High-contrast 0.1 Hz, 4 PW laser

We have developed a high-contrast 0.1-Hz 4-PW Ti:sapphire laser. The amplified energy reached 112 J by adding another booster amplifier to the current PW laser. The broad spectrum and the high temporal contrast of the seed laser pulse for amplifiers were obtained by employing the cross-polarized wave generation and the OPCPA techniques. The final spectral width was maximized by compensating for the gain depletion effect induced during amplification. This high-contrast 0.1-Hz 4-PW laser will be applied to explore relativistic laser-matter interactions in the laser intensity exceeding 10^{22} W/cm^2.

Unpredictability of the predictable: tunnel ionization, population trapping, filamentation and applications

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A quick historical review of the impact of laser technology on high laser field physics leading to the confirmation of tunnel ionization and the discovery of high harmonic generation, hence, attosecond science will be given first. This will be followed by the discussion of population trapping in atoms and molecules, super-excitation of molecules, filamentation and possible applications in pollution sensing and weather control.

Route to Single Cycle Exawatt for Pulse Laser Subatomic Physics

Gérard Mourou, IZEST École Polytechnique,

Hitherto, the laser has been very successful to study atomic physics. The possibility to amplify lasers to extreme peak power offers a new paradigm unifying the atomic and subatomic worlds, to include Nuclear physics, High Energy Physics, Astrophysics and Cosmology. This application needs extreme intensities. At the moment we are experiencing a rush toward the 10 PW led by the 3-pillar ELI infrastructure along with Apollon in France and similar infrastructures in Russia, USA, China and Korea.

The applications include x-ray and TeV /cm with the goal to go beyond the High Energy Standard Model and contribute to apprehending Cosmic Acceleration and revealing Dark Matter. The societal applications are also numerous with proton therapy, short-lived isotope production, nuclear waste transmutation and the like.

Microphysics experiments using PW lasers for bridging from laboratory to universe

– Collisionless Shocks, Collective Instabilities, Particle accelerations –

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Collisionless shocks and collective beam-plasma instabilities are of great interest in investigation of novel inertial confinement fusion and a wide range of astrophysical phenomena, for instance, cosmic ray acceleration, supernova remnants (Fig.1**a**), accreting black hole systems, active galactic nuclei and gamma-ray bursts, as well as in potential applications such as hadron therapy. The experiment on interactions of ultraintense laser pulses with near critical density plasmas has been performed, using a 1 PW laser with a 30 J energy and 30 fs duration, focused on the high density gas jet producing a plasma density of $>10^{20}$ cm^{-3}. Here we show for the first time *in-situ* observation of shock formation associated with transition from electrostatic to electromagnetic shocks (Fig, 1**b**), self-generated magnetic fields, ion and electron accelerations. The analysis of collective beam-plasma instabilities revealed the unstable oblique modes of self-generated magnetic fields as well as the Weibel-type instability, of which growing filamentary structures were visually demonstrated in the experiment. Measured spectra of particle acceleration on He ions, protons and electrons exhibit their distinct spectral features by comparison between electrostatic and electromagnetic dominant cases. The particle acceleration mechanism for the electromagnetic dominant case may be conjectured as the first order Fermi acceleration mechanism in conjunction with the Weibel-instability-mediated collisionless shocks. Ultrafast laser-plasma experiments to explore microphysics of collisionless shocks provide in-depth insights into many astrophysical phenomena.

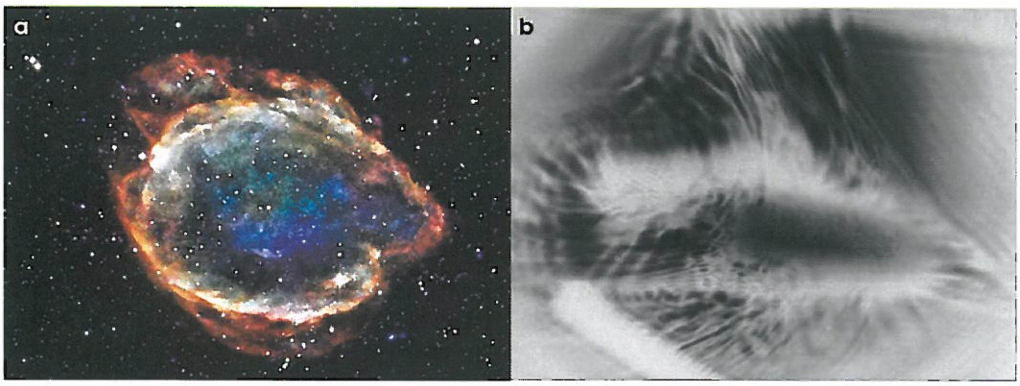

Fig. 1 (a) The supernova remnant called G299, as seen by NASA's Chandra X-ray observatory. (b) Collisionless shocks observed in the present experiment.