Interpretation of Extremely Metal-Poor Stars as Candidates of First Generation Stars

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In a past decade, the two survey projects, HK survey \cite{1} and Hamburg/ESO survey \cite{2} have revealed many extremely metal-poor (EMP) stars ([Fe/H] < −2.5). These stars are considered to be born in the very early Universe and to have useful information on the star formation history of the Galaxy. Among these EMP stars, three stars, HE1327-2326, HE0107-5240 and HE0557-4840, are reported to have iron abundance of [Fe/H] =-5.4, -5.3 and -4.8, respectively. They have a strong impact on the EMP star surveys because (1) they are the most iron-deficient stars with [Fe/H] < −4.5 currently known and (2) they share the variety of peculiar abundance patterns compared with other EMP stars as well as the Sun. In particular, the very large carbon enhancement ([C/Fe]) of the three stars, which is 4.3, 4.0 and 1.7 respectively, is the prime example.

We discuss in the paper about the nucleosynthesis in EMP stars based on the binary scenario \cite{3} (see also the contributions by T. Suda and Y. Komiya) in an effort to reproduce the abundance pattern of these stars. The binary scenario assumes the mass transfer onto the low-mass companion seen today from intermediate mass stars that experienced internal mixing and dredge-up. We followed the nucleosynthesis in the He-burning shell of the intermediate-mass EMP (or metal-free) stars whose surface abundances can be altered through the so-called “Helium Flash Driven Deep Mixing” during the thermally pulsating AGB phase. In EMP AGB stars, the He-flash driven convection can reach the bottom of hydrogen burning shell, which leads to the engulfment of hydrogen into the convective zone and proton burning via \(^{12}\text{C}(p, \gamma)^{13}\text{N}(e^+\nu)^{13}\text{C}\). The part of the produced \(^{13}\text{C}\) can be the neutron source in the He-flash convective zones through \(^{13}\text{C}(\alpha, n)^{16}\text{O}\) reaction.

The present work focuses on the behavior of proton- and neutron-capture elements using the nuclear network for a wide range of model parameters such as the amount of mixed hydrogen and the strength of helium flash. The results are compared with the observed abundances of the most iron-poor stars listed above. We also discuss the possibility that they belong to the first generation stars group.

References

