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Studying the nucleosynthesis in explosive stellar environments

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Understanding the nucleosynthesis processes in various astrophysical scenarios such as x-ray bursts and supernovae involve the study of numerous capture reactions. A Type-I x-ray burst (XRB) is an explosion in a binary system of an accreting neutron star and a companion star. The dominant (p,γ) nucleosynthesis flow in XRBs is halted at several waiting point nuclei such as ^{22}Mg, $^{24-26}$Si, $^{28-30}$S and ^{34}Ar due to (p,γ)-(γ,p) equilibrium. It has been suggested that the flow can be bypassed by alpha-capture reactions on these waiting point nuclei (αp-process). However, the present uncertainties in the relevant alpha-capture reaction rates at these waiting points hinder the ability to accurately predict the light curve and ash composition of XRBs. Core-collapse supernovae (CCSNe) occur when massive stars exhaust their core fuel, resulting in the gravitational collapse of the iron core leading to an outward shock wave that results in one of the strongest explosions in the universe, ejecting a variety of chemical elements into the interstellar medium. Properties of CCSNe can be obtained by studying the signatures from prominent remnants such as ^{44}Ti and ^{56}Ni, of which the observed abundances are affected by proton, alpha and neutron captures.

A large number of nuclear reactions affect the nucleosynthesis in these two environments, and precise knowledge of these nuclear reaction rates are needed to constrain astrophysical models to better understand the underlying explosion mechanisms. Constraining many of these reaction rates using direct techniques is experimentally difficult due to low reaction cross sections and the need for sufficiently intense radioactive beams. Sensitivity studies that have been performed for these two astrophysical scenarios, as well as several experimental techniques currently utilized to constrain a few of these reaction rates affecting the nucleosynthesis in XRB and CCSNe environments will be presented.

Primary author: JAYATISSA, Heshani (Los Alamos National Laboratory)

Presenter: JAYATISSA, Heshani (Los Alamos National Laboratory)

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