# Fission-Fusion: a new Reaction Mechanism for Nuclear Astrophysics based on Laser-Ion Acceleration*

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High power short-pulse lasers with peak powers presently reaching hundreds of Terawatts and even Petawatt levels routinely reach focal intensities of $10^{18}$ - $10^{21}$ W/cm$^2$. These lasers are able to produce a wide array of secondary radiation, from relativistic electrons to multi-MeV/nucleon ion beams [1]. Compared to ion beams generated by conventional accelerators, laser-accelerated ion bunches can reach ultra-high densities around solid-state density, exceeding classical ion beams by up to 15 orders of magnitude. These unprecedented properties will soon allow to investigate a new reaction mechanism, fission-fusion, opening the perspective to generate extremely neutron-rich fusion products e.g. towards the N=126 waiting point of the r process path. Laser-accelerated $^{232}$Th ions (ca. 7 MeV/u) from a first target foil pass through a second Th foil, where target-like and beam-like Th nuclei will desintegrate into heavy and light fission fragments. Due to the very high beam density subsequent fusion between two light (neutron-rich) fission fragments can occur, resulting in a very neutron rich fusion product. A new EU-funded large-scale research infrastructure ELI (Extreme Light Infrastructure [2]) will be built until 2015, with its pillar in Bucharest being exclusively devoted to high-power laser-based nuclear physics. With this new facility the intensity limit of high-power lasers will be pushed by about three orders of magnitude to yet unprecedented $10^{24}$ W/cm$^2$. It will be one of the experimental goals pursued there to develop the new fission-fusion reaction mechanism.

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[1] A. Henig *et al.*, Phys. Rev. Lett. **103**, 245003 (2009).
[2] http://www.extreme-light-infrastructure.eu/