Intense coherent XUV radiation produced through high order harmonic generation in plasma plumes

High order harmonic generation using ultrashort pulse lasers is an attractive means of producing coherent radiation in the extreme ultraviolet (XUV) spectral range, which may serve as a much simpler alternative to the soft x-ray lasers. It can also have the additional advantage of having ultrashort sub-femtosecond duration pulses. Mostly gas jets are used for high order harmonic generation. However, they provide a low conversion efficiency. Alternatively, one can use plasma plumes produced from low intensity laser pulse irradiation of solid targets as the medium for harmonic generation. This may be much more advantageous compared to the use of gas jets since the availability of a much wider range of target materials for plasma production increases the possibility of resonant enhancement of some particular harmonic orders.

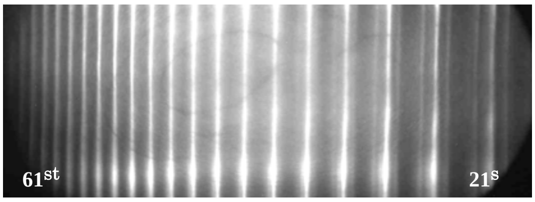

Fig.1 : Harmonics from silver plasma : 9th to 63rd harmonics have been recorded

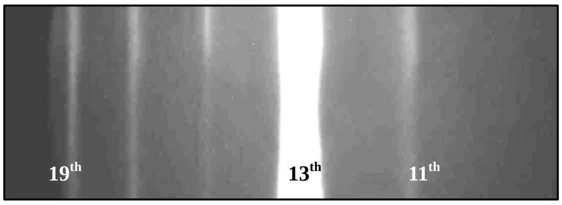

Fig.2 : Bright 13th harmonic in indium plasma : Intensity 200X that of nearby harmonics

At the Laser Plasma Laboratory, high order harmonic generation has been studied in plasma plumes and resonant enhancement of some single harmonics has been observed. The laser used in the study was 100 mJ, 48fs Ti:sapphire laser. A 300 ps prepulse (a portion of the uncompressed laser beam) was used to produce the plasma from different solid targets. The high intensity ultrashort laser traversed the plasma plume, parallel to the target surface and produced higher harmonics. Fig.1 shows harmonic spectrum obtained from silver plasma. Harmonics as high as 63rd order were observed.

Spectral tuning of the high order harmonics was attempted through chirp control of the high intensity laser pulses. Chirp variation of the laser pulse propagating through a GaAs plasma showed a considerable enhancement of the intensity of the 27th harmonic compared to that of the neighboring harmonics. Next, a detailed experimental study of harmonic intensity enhancement in various indium-containing plasma plumes of In, InSb, InGaP, and InP by controlling the chirp of the driving laser radiation was carried out. It was found that the chirp control allows optimization of the 13th harmonic (61 nm) intensity to reach a 200-fold enhancement with respect to the neighboring harmonics (Fig.2). Further, a 10-fold enhancement of the intensity of the 21st harmonic radiation (37.8 nm) in the case of InSb plume was observed using positively chirped laser pulses.

These studies have demonstrated the capability of the generation of an almost monochromatic harmonic radiation through interaction of laser with the ablated plasma. Such an approach may pave the way for efficient single harmonic enhancement in the XUV range using plasma plumes of different materials.

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