Robustness of the Main R-Process

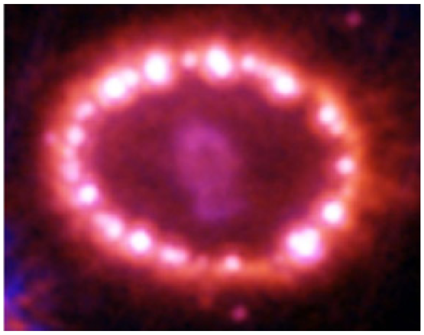

Fig.1: SN 1987a[1].

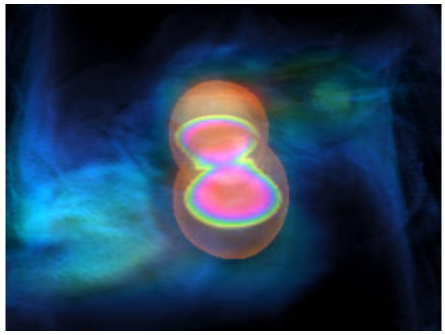

Fig.2: NS-NS Merger Simulation[2].

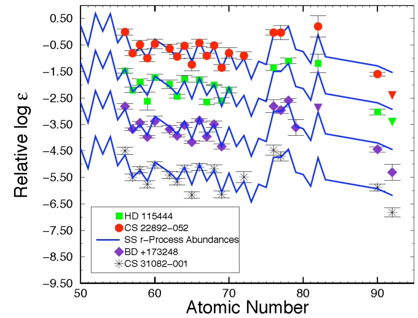

Fig.3: Four "R-Process Sisters", showing the same relative abundances of r-process elements for the sun and UMP halo stars[4].

The rapid neutron capture process (r-process) synthesizes roughly 50% of all elements past the Fe-peak and all of the actinides. While the site of the r-process remains unknown – the high entropy shell surrounding a proto-neutron star left behind by a core collapse supernovae (fig.1) and, to a lesser degree, neutron star mergers (fig.2) being currently the most promising ones – there is hope that more detailed knowledge of the properties of nuclei far from stability can help us to constrain the astrophysical environment in the future.
For example, in and beyond the actinide region, fission (β-delayed, spontaneous, neutron- and neutrino-induced) competes with β-decays and neutron captures, providing a way to cycle the r-process, as the fragments provide a continuous influx of new seed nuclei. If the timescales are right, a quasi steady flow of nuclei can be achieved. Abundance yields of steady flow r-process calculations are not sensitive to the details of the expansion, but to the nuclear microphysics, thus providing an attractive explanation of the robust nature of the main r-process (fig.3). Furthermore, the coincidence of the region of separation in the r-process abundance pattern between the weak and the main components (fig.4) with the region where a significant fraction of the expected fission fragments ends up is also very intriguing and deserved further investigation.
To explore the impact of fission on the endpoint (fig.5) and final abundance pattern on the r-process, we are currently working on implementing fission into a dynamical r-process network. The idea is to combine the excitation energies of parent nuclei with the results of a statistical model fission calculation to get the changes in massfractions for a given timestep. In addition, since fission barriers and fragment distributions are not yet well understood, a systematic study thereof is under consideration.

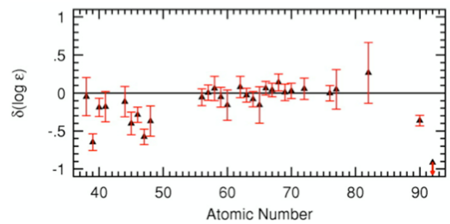

Fig.4: CS 22892-052 showing the weak component or r-process in disagreement with the solar proportions[5].

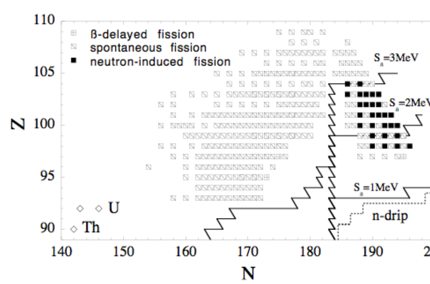

Fig.5: Possible endpoints of the r-process[3].

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