Proposal of laser nuclear physics experiments to simulate neutron bursts

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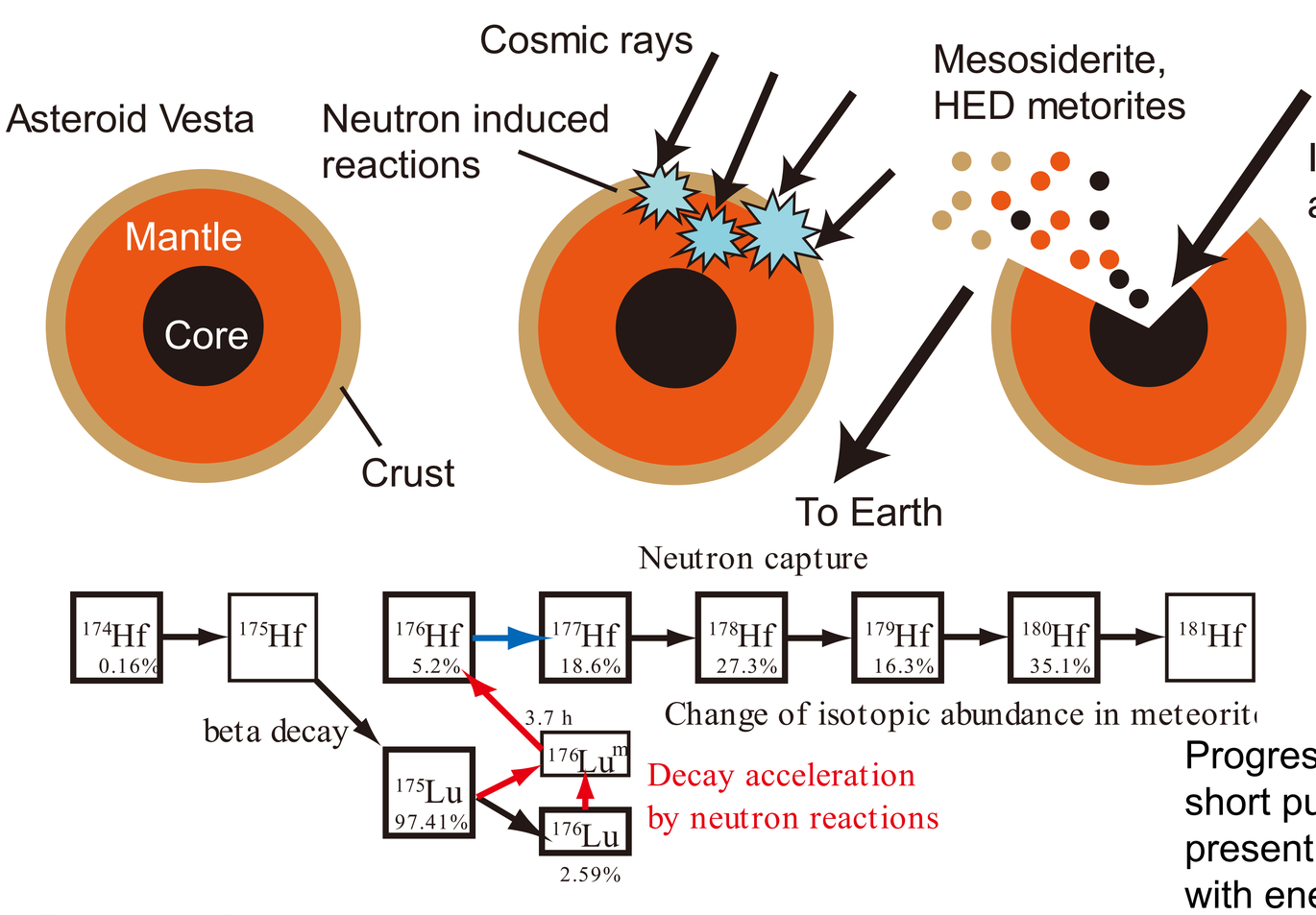
1. Introduction

A. Evidence of Neutron Burst in presolar grains

The isotopic abundance anomalies of Zr isotopes in Type-X SiC presolar grains shows irradiation of neutrons whose intensity is higher than that of s-process. Meyer 2000 [4] proposed supernova neutron bursts with a flux of 10^{17} neutrons/cm^3 for 1 s irradiation.

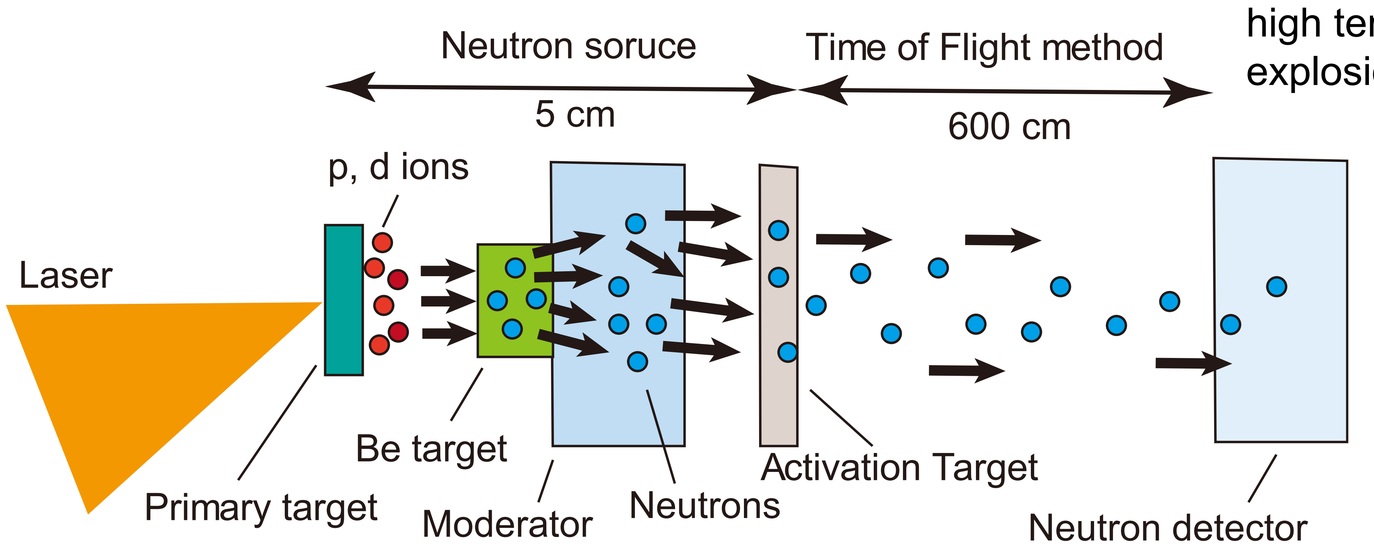
B. High energy neutron irradiation on meteorites

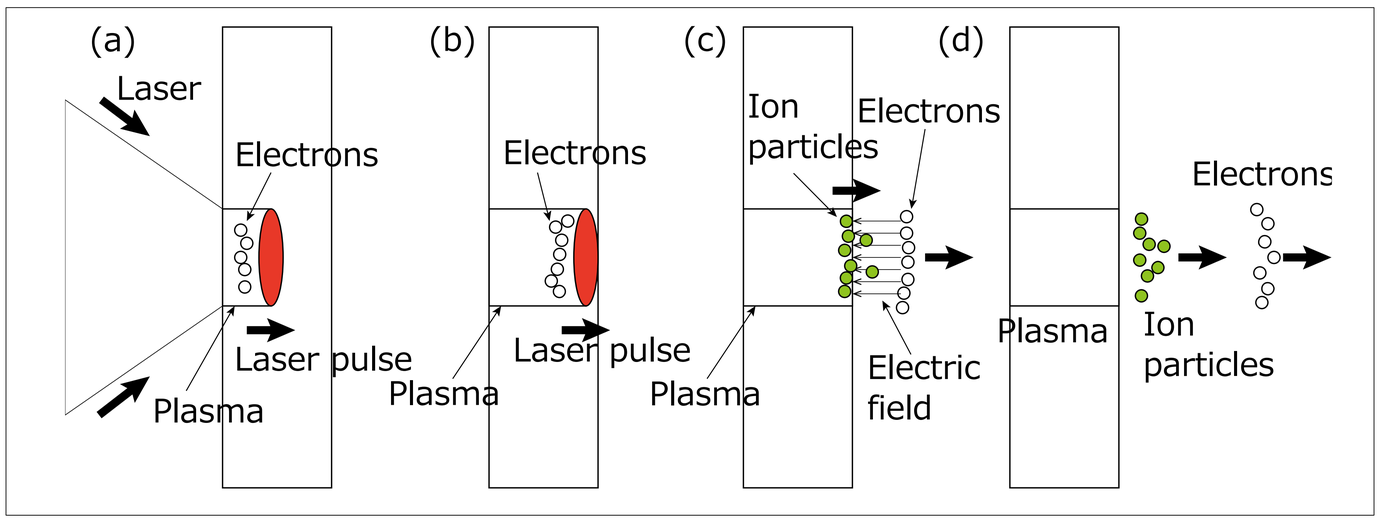


The isotope abundance anomalies in meteorites HED and mesosiderite originating form asteroid Vesta show the irradiation of neutrons in our solar system. Furthermore, the signature of decay acceleration of a long-lived radioisotope ^{176}Lu. We have proposed decay acceleration by cosmic-ray neutrons through short-lived isomer in ^{176}Lu [5].

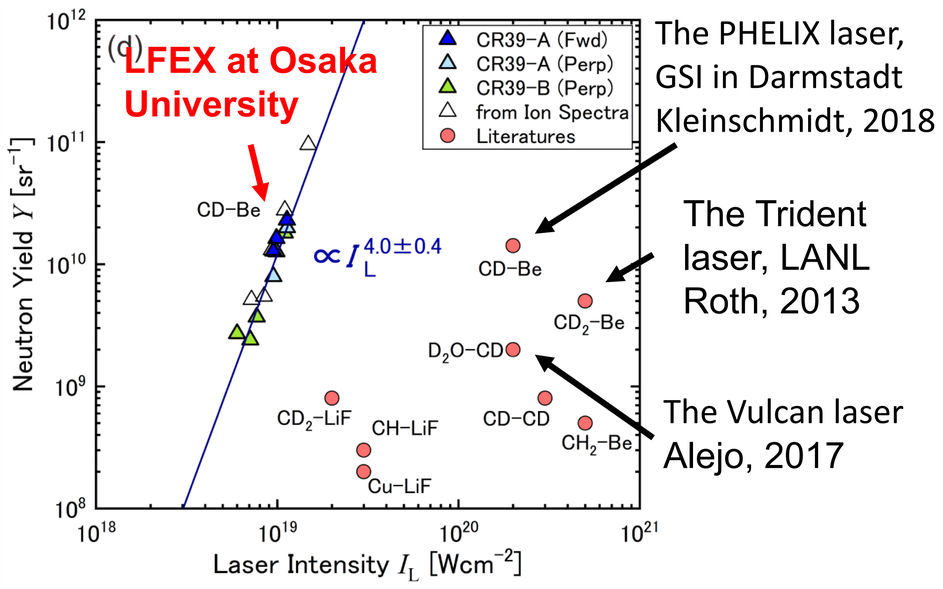
Progress of Laser Science enabled to produce high-flux and short pulse of particles through laser plasma interactions. At present, electrons with energies of several GeV and protons with energies of approximately 150 MeV could be generated. Their features are suitable for study of nuclear reactions in high temperature stellar plasma such as supernova explosions [1-3].

2. Proposal of experimental method





We have proposed the nuclear astrophysics experiments using high flux and short pulse of neutrons generated through laser plasm interactions. This is useful for the study of neutron bursts and cosmic-ray neutron effects. We have verified the TOF method for measuring of the neutron energy spectrum for each laser shot using the activation methods [6,7].



Neutron yields generated by laser

At present, it is possible to generate neutrons with a flux of 10^{11} neutrons/sr/shot using a single laser shot.

Reference

[1] T. Hayakawa et al. Quantum Beam Sci. 1, 3 (2017)
[2] P. Hill & Y. Wu PRC 103, 014602 (2021)
[3] V. Horný et al. PRC 109, 025802 (2024)
[4] B. Meyer et al. ApJL, 540, L49 (2000)
[5] T. Hayakawa et al. Comm. Physics, 6, 299 (2023)
[6] T. Mori et al. PRC 104, 015808 (2021)
[7] T. Mori et al. JPG 49, 065103 (2022)