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Probing Heavy Element Nucleosynthesis Through Electromagnetic Observations

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Half of the elements heavier than iron are produced by a sequence of neutron captures, beta-decays and fission known as r-process. It requires an astrophysical site that ejects material with extreme neutron rich conditions. Once the r-process ends, the radioactive decay of the freshly synthesized material is able to power an electromagnetic transient with a typical intrinsic luminosity. Such kilonova was observed for the first time following the gravitational signal GW170817 originating from a merger of two neutron stars. This observation answered a long lasting question in nuclear astrophysics related to the astrophysical site of the r-process.

In this talk, I will summarize our current understanding of r-process nucleosynthesis. I will also illustrate the unique opportunities offered by kilonova observations to learn about the in-situ operation of the r-process and the properties of matter at extreme conditions. Achieving these objectives, requires to address fundamental challenges in astrophysical modeling, the physics of neutron-rich nuclei and high density matter, and the atomic opacities of r-process elements required for kilonova radiative transfer models.

Finally, I will introduce a new nucleosynthesis process, the νr-process, that operates in ejecta subject to very strong neutrino fluxes producing p-nuclei starting from neutron-rich nuclei. It may solve a long standing problem related to the production of ^{92}Mo and the presence of long-lived ^{92}Nb in the early solar system.

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