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Peer Review

Review of: "Attractive Features of Higgsino Dark Matter in the Next-to-Minimal Supersymmetric Standard Model"

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The authors of the paper "Attractive Features of Higgsino Dark Matter in the Next-to-Minimal Supersymmetric Standard Model" explore a GNMSSM scenario in which the lightest supersymmetric dark matter (DM) candidate is a Higgsino-dominated neutralino, similar to a pure Higgsino lightest supersymmetric particle (LSP) scenario in the MSSM. It is well-established that the minimum mass of a Higgsino DM candidate in the MSSM must be around 1 TeV. However, in the GNMSSM, a Higgsino DM can possess a considerably lower mass while still satisfying all phenomenological constraints. This feasibility arises because, in the GNMSSM, the Higgsino can mix with the singlino, allowing it to pass all constraints.

The main finding of this study is that a Higgsino DM candidate can have a mass as low as 660 GeV, substantially below the 1 TeV allowed in the MSSM.

The authors elaborate on the characteristics of the GNMSSM with respect to the Higgs sector, neutralino masses/mixings, relic density, direct detection (DD), and indirect detection phenomenology in considerable detail. They outline the framework for their numerical study utilizing tools such as SARAH, SPheno, FlavorKit, MicroOMEGAs, HiggsSignals, HiggsBounds, MultiNest, and EasyScan. The results are presented through 2D profile likelihood plots within the GNMSSM parameter space, and in particular, the authors discuss these numerical results in the context of GNMSSM parameters relevant for DM and DD.

Further, the authors examine the impact of more recent experimental constraints from the Higgs sector and the LZ experiment on the GNMSSM parameters and the LSP mass.

doi.org/10.32388/I90DZR

From a technical perspective, the study appears robust. However, it would enhance the paper's contribution to the field if the authors could delineate how their findings innovate beyond previous work on Higgsino-Singlino DM scenarios, such as those discussed in references 2204.06082, 2408.03656, and other papers. Additionally, the organization of the discussion regarding numerical results could be improved. Initially, the authors present results considering outdated constraints and later incorporate the most recent constraints in section 4. Clarifying this progression would benefit the reader's comprehension and the paper's coherence.

Despite these concerns, the findings presented are interesting.

Declarations

Potential competing interests: No potential competing interests to declare.