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Electroweak Phase Transition with an SU(2) Dark Sector

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We consider a non-Abelian dark SU(2)D model where the dark sector couples to the Standard Model (SM) through a Higgs portal. We investigate two different scenarios of the dark sector scalars with Z2 symmetry, with Higgs portal interactions that can introduce mixing between the SM Higgs boson and the SM singlet scalars in the dark sector. We utilize the existing collider results of the Higgs signal rate, direct heavy Higgs searches, and electroweak precision observables to constrain the model parameters. The SU(2)D partially breaks into U(1)D gauge group by the scalar sector. The resulting two stable massive dark gauge bosons and pseudo-Goldstone bosons can be viable cold dark matter candidates, while the massless gauge boson from the unbroken U(1)D subgroup is a dark radiation and can introduce long-range attractive dark matter (DM) self-interaction, which can alleviate the small-scale structure issues. We study in detail the pattern of strong first-order phase transition and gravitational wave (GW) production triggered by the dark sector symmetry breaking, and further evaluate the signal-to-noise ratio for several proposed space interferometer missions. We conclude that the rich physics in the dark sector may be observable with the current and future measurements at colliders, DM experiments, and GW interferometers.

Summary

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