PRODUCTION OF LIGHT P-PROCESS ISOTOPES OF MO AND RU IN CORE-COLLAPSE SUPERNOVAE.

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Introduction: The provenance of the solar system’s supply of the light p-process nuclei $^{92,94}$Mo and $^{96,98}$Ru remains poorly understood. Nucleosynthesis models that successfully reproduce the abundances of the heavy p-process isotopes fail to account for the light p-process isotope production [1,2]. This suggests that an as yet not fully identified process is responsible for the bulk of the production of $^{92,94}$Mo and $^{96,98}$Ru. We speculate that expansions of high-entropy matter near the mass cut in core collapse supernova may be that process. These ideas bear on the isotopic signatures in presolar B grains with p-process and r-process enhancements [3], on the isotopic effects in Mo in whole rock samples [4], and on the production of the short-lived radioactivity $^{92}$Nb [5].

High-Entropy Expansions: We have explored two types of expansions of high-entropy matter near the supernova mass cut for production of light p-process isotopes. In either of the two expansions, we envision the material being ejected by the copious neutrinos from the cooling neutron star.

Alpha-rich freezeouts with neutrinos. Standard alpha-rich freezeouts can produce light p-process isotopes if the electron-to-baryon ratio $Y_e$ is near 0.48. However, these freezeouts never have these isotopes as the most overproduced, so such models cannot explain the solar system’s supply of $^{92,94}$Mo and $^{96,98}$Ru [6]. We have recently shown, however, that if the expansion of matter is relatively slow and the model includes on-going neutrino interactions, successful production of the light p-process isotopes can occur [7].

Rapid expansions of proton-rich matter. We have also recently shown that sufficiently rapid expansions of slightly proton-rich matter can also produce light p-process nuclei [8]. Here a persistent disequilibrium between free nucleons and abundant alpha particles plays a key role.

Discussion: In either of the two scenarios, the light p-process isotopes would be among the last to leave the exploding star. The neutrino-driven wind becomes increasingly neutron rich as the nascent neutron star evolves, so it may be that r-process isotopes follow from the same site a few tenths of a second later. We may thus naturally expect a connection between the r-process and the bulk of the p-process isotopes of Mo and Ru. Interestingly, we find robust production of $^{92}$Nb at the level of $^{92}$Nb/$^{92}$Mo roughly 1 in the first scenario but little $^{92}$Nb production in the second.