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Deriving Progenitors of Extremely Metal-poor Stars with Nucleosynthesis Yields of Massive Stars

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The most metal-poor stars offer a unique window into the chemical enrichment processes driven by Population III stars in the early Universe. The observed chemical abundance patterns in these stars provide critical constraints on the nucleosynthetic yields of metal-free progenitors, shedding light on their zero-age main-sequence masses. In this work, we analyze 406 very metal-poor stars with the latest high-resolution spectroscopic data from LAMOST and Subaru, presenting the most extensive investigation to date of the initial mass distribution of the first stars. The results challenge the traditional Salpeter initial mass function. By incorporating supernova explodability theory, we propose a modified power-law function that successfully accounts for the observed mass distribution, emphasizing that the initial metal enrichment arose predominantly from successful supernova explosions. Our findings suggest an extremely top-heavy or nearly flat initial mass function for Population III stars, characterized by a high explosion energy exponent. This study highlights the critical role of the nucleosynthesis in massive stars and explosion mechanisms in shaping the chemical evolution of the early Universe.

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