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Two-Step Cosmological Selection: Electroweak Scale and Its Unifying Legacy

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The hierarchy problem between the electroweak (EW) scale and the Planck scale remains a central puzzle in modern physics. A promising approach is the cosmological selection via volume-weighted dynamics in a multiverse landscape, where the EW scale is dynamically selected as the configuration that maximizes the vacuum energy. We propose a two-step cosmological selection (TCS) mechanism. By minimally extending the Standard Model with a complex scalar singlet χ and $U(1)$ symmetry, the origin of the EW scale is explained elegantly by the TCS mechanism. The mechanism also has the potential to account for the neutrino masses generation. Once the $U(1)$ symmetry is broken explicitly by the soft breaking terms, the framework predicts a viable dark matter candidate. Its abundance can be produced via ultra-relativistic freeze-out during reheating and correlates directly with the reheating temperature.

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