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IFE/P6-03: Shock Studies in Nonlinear Force Driven Laser Fusion with Ultrahigh Plasma Block Acceleration

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Sauerbrey's measurement [1] of ultrahigh acceleration of plasma blocks by 10ˆ{20} cm/sˆ2 with ps laser pulses at very high intensity –confirmed by Földes et al. [2] –are 10,000 times higher than any acceleration with ns laser pulses. At ns, thermal pressure with losses and delays dominates the interaction, while the ps case is dominated by the instantly acting nonlinear (ponderomotive) force. The ps acceleration of 10ˆ{20} cm/sˆ2 was theoretically and numerically predicted in 1978 [3] (see p. 179). The mechanism is different from electron acceleration in vacuum, first derived against preceding knowledge 1988 [4] as a nonlinear interaction process, and is different from acceleration of ion beams due to relativistic self-focusing [5].
Based on the measurements [1,2] the mechanism of the ps acceleration in contrast to that with ns pulses can now be understood as the non-thermal >99% efficient transfer of optical energy into macroscopic motion of the irradiated electron cloud in the space charge neutral plasma, where the inertia is determined by the cloud of the attracted ions. The sufficient small Debye length is essential in the high density plasma blocks. It is not trivial to distinguish the acceleration mechanisms of electrons in vacuum [4] of ion beams up to GeV [5] and that of space charge quasi-neutral plasma blocks [6] which were mostly interrelated and rather complicated. The clarification is shown how the block acceleration with full agreement between measurements [1] and the nonlinear force theory [6] led now to realize the fundamental difference to the thermokinetic processes with ns pulses. This is guided by the measurements of the ultrahigh block accelerations with consequences to a new scheme of fast ignition of laser fusion [7].

[1] Sauerbrey R 1996, Physics of Plasmas 3: 4712
[2] Földes I B, Bakos J S, Gal, K. et al. Laser Physics 10: 264
[3] Hora H 1981 Physics of Laser Driven Plasmas. New York: John Wiley
[4] Hora H 1988 Nature 333: 337; Hora H, Hoelss M, Scheid W et al. 2000 Laser & Part. Beams 18: 135
[5] Hora H 1975 J. Opt. Soc. Am. 65: 228; Cicchitelli et al. 1990 Phys. Rev. A41: 3727; Häuser T et al. 1992 Phys. Rev. A45: 1278
[6] Hora H. Laser & Part. Beams 2012 doi:10.1017/S0263034611000784
[7] Hora H, Miley G H et al. Energy & Environm. Science 3, 479

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Collaboration (if applicable, e.g., International Tokamak Physics Activities)

International ICF Cooperation about Nonlinear Force Driven Plasma Blocks

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