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Probing Neutron Star Merger Properties with Metal-Poor Stars

The astrophysical production site of the heaviest elements in the universe remains a mystery. Incorporating heavy element signatures of metal-poor, r-process enhanced stars into theoretical studies of r-process-process production can offer crucial constraints on the origin of heavy elements. In this study, we apply the "Actinide-Dilution with Matching" model to a variety of stellar groups ranging from actinide-deficient to actinide-enhanced to empirically characterize r-process ejecta mass as a function of electron fraction (Y_e). We find that actinide-boost stars do not indicate the need for a unique and separate r-process progenitor. Rather, small variations of neutron richness within the same type of r-process event can account for all observed levels of actinide enhancements. The very low-Y_e, fission-cycling ejecta of an r-process event need only constitute 10-30% of the total ejecta mass to accommodate most actinide abundances of metal-poor stars. We find that our empirical Y_e distributions of ejecta are similar to those inferred from studies of GW170817 mass ejecta ratios, which is consistent with neutron-star mergers being a source of the heavy elements in metal-poor, r-process enhanced stars. Furthermore, results from this model can constrain merger properties and distributions of neutron stars in the early universe.

Keywords

Compact Object Mergers

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