Perspectives for Laser-Driven Nuclear Science

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High-power, short-pulse lasers have proven being capable to produce high energy γ rays, charged particles and neutrons, and to induce all kinds of nuclear reactions. Upcoming new facilities will enter for the first time into new domains of power and intensities of few PW and $>10^{22}$ W/cm^2, opening new realms for laser-driven nuclear physics (and astrophysics) related studies. Some prototypical examples will be outlined in the presentation: (i) *Nuclear fusion reactions from laser-accelerated fissile ion beams* [1]: laser-driven ultra dense heavy ion bunches can be exploited to generate extremely neutron rich isotopic species, which cannot be accessed by conventional acceleration schemes, yet being crucial for the understanding of the astrophysical (r-process) nucleosynthesis in the universe. Together with the envisaged acceleration scheme of radiation pressure acceleration (RPA) for heavy ion species, also potential collective effects will be addressed that may affect the stopping power of these very dense ion bunches. Finally the novel 'fission-fusion' reaction mechanism will be introduced. (ii) *Nuclear (de-)excitation induced by lasers:* nuclear (de-)excitation schemes involving the bound states of electron cloud will be discussed, such as NEEC (Nuclear excitation following electron capture from continuum) or NEET (Nuclear Excitation following an electronic de-excitation) [2]. They will appear in hot laser-driven plasmas with different rates compared to isolated atoms or materials in normal conditions. Moreover, the possible enhancement of the decay of the long-lived ^{26}Al radioisotope in astrophysical environments can be studied under the extreme (laser-induced) conditions present in the inner cores of planets or stars [3]. (iii) *Nuclear reactions in laser plasmas:* The availability of high-intensity laser facilities capable of delivering several petawatt of power into small volumes of matter at high repetition rates will give the unique opportunity to investigate nuclear reactions and fundamental interactions under extreme plasma conditions [4]. In particular the effect of electron screening will be discussed, e.g. in low energy fusion reactions and on weakly bound nuclear states.

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[1] D. Habs et al., Appl. Phys. B 103, 471 (2011).
[2] F. Hannachi et al., proposal included in the ELI-NP Technical Design Report (2015).
[3] K.-M. Spohr et al.,proposal included in the ELI-NP WhiteBook, http://www.eli-np.ro/documents/ELI-NP-WhiteBook.pdf
[4] S. Tudisco et al., proposal included in the ELI-NP Technical Design Report (2015).