resolved autocorrelation measurements, temporal or spectral interferometry etc have been developed. Development of simple and inexpensive diagnostic systems capable of real time characterization of ultrashort laser pulses and associated pre-pulses (if any) is highly desirable. The fringe resolved interferometric autocorrelation (FRIAC) signals, which can be recorded in simple, inexpensive and compact setups, are widely used for ultrashort laser pulse measurement, but they are not very sensitive to the pulse chirp and asymmetry.

In Laser Plasma Laboratory, a new technique for sensitive detection and estimation of chirp and pulse asymmetry of ultrashort laser pulses has been worked out and implemented experimentally using 200fs laser pulses from cw mode-locked Nd:glass laser oscillator. This technique is based on unbalanced fringe resolved interferometric autocorrelation (UFRIAC) signals and uses a procedure of unbalanced fringe resolved interferometric autocorrelation envelope function difference (UFRIACED) to generate spectrally modified signals, which are sensitive to pulse chirp and asymmetry [*A.K. Sharma, P.A. Naik, P.D. Gupta, Opt. Exp. 12, 1389, 2004; ibid, Opt. Commun. 246,195,2005*]. For any new diagnostics, it is very important to carryout noise analysis for its performance in real laboratory environment. It was found, both theoretically and experimentally, that the UFRIACED method works very well even for noisy FRIAC signals [*A.K. Sharma, P.A. Naik, P.D. Gupta, Opt. Commun. 259, 350, 2006*].

The second order UFRIAC signals have been recorded using simple, low cost real time interferometric autocorrelator with extended temporal scan range, in which a commercial grade light emitting diode and audio speakers have been used as a quadratic detector and optical delay line respectively [*A.K. Sharma, P.A. Naik, P.D. Gupta, Appl. Phys. B 82, 407, 2006; ibid, Opt. & Laser Technol. 2006 In press*]. The UFRIAC and UFRIACED signals are displayed on a digital storage oscilloscope interfaced with a personal computer either via GPIB card or standard USB port. A computer program has been written to analyze these signals, which generates various spectrally modified signals for visual detection of pulse chirp and asymmetry. A typical UFRIAC signal and corresponding UFRIACED signals are given in fig. L.2.1. The pulse duration is derived from the number of interference fringes in the UFRIAC signal. This technique is superior to the modified spectrum auto-interferometric correlation technique, as the latter does not provide any information about pulse asymmetry. Moreover, it is twice more sensitive towards the chirp and much less sensitive to various perturbations.

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L.3 Intense coherent XUV radiation produced through higher order harmonic generation in plasma plumes

Higher 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.

At the Laser Plasma Laboratory, higher 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 100mJ, 48fs Ti:sapphire laser. A 300ps 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. Figure L.3.1 shows harmonic spectrum obtained from silver plasma. Harmonics as high as 63rd order were observed.

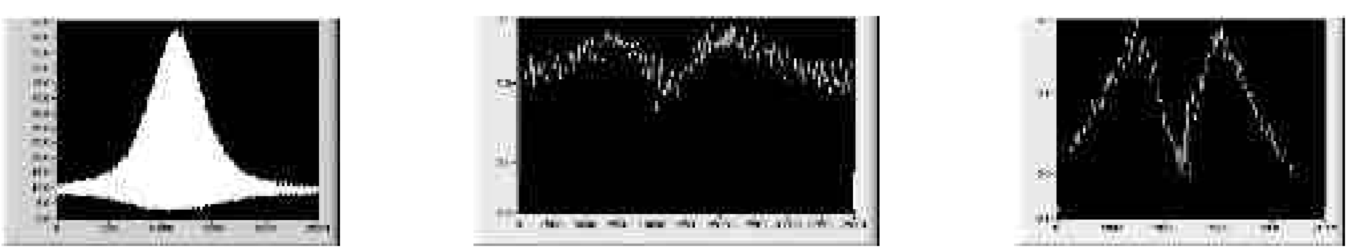

Fig. L.2.1 *Typical UFRIAC signal of 200fs laser pulse (left), corresponding UFRIACED signals for sensitive detection of chirp (middle) and for pulse asymmetry (right).*

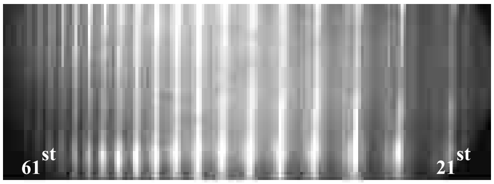

Fig. L.3.1 *Harmonics from silver plasma: 9^{th} to 63^{rd} harmonics have been recorded.*

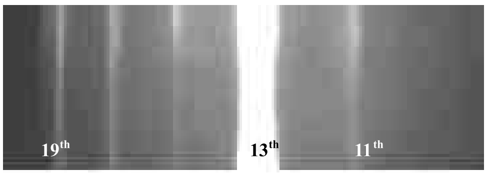

Fig. L.3.2 *Bright 13^{th} harmonic in indium plasma: intensity 200X that of nearby harmonics.*

Spectral tuning of the higher 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 27^{th} harmonic compared to that of the neighboring harmonics [*J. Opt .Soc. Am B (2006) In Press*]. 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 13^{th} harmonic (61nm) intensity to reach a 200-fold enhancement with respect to the neighboring harmonics (fig.L.3.2). Further, a 10-fold enhancement of the intensity of the 21^{st} harmonic radiation (37.8nm) 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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L.4 Twin point x-ray sources for radiograph

Laser Plasma Laboratory has developed a novel technique of simultaneous generation of mutli-keV monochromatic twin point x-ray sources in a vacuum diode with laser plasma cathode. The diode consists of a planar aluminium slab target as the cathode and two identical point-tip anodes of titanium. The separation between anode-cathode and that between the two anodes were 3 mm each. An Nd:YAG laser beam (energy ~ 2 - 40mJ, FWHM pulse duration ~ 20ns, repetition rate of 1Hz) was focussed symmetrically with respect to the two anodes on the aluminium target to produce plasma. Electrons from the sheath region of the expanding laser-produced plasma were accelerated in an externally applied electric field and bombarded the anode tips to generate characteristic K-shell x-ray radiation. Approximately 10^9 photons / pulse (Ti Kα at $h\nu \approx 4.51$keV) were generated in a pulse of 20-25ns duration, from each source of ~ 300m diameter. Brightness of each source was estimated to be 4 x 10^{18} photons / cm^2-sec-sr. Single shot twin radiographs of physical objects were recorded on phosphor-coated fibre-optic-plate coupled with intensified CCD camera kept at a distance of ~ 15cm from the twin x-ray sources [For more details, please see: *A. Moorti, P.A. Naik and P.D. Gupta, Rev. Sci. Instrum. 76, 106101, 2005*]. Such a source can also be attractive for single shot differential imaging by using different materials for the two anodes and for pump-probe type experiments, involving a laser as an excitation source, as the x-ray pulse can be temporally synchronized with respect to the laser pulse.

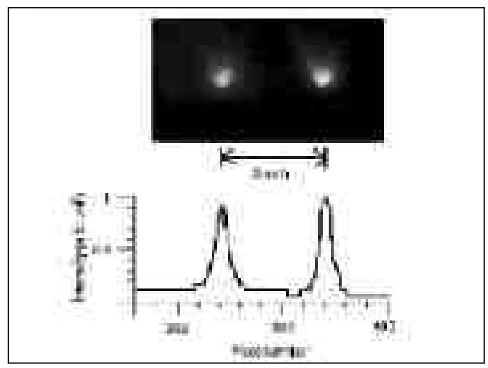

Fig. L.4.1a *The x-ray images of the two sources. The lineout shows their intensity profiles.*

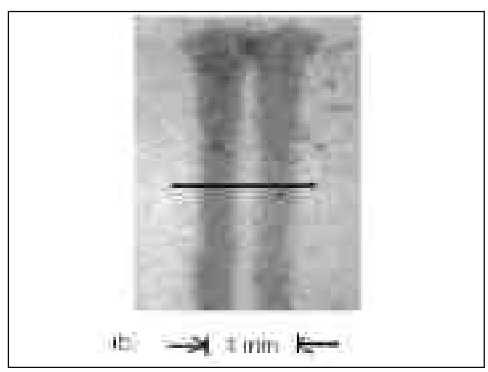

Fig. L.4.1b *X-ray radiograph of a metal taken using the twin x-ray source.*

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