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Feasibility studies to detect r-process nuclear emissions from the binary-neutron-star merger remnants with the HEX-P satellite

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The r-process nucleosynthesis site in the Universe is one of the important astrophysical questions. The r-process site should be a neutron-rich environment, and the binary neutron-star mergers (NSMs) are considered to be the most promising site. Nuclear gamma rays through the decay of unstable nuclei will provide direct evidence of r-process synthesis. However, the gamma-ray radiation is extremely weak (Hotokezaka et al., 2016), and the sensitivity of the near future MeV missions is limited to detect gamma-rays from NSMs at Mpc distances or NSM remnants in our Galaxy (Terada et al., 2022).

In this study, we focus on the hard X-ray band, which enables us to detect K X-rays emitted through the decay chain of r-process nuclei. Here, we performed the feasibility study to detect NSMs with the next-generation US-lead hard-X-ray mission, HEX-P. The mission is proposed to have the large effective area (4400 cm^2) in the soft to hard X-ray bands (2-200 keV). As demonstrated in Terada et al. (2022), the NSM is expected to have a unique spectral shape compared with other high-energy sources. Therefore, we examined the slope of the energy spectra simulated for NSMs in the 2-200 keV band. Accordingly, we performed an observation simulation with the exposure of 1 Ms to investigate the ratio of (25-70 keV)/(2-25 keV) and (70-200 keV)/(25-70 keV) fluxes. We used the same nuclear model in Terada et al. (2022), but with X-ray irradiation data from the daughter nuclei of r-process nuclei. As a result, the NSM can be distinguished from other sources with at least 3σ significance for the age of up to 10^4 years within a distance of 100 pc. In this presentation, we will discuss the feasibility to detect nuclear gamma-rays lines with the HEX-P for gamma-ray diagnostics in the neutron environment.

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