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Explaining a class of multi-lepton excesses at the LHC with a heavy pseudo-scalar of a 2HDM+S model

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The Standard Model (SM) of particle physics is complete after the discovery of a Higgs-like boson at the Large Hadron Collider (LHC) by ATLAS and CMS collaboration. Although the measured properties of it is compatible with the one predicted by the SM, this does not exclude the possible existence of additional scalar bosons as long as the mixing with the SM higgs is small. In fact, in recent years the so called “multi-lepton anomalies” emerged as deviations from the SM predictions in several analyses of multi-lepton final states from ATLAS and CMS. These excesses are reasonably well described by a 2HDM+S model, where the mass of the heavy scalar $m_H \approx 270 \text{ GeV}$, the mass of the singlet scalar $m_S \approx 150 \text{ GeV}$. In this talk I will concentrate in describing a new class of multi-lepton excesses that can be explained with the CP-odd particle of the same 2HDM+S model. We have considered the dominant decays of the heavy scalar, $H \rightarrow Sh, SS$ and looked at various multi-lepton final states to explain the excess. With this motivation, a candidate for a scalar resonance has been reported with a mass of 151.5 GeV by looking at the existing SM higgs searches in the $\gamma\gamma$ and $Z\gamma$ channels with associated leptons, di-jets, bjets and missing energy. There are a number of small excesses in searches at the LHC for heavy (pseudo)-scalars in the mass range $400\text{-}600 \text{ GeV}$, here we have assumed that to be the heavy pseudo-scalar of the 2HDM+S model. The region of the parameter space that explains the multi-lepton excesses, the leading decays of the heavy pseudo-scalar are $A \rightarrow ZH, t\bar{t}$ producing four top and four lepton final states. Here we will discuss the multi-lepton final state in conjunction with the multi-lepton excesses observed at the LHC.

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