A SUPERNOVA WITH MIXING FALLBACK AS A LAST SPIKE OF SHORT-LIVED RADIONUCLIDES ^{107}Pd, ^{129}I AND ^{182}Hf IN THE EARLY SOLAR SYSTEM.

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Introduction: Stellar nucleosynthesis processes contributed to the inventories of the Solar-System short-lived radionuclides (SLRs) [1] except for ^{10}Be that is likely to have been a spallation product by high-energy particle irradiation. The abundances of ^{26}Al, ^{41}Ca and possibly ^{60}Fe in the early Solar System may require injection from a stellar source just prior to or soon after the Solar System formation [e.g., 2, 3] although they could be inherited from the solar parent molecular cloud when considering the contribution from mass loss winds from massive stars [4].

Paradium-107, ^{129}I, ^{144}Sm, ^{182}Hf, and ^{244}Pu are the *r*-process nuclides and their presence in the Solar System has been commonly considered as a heritage from the ISM. Those *r*-process radionuclides could be present in the ISM at steady state if the *r*-process nucleosynthesis occurred frequently and the production rates of the *r*-process SLRs and decay rates were balanced. Core-collapse supernovae have been considered as a plausible site for the *r*-process. However, recent studies have suggested that the neutrino-driven wind during core-collapse supernova explosion is proton-rich and does not contain enough neutron for efficient *r*-process nucleosynthesis [e.g., 5].

Another plausible site for *r*-process is a compact binary merger of neutron stars (CBM), where the efficient *r*-process is predicted to occur under a neutron-rich condition [e.g., 6]. The CBMs have been proposed to be the progenitors of short-duration γ-ray bursts [e.g., 7], and the event rate may be smaller than ~5 Myr^{-1} following the rate of short-duration γ-ray bursts in the Galaxy [8]. If this is the case, the abundances of the *r*-process SLRs in the ISM may be no more at steady state, but fluctuate with time depending on the rare CBM events. The *r*-process SLRs may thus require late addition to account for their abundances in the early Solar System. Here we explore the possibility of "last spike" of heavy SLRs by a single mixing-fallback supernova that can explain the abundances of ^{26}Al, ^{41}Ca, ^{53}Mn and ^{60}Fe [2, 3], where heavy SLRs can be synthesized by neutron-burst [e.g., 9].

Injection of SLRs by a Mixing-Fallback Supernova: Core-collapse SNe with low abundances of ejected ^{56}Ni have been found, and their low ^{56}Ni abundances are attributed to the fallback of deep region of the pre-supernova star onto the central remnant (neutron stars or black holes). The fallback region may undergo mixing due to Rayleigh-Taylor instabilities and only a small fraction of mixed materials may escape from the fallback and be ejected (mixing-fallback). Takigawa et al. (2008) [2] proposed that a mixing-fallback supernova could reproduce the initial abundances of ^{26}Al, ^{41}Ca, ^{53}Mn, and ^{60}Fe in the Solar System. Liu (2014) [3] evaluated the mixing-fallback supernova model as a source of the Solar System ^{26}Al, ^{41}Ca, and ^{60}Fe for reevaluated initial abundances of ^{41}Ca [10] and ^{60}Fe [11], and showed that the late injection from a single mixing-fallback supernova could explain the abundances of ^{26}Al, ^{41}Ca, and ^{60}Fe without a significant shift of oxygen isotopic composition.

Abundances of ^{107}Pd, ^{129}I, and ^{182}Hf injected into the Solar System by a Mixing-Fallback Supernova: In this study, we followed the calculation procedures of [2] and [3] to obtain the abundances of SLR injected into preexisting Solar System materials using the supernova nucleosynthetic yield by [12] for 15, 19, 20, 21, and 25 solar mass. We determined the size of the mixing-fallback region and the fraction of mixed materials escaping from the fallback region to minimize deviations of modeled abundances of ^{26}Al, ^{41}Ca, ^{53}Mn, ^{60}Fe, ^{107}Pd, ^{129}I, and ^{182}Hf from their estimated initial abundances in the early Solar System [1, 3]. We found that the mixing-fallback supernova could reproduce the initial abundances of ^{26}Al, ^{41}Ca, ^{53}Mn, ^{60}Fe, ^{107}Pd, ^{129}I, and ^{182}Hf in the Solar System within a factor of two if the boundary of the mixing-fallback was located in the He/C layer as in [3]. The fraction of mixed materials escaping from the fallback region was ~10^{-5}, which is also consistent with the estimate by [3]. We thus conclude that the abundances of heavy SLRs (^{107}Pd, ^{129}I, and ^{182}Hf) in the Solar System could be explained by the injection as a last spike from a mixing-fallback supernova that injected ^{26}Al, ^{41}Ca, ^{53}Mn, and ^{60}Fe.

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