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One-loop analysis of dark matter constraints in a complex scalar extension of the Standard Model

We investigate the complex singlet extension of the Standard Model, which provides a pseudo-Nambu-Goldstone dark matter candidate. In addition to the latest and most stringent bounds from dark matter direct detection experiment, we impose the observed DM relic abundance and a novel condition that the imaginary component of the singlet field does not develop a vacuum expectation value, ensuring its stability as dark matter. We perform a full one-loop analysis of the effective potential, including counterterm contributions, and examine their impact on the allowed parameter space. Our results reveal that viable regions still exist, some of which appear only when counterterms are properly included, highlighting the importance of quantum corrections and the vacuum structure in precision dark matter studies.

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