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Perspectives for nuclear astrophysics using ultra-dense ion beams and highly brilliant gamma beams

Tuesday, 8 June 2010 12:00 (20 minutes)

Along with the availability of high power, short pulse lasers arises the perspective of generating ultra-dense, laser-accelerated ion beams, which is one of the most active fields of research in virtually all major high-power laser laboratories world-wide. We plan to apply the new Radiation Pressure Acceleration (RPA) mechanism for ion acceleration, which was recently observed [1,2,3]. We are exploring the possibility to establish a new nuclear reaction mechanism, fission-fusion, where in a first step bunches of solid state density of e.g. ˆ232Th with about 10 MeV/u will be produced (thus exceeding the density of ion bunches from classical accelerators by about 15 orders of magnitude), which then pass through a second Th foil where they desintegrate into light and heavy fission fragments. A strongly reduced atomic stopping power is expected in the interaction of the very dense ion bunches via collective effects, which is important to obtain intense fission fragment beams.

The high density of the projectile and target ions furthermore leads to a reasonable subsequent fusion yield between neutron-rich light fission fragments. This may grant access to the production of extremely neutron-rich nuclei in the region of the astrophysical r-process near the waiting point N=126. Moreover, highly brilliant gamma-beams with MeV energies can be produced via Compton-backscattering of laser photons (ca. 1 eV) off brilliant electron bunches from conventional accelerators (storage ring or energy recovery linac). High-resolution spectroscopy (Delta E_gamma/E_gamma ˜ 10ˆ-4) using nuclear the resonance fluorescence technique can be applied to shed new light on short-lived neutron-deficient nuclei relevant for the astrophysical p- or rp nucleosynthesis processes. Ultra-dense laser ion acceleration as well as a brilliant gamma source based on the above concept is presently under study for the nuclear physics pillar of the European ELI (Extreme Light Infrastructure) large scale research facility to be built within the next 5 years in Bucharest [4].

[1] A. Henig et al., Phys. Rev. Lett. 103, 245003 (2009).
[2] T. Tajima, D. Habs, X. Yan; Laser Acceleration of
Ions for Radiation Therapy, RAST 2, 221 (2009).
[3] S. Steinke et al., 'Efficient ion acceleration by collective
laser-driven electron dynamics with ultra-thin foils', submitted to
Phys. Rev. Lett. (2009), arXiv:0909.2334v1 [physics.plasm-ph]
[4] http://www.extreme-light-infrastructure.eu/

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no

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no

Would you prefer your contribution to be an oral presentation? (please answer yes or no)

yes

Are you a student, postdoc or an attendee from an "emerging"country and would like to apply for financial support?

no

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