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Ultra-Intense Lasers generated Shock Waves

Amit D. Lad[1], Kamalesh Jana[1], Will Trickey[2], Chris Underwood[2], Ankit Dulat[1], Aparajit C.[1], M. Shaikh[1], Yash M. Ved[1], Alex P. L. Robinson[3], John Pasley[2] and G. Ravindra Kumar[1]
[1] Tata Institute of Fundamental Research, [2] York Plasma Institute, University of York, [3] Central Laser Facility, Rutherford-Appleton Laboratory
e-mail (speaker): amitlad@tifr.res.in

Ultra-intense, femtosecond laser pulses are capable of producing hot, dense plasma and thereby generate intense shock waves. In the present study, a system is considered in which the laser contrast is high; yet, there is sufficient energy in the pre-pulse to form a limited pre-plasma. This turns out to have an interesting consequence as the cold target is now sitting sufficiently close to the probe critical surface. The cold target explodes under the influence of the intense pump pulse, driving a strong shock outward into the pre-plasma, where it is witnessed by changes in the probe reflectivity and Doppler shift [1-4].

A detailed understanding of the critical surface motion of high intensity laser produced plasma is very crucial parameter for understanding the interaction [1]. Experimentally resolving the ultrafast dynamics of high intensity laser driven plasma at both the relevant length scales and timescales simultaneously is a challenging due to mainly the lack of diagnostic approach. Here, we present a novel technique based on pump-probe Doppler spectrometry to map spatially and temporally the ultrafast dynamics of hot-dense plasma generated by femtosecond, relativistic laser pulses [2]. Our technique offers hundreds of femtoseconds time resolution simultaneously with a few micrometer spatial resolution across the transverse length of the plasma. The experiment was carried out using TIFR 150 TW laser system with peak intensity of 10^{19} W/cm^2. The part of main beam is extracted using the thin beam-splitter and converted to second harmonic (400 nm). The up-converted harmonic probe allows us interrogate the dynamics in plasma which is over-dense with respect to pump laser. A normally incident time-delayed probe pulse reflected from its critical layer experiences a change in its wavelength due to the motion of the critical layer. Measuring the time dependent Doppler shifts at different locations across the probe beam we obtain two-dimensional velocity maps of the probe-critical plasma layer at ultrafast timescales [Fig. 1]. The time and spatial resolution offered by the proposed technique could be improved using a short duration probe pulse and increasing number of detection channels respectively. Harmonics of the pump can be used to penetrate more deeper and capture the ultrafast motion of the solid density plasma [3,4]. Early time measurements using this technique provide very important information about shock wave generation and propagation in dense medium [2].

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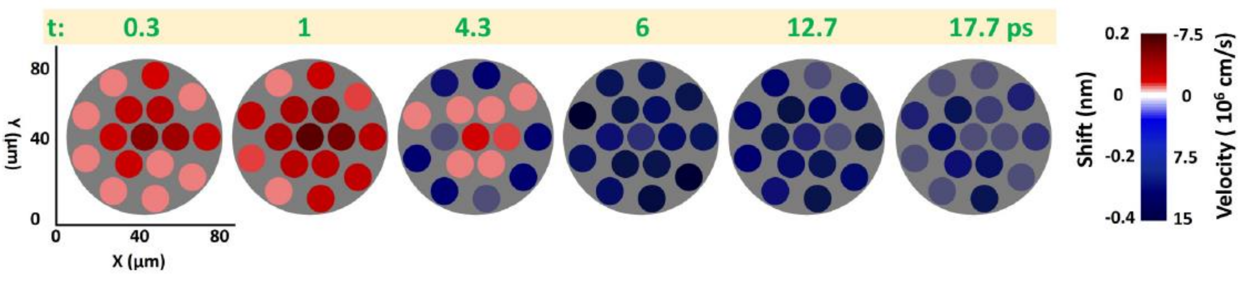

Figure 1. Spatially resolved Doppler shifts and corresponding velocity maps.