L.3 : Single shot tilted pulse-front autocorrelator for diagnostics of ultra short pulse laser beams

Ultra-intense laser systems essentially involve ultrashort laser pulses. They necessarily use one or more dispersive elements such as prisms, gratings, tilted optical windows etc, in their set-up. This makes these systems quite susceptible to pulse-front tilt (PFT). The latter is the angle between the phase-front (which is always perpendicular to the direction of propagation) and pulse-front of an ultrashort pulse laser beam. PFT may arise either due to angular dispersion caused by a single disperser, imperfect alignment of a double disperser or due to the simultaneous presence of spatial and temporal chirps even in absence of angular dispersion. In particular, PFT can cause significant increase of the effective laser pulse duration at the focus, resulting in a decreased intensity. On the other hand, PFT in laser beams may be useful in several applications such as travelling wave pumping of x-ray lasers and dye lasers, optical parametric amplifiers, efficient harmonic generation, THz generation etc. Quantitative measurement of the pulse-front tilt in ultrashort pulse laser beams and its sign is essential for introducing an optimum PFT in laser beams for the applications mentioned above or in eliminating it altogether for some other applications.

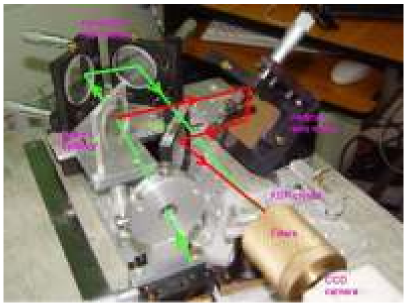

Fig.L.3.1 Setup of tilted pulse front autocorrelator

A simple, low cost, single-shot tilted pulse front autocorrelator (TPFAC) has been developed in-house at the Laser Plasma Division. Fig.L.3.1 shows a photograph of the setup. It has been used for the detection and the quantitative estimation of the PFT in a 200fs pulse duration laser beam from a cw mode-locked Nd:glass oscillator. A single prism and an inverted pair of identical prisms were used for generating PFT with and without angular dispersion respectively. Using this setup, it has been demonstrated that TPFAC can also be used to detect the sign of the PFT in a visually straight forward manner.

Fig.L.3.2a depicts a typical autocorrelation (AC) trace recorded when the laser beam was incident on a single SF10 prism at a propagation distance of 1m. It is seen that the AC trace lies in the 1st and 3rd quadrants of the Cartesian co-ordinate system. AC traces were also recorded at different propagation distances and also when the laser beam was incident on an inverted prism pair. The AC trace in Fig.L.3.2b shows a PFT obtained in the case of an inverted prism pair with an inter-prism separation of 3.4m. It is seen that the AC trace now lies in the 2nd and 4th quadrants. The sign of PFT is opposite in the two cases. The effects of beam size and propagation distance on the PFT have also been studied experimentally. A theoretical model has been developed which predicts quite accurately the observed experimental results.

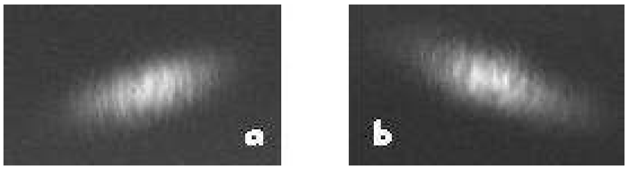

Fig.L.3.2: Typical AC traces for the case of (a) a single prism; (b) a pair of prisms

The sensitivity of the PFT measurement for a given beam crossover angle was also studied. In our case, it was calculated to be 0.0042 fs/mm for a beam cross-over angle of 6^0. The minimum detectable rotation angle of the AC trace depends on the spatial resolution of the CCD camera used to record the AC trace. [For more details, see : *A.K. Sharma, R.K.Patidar, M.Raghuramaiah, P.A.Naik, and P.D.Gupta, Optics Express 14, 1313, 2006 ; also linked in Virtual J. Ultrafast Science 6, 2007]*.

Contributed by:
A. K. Sharma (aksharma@cat.ernet.in) and P.A.Naik

L.4 : Deposition of metal nanoparticles using multi-picosecond laser pulses

Nanostructures of different materials are of great interest in nonlinear optics due to their special properties arising due to their physical dimensions being much smaller than the light wavelength. Pulsed laser deposition is used as the standard technique for nanoparticle deposition. It is well accepted that when a solid target is ablated by the laser radiation, the ablating material is in the form of atoms, ions (and electrons), and clusters. These atoms and clusters tend to aggregate during the laser pulse or soon afterwards, leading to the formation of larger clusters. In addition, heterogeneous decomposition, liquid phase ejection and fragmentation, homogeneous nucleation and decomposition, and photomechanical ejection are among the processes known to lead to nanoparticles production. Many of these processes would be governed by the intensity and pulse duration of the laser beam used for ablation. The lasers used for pulsed laser deposition for making solid clusters are normally of few fs to few ps duration. At Laser Plasma Laboratory, pulsed nanoparticle deposition of various metals has been carried out using sub-nanosecond duration pulses (300ps) at different focussing conditions.

The experiments were carried out using the uncompressed pulses (300 ps duration, 30 mJ energy) from a chirped-pulse amplification based 10TW Ti:sapphire laser system. The samples were placed inside a vacuum chamber and the laser pulses were focussed on the targets at two regimes of focussing. In the first case (referred to as tight focussing), the intensity of laser radiation was in the range of 2×10^{12} Wcm^{-2}, and in the second case (referred to as weak focussing), the intensity was considerably lower (4×10^{10} Wcm^{-2}). Silver, indium, stainless steel, and chromium were used as targets.

The structure of the deposited films was analyzed using different techniques. The absorption spectra of the deposited films were analyzed using a spectrograph. The analysis of the sizes of deposited nanoparticles was carried out using the total reflection x-ray fluorescence (TXRF). The structural properties of the deposited films were analyzed using a scanning electron microscope, a transmission electron microscope), and an atomic force microscope. The first three facilities are at SUMRD, RRCAT and the last one at LSED, RRCAT. Float glass, silicon wafer, and various metal strips (silver, copper, and aluminum) were used as the substrates for nanoparticle deposition for use with the above facilities.

The absorption spectra of the materials deposited on float glass were used to determine the presence or absence of nanoparticles from the appearance of strong absorption bands associated with surface plasmon resonance (SPR). In all metals, in the case of tight focusing, the peaks of SPR were centered in the range of 440 to 490 nm, indicating presence of nanoparticles. In the case of the deposition of silver film at the weak focussing conditions, no absorption peaks were observed in this region, indicating the absence of nanoparticles. The structure of the deposited films was analyzed using TXRF, which identified the presence of nanoparticle deposition in tight focussing condition of the laser. In the case of weak focussing, it showed a thin film-like deposition of metal, without any presence of nanoparticles. X-ray fluorescence measurements and SEM studies gave the average size of the silver nanoparticles to be 60 nm. The TEM measurements also confirmed the presence of silver nanoparticles in these deposited films. The atomic force microscopy also gave the average size of silver nanoparticles to be 65 nm. The details of this study can be found in *Applied Optics 46, 1205, 2007.*

Indium nanoparticles are quite important as they have a number of practical applications like potential nano-lubricants, as possible candidate for single electron transistors, as tags for detection of DNA hybridization, as printing blocks in nano-xerography, and as starting material for convenient synthesis of InP. Hence, a detailed study of the structural, optical and nonlinear optical properties the indium nanoparticles prepared by the laser ablation of bulk indium target in the vacuum at the tight focusing conditions and those prepared by laser ablation in liquids, was carried out. Details of this study are given in *Applied Phys. B 86, 337, 2007*

Contributed by:
U.Chakravarty (uday@cat.ernet.in) and P.A.Naik

L.5. : Use of a hollow conic beam to enhance atom transfer in BEC set-up

To achieve Bose-Einstein condensation (BEC) of Rb^{87} atoms, a double magneto-optical trap (MOT) system has been made operational recently at Laser Physics Applications Division. In this set-up (Fig.L.5.1), a vapour-cell MOT is loaded in a chamber (at pressure 2×10^{-8} torr) where Rb vapour is generated using a getter source. The trapped and cooled atoms in this MOT are then subjected to a continuous wave resonant push beam to load another MOT in a UHV chamber (~8×10^{-10} torr) where RF evaporation will be used for further cooling. The number of atoms in this MOT and in the vapour-cell MOT were measured by