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The impact of fissioning nuclei on r-process nucleosynthesis observables[1]

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In very neutron-rich conditions, as can be found in neutron star merger environments, the r process can synthesize up to the heaviest, most unstable nuclei, the fissioning actinides. The aim to pinpoint whether fission is indeed occurring in r-process scenarios is of particular interest following the observations of the electromagnetic counterpart for the GW170817 neutron star merger event which strongly implied the presence of lanthanide species. However, presently there is no evidence that this event produced elements heavier than the lanthanides such as gold, platinum, and beyond, which includes the actinides. Understanding the effects of fission in the r process requires knowledge of fission properties for hundreds of nuclei on the neutron-rich side of stability, about which little is experimentally known. The r-process nucleosynthesis studies I will present explicitly connect the nuclear data to r-process observational signatures. For instance, a feature of enhanced lanthanide production, the r-process rare-earth abundance peak, could be intimately linked to the nuclear structure and deformation of neutron-rich lanthanide species or produced via late-time fission deposition. We will examine these possibilities in the context of a numerical approach utilizing Markov Chain Monte Carlo which seeks to find conditions capable of producing a rare-earth peak consistent with both observational and experimental data. Since nuclear fission is an especially exotic and energetic process, we will discuss ways in which the presence of fission may lead to observable signatures in astrophysical scenarios, thereby confirming the production of the heaviest r-process elements. We will also explore the potential for future experimental and theoretical efforts to refine our knowledge of fission in the r process. The question of where nature primarily produces the heavy elements can only be answered through such collaborative efforts between experiment, observation, and theory.

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