7th Lisbon Mini-School on Particles and Astroparticle Physics

09-14 May 2022

Physics Beyond the Standard Model in the Higgs and Flavour Sector

M. (Gui) N. Rebelo, 13 May 2022, Inatel, Oeiras

rebelo@tecnico.ulisboa.pt

Joao Penedo gave an overview of the main topics of research of CFTP

From the theoretical point of view neutrino, Higgs and flavour Physics are interconnected

There is the need for Physics Beyond the SM

Several possibilities: extend the Higgs sector, or the flavour sector or the gauge sector

Rôle of Symmetries

New sources of CP violation

Stringent experimental constraints on new Physics

Dark Matter candidates

Work in collaboration with Gustavo C. Branco: gbranco@tecnico.ulisboa.pt

Great Expectations based on the European Strategy for Particle Physics

Text from Joaquim Silva-Marcos

A fundamental major breakthrough in particle physics Beyond the Standard Model is expected at CERN in the next years to come, in particular at the LHC, where a relentless search for New Physics (NP) continues at this very moment. Until now, the overall results from experiments (ATLAS, CMS, ALICE and LHCb) were consistent with the predictions of the Standard Model (SM). But recently tantalising evidence for new physics has been reported. It is therefore of uttermost importance that the search for NP, at the level of experiment, is met with an even relentless search for new theoretical frameworks and models that — as was the case with the SM — permit us to understand the new data coming from CERN's LHC. The purpose of this thesis-proposal is to contribute to the understanding of NP. The thesis will focus on physics Beyond the SM, in particular, on extensions of the SM with Vector-like fermions (VLF) as is the case of Vector-like Quarks (VLQ). These form the simplest extensions of the Standard Model which are in agreement with present experimental data, while providing a rich variety of New Physics, which may be at the reach of the LHC and the next generation of accelerators.

Physics Beyond the SM

Vector-like quarks

However, we may also focus on other New Physics issues.

E.g. there is no known fundamental principle why the Universe should have only 4 dimensions. Extra dimension (ED) models are inspired by string theory, which itself is based on the existence of additional spatial dimensions. As known, string theory is a main candidate for an all-including quantum theory which allows for gravity, thus unifying all elementary particle interactions. ED models have some advantages over supersymmetric theories (which is another serious candidate for New Physics). Besides the fact that they lead to the unification of the gauge couplings, either at high 10^16 GeV scales for small warped extra dimension models, or at the lower TeV scales for large flat ED models, they also address the long standing puzzle of the gauge hierarchy problem, i.e. the huge discrepancy between the gravitational scale and the electroweak scale. Furthermore, there is a viable Kaluza-Klein WIMP candidate for the dark matter of the universe. In addition, ED models explain the large mass hierarchy of the different types and generations of the SM fermions through a geometrical mechanism.

Extra Dimensions

All these aspects (and others) will be the focus of this Thesis Proposal.

The aim is clearly to produce new work to be published in international renown journals

Contact: J. Silva-Marcos, Email: juca@cftp.ist.utl.pt

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