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Nuclear astrophysics with gamma-ray/neutron provided from high peak power laser

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High peak power laser has been developed quickly, which leads to generation of radiations such as gamma-rays and neutrons with energies higher than 1 MeV. These laser-driven radiations have unique features of high flux, ultra-short pulse, and continues energy distribution. These features are suitable for study of nuclear reactions in the universe, such as nuclear photoreactions with high energy gamma-rays in supernova explosions (gamma-process) and nuclear reactions with high-energy neutrons generated by spallation reaction with high energy cosmic-rays. In general, the energy spectrum of particles in stars and cosmic-rays have continues energy distribution, which may be similar to that generated by high peak power laser, and its event may occur in short time scale from ms to s. Neutrons have also important roles for stellar nucleosynesis for production of elements heavier iron. Furthermore, gamma-rays and neutrons may contribute to isotopic abundance anomalies observed in some elements in primitive meteorites. They may be caused by irradiations in parent bodies of meteorites in the solar system. T. Hayakawa et al. have theoretically proposed the experiments using laser-driven gamma-rays to study the nuclear photoreactions in supernovae [1]. Recently, high flux neutron pulses have been generated by the secondary reactions with ion pulses from laser-plasma interactions [2]. Such neutrons can also play an important role for the study of decay acceleration of long-lived radioisotopes which may have been considered by cosmic-ray irradiation in the early solar system [3]. Nuclear isomers are one of key for such studies. We discuss the possibility of experiments in nuclear astrophysics using laser-driven gamma-rays and neutrons.

[1] T. Hayakawa, et al. Quantum Beam Science, 1(1), 3 (2017).
[2] T. Mori, et al. Phys. Rev. C 104, 015808 (2021).
[3] T. Hayakawa, et al. Comm. Phys. 6, 299 (2023).

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