Reaction Rate Sensitivity in the neutrino p-process

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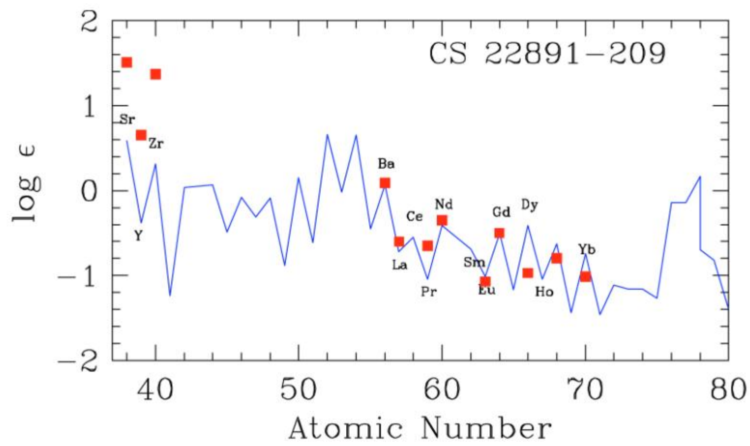
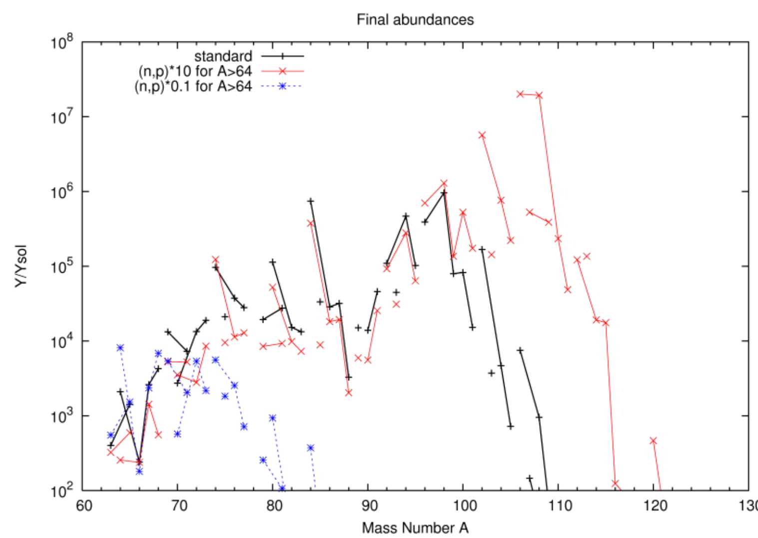
The chemical evolution of galaxies is dominated by contributions from supernovae type II (SNe II) and supernovae type Ia (Sne Ia). Early in the galactic evolution, contributions from massive stars will dominate due to their short evolution timescales. The signatures of these supernovae and hence the first generations of stars can be observed in the oldest (metal-poor) stars. The heaviest elements are attributed to neutron capture processes: the r-process (rapid neutron capture) and the s-process (slow neutron capture). However, these processes alone cannot explain the observed abundance trends for the nuclei between the iron peak and the r-process peak at A~130. Galactic chemical evolution studies propose an additional process, the lighter element primary process (LEPP), contributing to the nuclei in this mass region.

The ■p-process has been shown to be an important nucleosynthesis process, occurring in core collapse supernovae, that contributes to the synthesis of nuclei in the mass region 64<A<120. This makes the ■p-process a candidate for the LEPP process. The nucleosynthesis path of the ■p-process consists of a sequence of (p,g) and (n,p) or b+-reactions, where the slowest reactions set the timescale. Nucleosynthesis studies of such events as the neutrino-p process typically involve the use of reaction networks that include several thousand nuclei and associated reaction cross sections and lifetimes, most of which are only known theoretically. A majority of the nuclei involved are unstable and hence pose a challenge for experimental nuclear physicists. With improvements in existing facilities such as NSCL at MSU and ATLAS at ANL and with a future FRIB facility, experimental investigations of reaction rates and other nuclear quantities involving unstable nuclei will become feasible.

We have investigated the sensitivity of the np-process yields on the nuclear physics inputs, specifically on the reaction rates. While precise knowledge of nuclear physics inputs is vital to nucleosynthesis calculations, the uncertainties in the reaction rates do not allow for the ■p-process to fill in the entire region between the iron peak and the A~130 r-rocess peak.



Abundance distribution in metal-poor stars [from Cayrel et al 2004]. Red squares indicate observational data; the blue line represents solar-system (ss) r-rpocess. The ss r-process can explain well the observed abundance trendfor A>130 whereas for A<130 there is an obvious deficiency relative to observed abundances.



Variation of all (n,p) reactions in the ■p-process. Variation of (p,g) reactions in the ■p-process show a similar behavior though much weaker than for the (n,p) reactions.

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