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Relativistic Freeze-in with Scalar Dark Matter in a Gauged $B - L$ Model and Electroweak Symmetry Breaking.

We explore relativistic freeze-in production of scalar dark matter in gauged $B - L$ model, where we focus on the production of dark matter from the decay and annihilation of Standard Model (SM) and $B - L$ Higgs bosons. We consider the Bose-Einstein (BE) and Fermi-Dirac (FD) statistics, along with the thermal mass correction of the SM Higgs boson in our analysis. We show that in addition to the SM Higgs boson, the annihilation and decay of the $B - L$ scalar can also contribute substantially to the dark matter relic density. Potential effects of electroweak symmetry breaking (EWSB) and thermal mass correction in BE framework enhance the dark matter relic substantially as it freezes-in near EWSB temperature via scalar annihilation. However, such effects are not so prominent when the dark matter freezes-in at a later epoch than EWSB, dominantly by decay of scalars. The results of this analysis are rather generic, and applicable to other similar scenarios.

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