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New developments in understanding the r-process from observations of metal-poor stars

ANNA FREBEL, Massachusetts Institute of Technology

In their atmospheres, old metal-poor Galactic stars retain detailed information about the chemical composition of the interstellar medium at the time of their birth. Extracting such stellar abundances enables us to reconstruct the beginning of the chemical evolution shortly after the Big Bang. About 5% of metal-poor stars with $[Fe/H] < -2.5$ display in their spectrum a strong enhancement of neutron-capture elements associated with the rapid (r-) nucleosynthesis process that is responsible for the production of the heaviest elements in the Universe. This fortuity provides a unique opportunity of bringing together astrophysics and nuclear physics because these objects act as "cosmic lab" for both fields of study. The so-called r-process stars are thought to have formed from material enriched in heavy neutron-capture elements that were created during an r-process event in a previous generation supernova. It appears that the few stars known with this rare chemical signature all follow the scaled solar r-process pattern (for the heaviest elements with $56 \leq Z \leq 90$ that is). This suggests that the r-process is universal – a surprising empirical finding and a solid result that can not be obtained from any laboratory on earth. While much research has been devoted to establishing this pattern, little attention has been given to the overall level of enhancement. New results will be presented on the full extent of r-process element enrichment as observed in metal-poor stars. The challenge lies in determining how the r-process material in the earliest gas clouds was mixed and diluted. Assuming individual r-process events to have contributed the observed r-process elements. We provide empirical estimates on the amount of r-process material produced. This should become a crucial constraint for theoretical nuclear physics models of heavy element nucleosynthesis.