiment** — •Daariimaa Battulga, Arely Cortes Gonzalez, and Cigdem Issever — Institut für Physik, Humboldt-Universität zu Berlin

One of the most successful theories, the Standard Model (SM) of particle physics, describes the fundamental interactions amongst the subatomic particles. Yet, there are many unexplored areas in new physics beyond the SM. With the Higgs boson discovery, many open questions in particle physics can be explored further, such as searches for an extended Higgs sector, including additional heavy scalars. In this search, a heavy scalar $X$ in a mass range of $1-6$ TeV decays into a Higgs boson, and the light scalar $S$, in a mass range of $70-500$ GeV. Here, with a sufficiently high mass of the scalar $X$, the scalar $S$ and the Higgs boson are Lorentz-boosted. When it comes to where both the scalar $S$ and the Higgs boson decay into a pair of bottom quarks, they can be reconstructed and identified inside a large-radius jet. This talk presents the status of this search, which employs a new graph neural network to identify jets containing two bottom quarks. This study uses the proton-proton collision data collected by the ATLAS detector with the center of mass energy of $\sqrt{s} = 13$ TeV with an integrated luminosity of $\mathcal{L} = 140\,\mathrm{fb}^{-1}$.

T 72.6 Wed 17:15 Geb. 30.41: HS 3

**A novel machine learning-based background estimation for the X → SH → 4b analysis at the ATLAS experiment** — •Malin Horstmann, Nicole Hartman, and Lukas Heinrich — Technical University Munich, Germany

The search for additional scalar particles has been part of the ATLAS physics program since the Higgs discovery. The work presented has been done within the X → SH → 4b analysis at the ATLAS experiment, which searches for two additional scalars in the dominant decay mode of the Higgs. In order to interpret the data, an estimation of the expected background is necessary. We present a novel machine learning-based background estimation technique that uses a normalising flow and a Gaussian process. A particular focus will be on the propagation of the systematic uncertainties related to the neural network model.

T 72.7 Wed 17:30 Geb. 30.41: HS 3

**Probing new frontiers: Unveiling Dark Matter with novel collider signatures in Type-I 2HDM+$a$** — •Ilia Kalaitzidou[1], Spyridon Argyropoulos[1], and Ulrich Haisch[2] — [1]Physikalisches Institut, Universität Freiburg, Hermann-Herder Str. 3a, 79104 Freiburg, Germany Freiburg, Germany — [2]Max Planck Institute for Physics, Föhringer Ring 6, 80805 München, Germany

One of the biggest unresolved mysteries in particle physics is the nature of dark matter (DM). It has long been suggested that the Standard Model (SM) Higgs sector, or extensions of it, could be a portal to DM. The Two Higgs Doublet Model with an additional pseudoscalar singlet acting as a mediator between the SM and DM particles (2HDM+$a$) is a promising model to explore the dark sector at the Large Hadron Collider (LHC). The present work studies a 2HDM+$a$ with a moderately fermiophobic Type-I Yukawa sector and non-degenerate Higgs bosons. This model features a large region of parameter space that accommodates signatures poorly explored at the LHC. A sensitivity study for new experimental signatures is presented, extending to Higgs masses below the SM Higgs mass.