ORIGIN OF HEAVY ELEMENTS IN THE UNIVERSE – CONTRIBUTIONS FROM MASSIVE STAR EXPLOSIONS

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Explosions of massive stars have long been considered as the main site for the synthesis of heavy elements. Thereby, one distinguishes two types: *(a)* explosive shock nucleosynthesis – associated with the dynamic ejection of the stellar mantle with mainly iron-group nuclei being produced, including long-lived radioactive elements which decay upon expelling into the interstellar medium where they contribute to the supernova lightcurve – and *(b)* the neutrino-driven wind component, ejected from the surface of the newly born proto-neutron star. The latter forms as the central compact object during the associated core-collapse supernova. Proto-neutron stars are hot and lepton rich in which properties they differ from the well known neutron stars as the final remnants of core-collapse supernova explosions. Proto-neutron stars develop towards neutron stars via deleptonization, i.e. the emission of neutrinos of all flavors; thereby the neutrino-driven wind is driven off the proto-neutron star surface via continuous neutrino heating. Simultaneously, the nucleosynthesis relevant conditions – timescale of expansion, entropy, proton-to-baron ratio or equivalently the electron fraction – are determined entirely by details of the neutrino spectra and fluxes as well as their evolution during the proto-neutron star deleptonization period on the order of 10–30 seconds [1]. In general, large neutron excess favors the synthesis of heavy elements beyond iron. Quantitative nucleosynthesis predictions for such events necessitates the accurate description of neutrino-matter decoupling in terms of neutrino transport. In my talk I will emphasize the current frontier for the consistent modeling of weak processes and nuclear equation of state in studies of the proto-neutron star deleptonization [2,3], with focus on a “complete” set of weak processes. In particular, the nuclear medium determines spectral differences between electron neutrinos and antineutrinos. Therefore, we select a well calibrated nuclear equation of state being in excellent agreement with current constraints from nuclear theory as well as observations of massive neutron stars. Slightly neutron rich conditions are obtained, which yields the production of light neutron-capture elements, e.g., Zn and Mo with atomic numbers $32<Z<50$ [4]. The inclusion of light nuclear clusters, e.g., ^{2}H, ^{3}H, and ^{3}He and their corresponding set of weak processes cannot influence this significantly [5]. These results of the neutrino signal can be understood at the level of the neutrino opacity [6]. They rule out canonical core-collapse supernova explosions as site for the production of elements associated with the *r* process at mass number A~195.

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