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Supernovae and Nucleosynthesis[1]

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Nucleosynthesis by rapid neutron capture (the r-process) could be an important diagnostic of the explosive deep interiors of supernovae. The early appearance of r-process elements in the Galaxy, along with energetic requirements, strongly argues in favor of a supernova origin for r-process isotopes. However there is a current conundrum as to the relative contributions from various supernovae environments, e.g. MHD jets or neutrino energized winds. There are also possible contributions from failed supernovae (collapsars) leading to a black hole (BH), or the ejection of material during the mergers of neutron stars in binary systems, i.e. NS+NS or NS+BH systems. In this talk we will review the theoretical underpinnings of each possibility in the quest to deduce the relative contribution of each process. In particular, each model for r-process nucleosynthesis invariably leads to systematic discrepancies with the observed solar-system r-process abundances. For example, although the location of the abundance peaks near nuclear mass numbers A =130 and 195 identify an environment of rapid neutron capture near closed nuclear shells, the abundances of elements just above and below those peaks are often underproduced by more than an order of magnitude in model calculations. Similarly, most recent neutrino-driven wind simulations produce only the lighter r-process elements, while neutron-star mergers may miss the r-process peaks due to fission recycling. In this talk we demonstrate that the underproduction of elements above and below the r-process peaks can be supplemented via fission fragment distributions from the recycling of material synthesized during neutron star mergers, while the abundance peaks themselves are well reproduced in MHD jets in supernovae and collapsars. Moreover, we show that the relative contributions to the solar-system r-process yields from core-collapse supernovae and neutron star mergers required by this proposal are consistent with estimates of the relative Galactic event rates. We also describe the prospects for diagnosing the relative contributions of various sources from a measurement of the spectrum of the diffuse cosmic background of relic supernova neutrinos.

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