Reach for the Horizon of Extreme Light

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The horizon seemingly impossible to reach comes knocking on us if Professor Mourou plays his magic. A new frontier of extreme light at Exawatt is accosting us. This frontier has approached to us much closer than we thought till only recently when Gerard struck a thunder again. While IZEST [1] is working on kJ laser applications of extreme light [2], he now sees the possibility to create fs super-PW optical laser pulses from PW lasers [3]. Such laser pulses can be further converted into (1~10) EW (up to MeV) X-ray laser pulses in attoseconds and zeptoseconds (zs), using the method again pioneered by Gerard [4]. Such gamma-ray laser pulses simultaneously achieve the highest intensity and shortest laser pulses, in fact consistent with Mourou’s Conjecture [5], opening the new laser frontier at EW MeV in zs. We might draw a parallel to the invention of laser in 1960 that opened a new atomic physics; now this time a door is ajar to nuclei.

Among applications derived from this frontier, a class of novel ways to accelerate (and manipulate) particles may be introduced with fields ever higher than any in the past [6]. The above mentioned X-ray laser propagating in a crystal induces intense wakefields in the medium of crystal electrons (LWFA in a crystal). In an additional possibility this intense X-rays may be injected into vacuum and navigated in the vacuum as a nonlinear medium, creating an accelerating structure akin to the plasma fiber accelerators. The utilization of such coherent gamma-rays to drive acceleration of particles now becomes within our reach. Such X-rays may be focusable far beyond the diffraction limit of the original optical laser wavelength. In the ideal pancake 1D pulse the energy gain may be estimated to exceed PeV over the range of 10’s of meters. Once we preaccelerate ions to beyond GeV [7], such ions are capable of being accelerated in the above LWFA to similar energies over likewise distances. Such high energy proton (and ion) beams can induce copious neutrons, which can also give rise to intense compact muon beams and neutrino beams. These beams may be portable, thus usable for Earth tomography, for example. With this exceptional new physical parameters enabled by this technology introduced it is envisioned that a whole scope of new physical phenomena become accessible, which include the possibility of laser pulse self-focus in the vacuum, zeptosecond spectroscopy of nuclei, etc. Thus we are going to witness zs science along side of EW and PeV physics.

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