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The r-process in the neutrino-processed ejecta of neutron star mergers

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Recent studies suggest that binary neutron star (NS-NS) mergers robustly produce heavy r-process nuclei above the atomic mass number A $\sim$ 130 because their ejecta consist of almost pure neutrons (electron fraction of Ye < 0.1). However, the production of a small amount of the lighter r-process nuclei (A $\approx$ 90-120) conflicts with the spectroscopic results of r-process-enhanced Galactic halo stars. We present the result of nucleosynthesis calculations based on the fully general relativistic simulation of a NS-NS merger with approximate neutrino transport. It is found that the bulk of the dynamical ejecta are appreciably shock-heated and neutrino processed, resulting in a wide range of Ye ($\approx$ 0.1-0.4). The mass-averaged abundance distribution of calculated nucleosynthesis yields is in reasonable agreement with the full-mass range (A $\approx$ 90-240) of the solar r-process curve. This implies, if our model is representative of such events, that the dynamical ejecta of NS-NS mergers could be the origin of the Galactic r-process nuclei. Our result also shows that radioactive heating after $\sim$1 day from the merging, which gives rise to r-process-powered transient emission, is dominated by the β-decays of several species close to stability with precisely measured half-lives.