constant current switch mode power supply with maximum arc voltage of 180V and a regulated current up to 55A. The unique feature of the power supply is, that all the four lamps are parallel triggered with common trigger and booster circuit. Since each lamp is powered by individual DC power source, current flowing through the lamps can be individually controlled. This feature is essential to adjust the imbalance in the performance of gain modules.

The resonator is formed by plane-plane mirrors and stabilized by thermal lensing of the Nd: YAG rod. With the optimized single gain module, for an input pumping power of 10kW, we achieved more than 300Watts output power. The beam parameter product (BPP) was found to be 32mm mrad. Using a lensline-like setup the beam quality of multirod symmetrical resonator with 'n' modules and a total length of 'nL' is identical to that of a single resonator of length 'L'. In order to preserve the beam quality in dual gain set-up the same design was employed. And the resultant beam quality was found to be same as in the case of single gain module. Our future plan is to add two more gain modules i.e. total four modules to increase the output power beyond kW level and subsequent fiber coupling of the laser output will enable us to carryout material processing applications.

(Reported by: T P S Nathan; nathan@cat.ernet.in)

L.6 Development of fiber-optic distributed temperature sensor

A fiber-optic distributed sensors work on the principle of Optical Time-Domain Reflectometry (OTDR). A short laser pulse is launched into the fiber and the Raman backscattered signal is monitored at the launching end by time-gating the signal. Every point in the fiber produces the Anti-stokes and Stokes components of Raman scattered signal. The ratio of the anti-stokes to stokes signal is a direct function of the absolute temperature of the scattering point. Therefore, by obtaining the two signals individually one can obtain the continuous spatial variation of temperature along the fiber length. The performance of the sensor is adjudged by two parameters namely, spatial resolution and temperature resolution.

The spatial resolution determines how closely separated two hot zones are resolved. This parameter is governed entirely by the laser pulse width and the detector bandwidth. For higher spatial resolution one must select shorter pulses. A 100ns pulse will give at best a spatial resolution of 10m. The temperature resolution determines how closely separated two temperatures are resolved. The temperature resolution is determined by a number of factors such as backscattered signal level, signal averaging capability and detector noise.

In the present setup, a frequency doubled Nd:YAG laser having pulse width of 85ns and pulse energy of 2μJ is being used as the source of short laser pulses. A 200μm silica fiber (core 800micron, NA 0.21) is used as the sensor. A monochromater and photomultiplier tube is being used for detection, and a Boxcar unit is used to time-gate and average the signal. Digitized data is transferred to a PC for post-processing, which involves further digital filtering and calculation of stoke to antistoke intensity ratio.

In the present settings the spatial resolution has been determined to be 8.5m and a temperature resolution of 5°C has been obtained. Efforts are on to upgrade the laser being used in order to improve the temperature resolution. It is expected that a laser of higher pulse energy and better stability will enable us to achieve better temperature resolution although a resolution of 5°C may be adequate for early fault detection in many practical systems.

Fig. L.6.1 shows a representative case. Two 25m sections of the fiber were heated to a temperature of 65°C. The ratio of the Anti-stokes and Stokes signals is shown here. This data is digitally filtered and the temperature is calculated from it using a standard formula in which the only unknown variable is the absolute temperature.

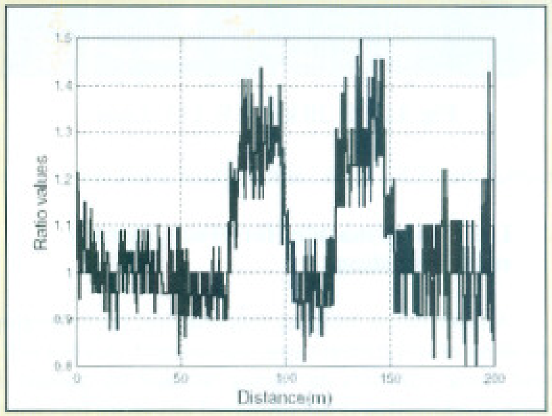

Fig. L.6.1 Ratio of Anti-stokes to Stokes signal from a 200m long fiber with two 25m sections heated to 65°C

(Reported by: T P S Nathan; nathan@cat.ernet.in)

L.7 Simultaneous measurement of pulse-front tilt and pulse duration of femtosecond laser beam

Since the last decade, chirped pulse amplification based ultra-short pulse laser systems are being increasingly used for a variety of research investigations in ultrahigh intensity laser matter interaction. Slight misalignment of the gratings used in these laser systems may produce a pulse-front tilt. The pulse-front may also get tilted on propagation through dispersive elements like prism due to the relative time delay introduced across the beam due to difference in group velocity and phase velocity of the pulse inside the medium. When such a beam with tilted pulse-front is focused, the resultant intensity may become much smaller than that expected due to temporal broadening of the pulse in the focal plane. It is therefore important to have diagnostic systems to detect and measure the pulse-front tilt so as to eliminate / minimize the same.

A setup was developed for simultaneous quantitative measurements of pulse-front tilt and pulse duration of ultra short laser pulses using a modified single shot autocorrelator. This is based on non-collinear second harmonic generation by overlapping an ultra short laser pulse with its spatially inverted replica in a non-linear crystal. The scheme used for recording single shot second order autocorrelator with spatial inversion is shown in Fig. L.7.1. The input laser beam is split into two equal intensity beams using a 50% reflectivity beam splitter. One of the two beams is horizontally retro-reflected, and the other vertically retro-reflected. The latter is once again reflected by a 100% reflecting mirror to direct it towards a type I phase matched KDP crystal. This arrangement introduces spatial inversion (left-right) in the first beam and up-down inversion in the second beam. The two beams are then made to overlap in a vertical plane in the KDP crystal at a small cross over angle. The spatial distribution of the second harmonic radiation is recorded with a CCD camera. In the absence of pulse front tilt, the harmonic emission image on the CCD camera has shape of an elongated ellipse. A scan in the direction of the minor axis of this ellipse gives information of pulse duration. In the presence of pulse front tilt, this ellipse gets rotated and from the angle of rotation, tilt angle can be determined.

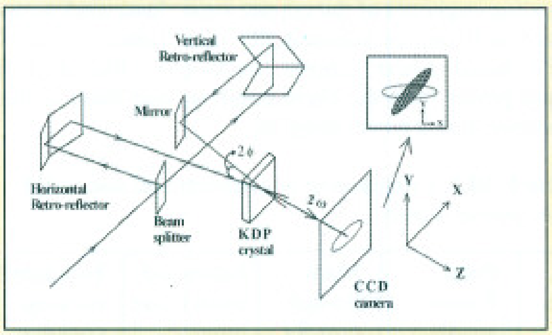

Fig. L. 7.1 Pulse-front tilt cum pulse duration measurement set-up

For the purpose of capability demonstration, a known pulse-front tilt was introduced in a laser beam. This was done by propagating the laser pulses through a prism. The tilt angle of the pulse-front was calculated to be ~16.8mrad. The pulse-front tilt angle measured by the setup was ~17.3mrad, very close to the expected value. Pulse duration of 255±10 fs was also deduced. This is close to the expected value of 250fs for the mode-locked pulses of the Nd: glass laser used. This system can serve as a valuable tool for simultaneous quantitative measurements of pulse-front tilt and pulse duration.

(Reported by: P. D. Gupta; pdgupta@cat.ernet.in

L. 8 Time resolved optical shear interferometer for laser-produced plasmas

Measurement of time evolution of electron density profile in laser produced plasmas is a pre-requisite for understanding the dynamics of laser - plasma interaction. This task is rendered rather formidable due to small spatial length scale (~10 to 100μm) and fast time scale (~10's ps to few ns) of the plasma involved. A time - resolved optical shear interferometer (Fig. L.8.1) has been set up. It consists of an indigenously built cyclic- type interferometer, which provides equal path lengths in the two arms. A second harmonic laser beam (λ = 532nm), produced by frequency up conversion of a part of the high power Nd: Glass laser output, using a phase – matched KDP crystal, probes the plasma. The interference fringe pattern (Fig L.8.1-inset) is detected using an in-house developed S-20 optical streak camera and recorded by a CCD camera – frame grabber system

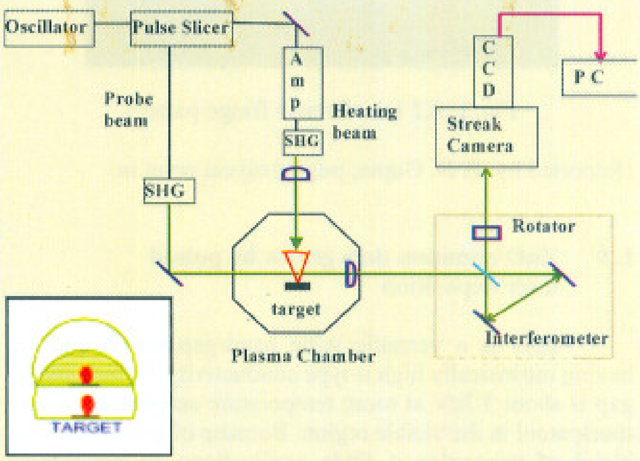

Fig. L.8.1 Schematic diagram of the time resolved optical shear interferometer

The above interferometer has been used to study expansion of an aluminum plasma produced by 4J, 5ns Nd glass laser (2ω) pulses. Fig. L.8.2 shows a typical time resolved interference fringe pattern for the time duration of 16ns of the probe beam up to a distance of 300μm from the target.