IN SEARCH OF THE S_3 EXTENDED STANDARD MODEL HIGGS SECTOR DARK MATTER: FROM THEORY TO NUMERICAL ANALYSIS

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The Standard Model (SM) of particle physics has been extensively tested for a few decades. The last missing piece, the Higgs boson, was discovered in 2012 with a combined mass of $m_h = 125.09 \pm 0.21(\text{stat.}) \pm 0.11(\text{syst.})$ GeV [1] based on data from the ATLAS and CMS experiments. Properties of the observed scalar particles are in agreement with those of the SM Higgs boson, nevertheless there is still no experimental verification that it is the only Higgs boson. Acknowledging the fact that the SM is the theory, which describes an approximate observable world it is worth taking a note that there is physics beyond the SM. One of the physical phenomena, which does not fit the frame of the SM is the absence of the Dark Matter (DM) candidate and thus SM fails to describe nearly 85% of matter. An extension of the Higgs sector would solve some of the issues. Thus we propose and are motivated that such extension could potentially solve several problems.

We study an extension of the SM in which there are two additional copies of the Higgs $SU(2)$ doublets added to the scalar potential. The extension of the SM Higgs sector we are interested in is the so-called three-Higgs-doublet model (3HDM). Such extension leads to eight additional scalar fields with respect to the SM. In general all scalar fields of the same electrical charge mix to form physical Higgs states. Based on mixing this can lead to some interesting properties. We are interested in a specific case of the 3HDM, i.e. the S_3-symmetric 3HDM [2], which is a permutation group of the three Higgs $SU(2)$ doublets. We take a look at the specific S_3 vacuum configuration C-III-c-ν^2 [3], i.e. a softly broken C-III-c vacuum configuration: $\{\hat{w}e^{i\sigma}, \hat{w}, 0\}$. Although a complex phase is present in vacuum it does not lead to spontaneous CP violation. By introducing an additional $\mathbb{Z}_2$ symmetry we prevent decay of the lightest scalar particle associated with the inert $SU(2)$ doublets to scalar particles associated with active $SU(2)$ doublets. Therefore the lightest inert scalar is presumably a DM candidate.

Dozens of new quantum field theory models are presented these days and new particles are proposed as a solution to current problems in particle physics. Therefore, for a viable model a study should be conducted along with comparing plausible data with the available experimental one. There are several possible ways to check particle physics model, which involves but is not limited by the scalar potential stability, tree-level unitarity, electorweak oblique parameters [4]. Precise calculations are needed in order to test theoretical expectations at decent accuracy. An indisputable contribution to the development of physics was made by a computer as a tool. There is an abundance of available computation tools and therefore we focus on some of them. For this reason, we want to introduce to basic computation tools and what it takes to start from a theoretical model and develop it to produce viable theoretical and experimental data. In our study we use `Mathematica` for spectrum generator and perform an additional check using `SARAH` [5], and for experimental constraints we consider `CalcHEP` [6] package to check relic density using `micrOMEGAs` [7] and compare decay rates with `HiggsBounds` [8]. We present preliminary results of the 3HDM S_3 C-III-c-ν^2 DM candidate by taking a look at experimental and theoretical constraints.

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