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Investigations of High Intensity, High Contrast Laser Solid with Short Pulses[1]

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Experimental discoveries related to laser-based ion acceleration from thin foils and the production of high brightness x-rays from high order harmonic generation from short pulses are presented. High power femtosecond lasers are ideally suited for use as tabletop particle accelerators since their short pulse duration enables very high intensities to be generated at high repetition rates from a compact laser. However, if laser pulse energy arrives before the main short pulse, it can interact with the target to cause ablation making high intensity investigations of laser-solid interactions difficult. In the following experiments, the laser pulse-to-pedestal contrast was improved to 15 orders of magnitude out to nanosecond timescales, allowing for excellent control over the interaction of a short pulse with solid density material. A sharply-rising laser pulse with 50 TW of power was focused to a 1.2 micron focal spot, achieving intensities over 10^{21}Wcm^{-2}. Protons accelerated due to sheath acceleration were studied in ultrathin targets. By sculpting the plasma density using shaped ultrafast pulses, control over the proton and ion spectra was also demonstrated. Finite spot effects from circular polarized laser pulses produced efficient acceleration for ultrathin foils, which resulted from the efficient conversion of laser light into high energy electrons. Finally, as the laser pulse drives the critical electron density relativistically, harmonics of the driving laser are produced. Harmonics up to order 60th were observed. It was observed that for a plasma scale length beyond a threshold value, parametric instabilities strongly modulated the harmonic spectra. Numeric simulations were performed to support the physical interpretation.

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