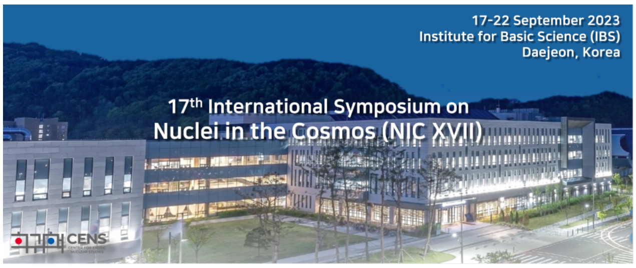

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Rapidly Rotating Massive Pop III Stars : A Solution for High Carbon Enrichment in CEMP-no Stars

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Very metal-poor stars that have [Fe/H]< -2 and are enhanced in C relative to Fe ([C/Fe]> 0.7) but have low enhancement of heavy elements ([Ba/Fe]< 0) are known as carbon-enhanced metal-poor-no (CEMP-no) stars. These stars are thought to be produced from the interstellar medium (ISM) polluted by the supernova (SN) ejecta of the very first generation (Pop III) massive stars. Although theoretical models of SN explosions from massive Pop III stars can explain the relative abundance pattern reasonably well, the very high enrichment of C $A(\mathrm{C}) > 6$) observed in many of the CEMP-no stars is difficult to explain when reasonable dilution of the supernova ejecta, that is consistent with detailed simulation of metal mixing in minihaloes, is adopted. We explore rapidly rotating Pop III stars that undergo efficient mixing and reach a quasi-chemically homogeneous (QCH) state. We find that rapidly rotating models that reach the QCH state can eject large amounts of C in the wind and the resulting dilution of the wind ejecta in the interstellar medium can lead to a C enrichment of $A(\mathrm{C}) < 7.7$ and can naturally explain the high C enrichment observed in CEMP-no stars. Additionally, the core of QCH stars can produce up to an order of magnitude of higher C than non-rotating progenitors of similar mass and the resulting SN can also lead to high C enrichment of $A(\mathrm{C}) < 7$. We find that the abundance pattern from our models that use dilution masses that are consistent with simulations can provide an excellent match to observed abundance patterns in many of the CEMP-no stars. We find that rapidly rotating massive Pop III stars are a promising site for explaining the high C enhancement in the early Galaxy as deduced from CEMP-no stars. This indicates that a substantial fraction of Pop III stars were likely rapid rotators.

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