L.9: A Pulse Stretcher for Laser Pulses

A novel Confocal Optical Pulse Stretcher (COPS) is simulated, designed and developed at Laser Systems Engineering Division of RRCAT. The COPS has several advantages over conventional pulse stretchers like its compactness with smaller number of optics. The optical configuration of COPS is such that the size of the beam, which oscillates in the pulse stretcher, becomes equal to its original size at the beam-splitter after each round-trip. Thus COPS can be effectively used without requiring additional optics of large diameters even when laser beam divergence is large.

The optical configuration of the COPS is shown in Fig..L.9.1. Two 100% reflecting concave mirrors M_1 and M_2, of equal focal lengths, f, are used to form confocal cavity and a partially reflecting plane mirror with a hole at the centre (scraper beam-splitter), M_3, is used as a beam-splitter. The central hole of M_3 is made at an angle of 45 with respect to normal to the surface and M_3 is configured at the common focal plane at an angle of 45 with respect to the axis of the confocal cavity of the COPS. The confocal nature of COPS ensures that the sizes of the successive parts of the laser beam at the beam-splitter remain same irrespective of the beam divergence of the laser beam. Suppose the reflectivity of M_3 is R% and p(t) is the instantaneous power of the pulse, which is incident on COPS, then the output of the COPS is given by

$$P(t) = (1-R)p(t) + \sum_{n=1}^{\infty} R^2(1-R)^{n-1}p(t-n\tau) \quad \text{---} \quad (1)$$

where 4f/c is the optical delay time of COPS. The temporal stretching of pulses by COPS of fixed length is determined by the reflectivity of M_3. The reflectivity of M_3 is chosen such that more number of terms of Eq. (1) are effective such that energy content of the successive pulses, exiting from COPS, are significant to contribute effectively to have maximum temporal stretching. It is shown that the value of $R = 0.67$ of M_3 would provide maximum stretching of incident pulse by COPS [*R. Khare et. al., to appear in Optics Communications*]. A scraper beam-splitter of 70% reflectivity is developed for COPS because this value is the nearest to the optimum value and it is easier to fabricate in house. A hole of diameter 5 mm was made at the centre at an angle of 45° to the surface of the circular substrate of diameter 75 mm and thickness 10 mm. The COPS was experimentally demonstrated on a pulsed copper vapour laser (CVL).

The unstretched CVL pulse shown in Fig.L.9.3a. The temporal pulse profile of the CVL pulse is digitized and Eq. (1) is used to simulate the temporal profile of the stretched pulse by COPS.

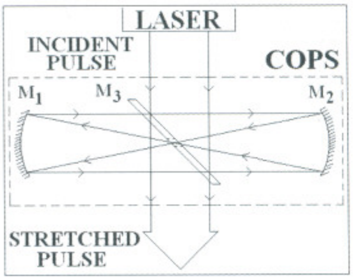

Fig. L.9.1: Schematics of the COPS

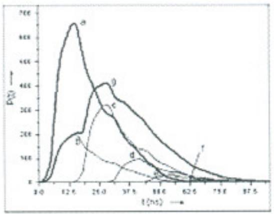

Fig. L.9.2: Simulation of temporal evolution of stretched pulse by COPS

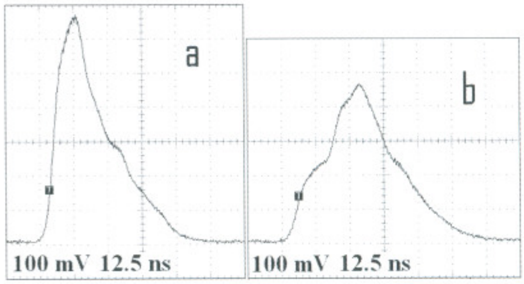

Fig. L.9.3: The shape of pulse (a) unstretched and (b)stretched CVL.

The temporal evolution of the stretched pulse produced by COPS is shown in Fig. L.9.2. The curve (a) shows the temporal profile of the simulated incident pulse and curves (b), (c), (d), (e), and (f) depict the temporal profiles of the pulses, which exit from COPS after successive optical delays.[Eq. (1)]. The curve (g) gives the temporal profile P(t) of the stretched pulse produced by COPS. The CVL pulse, stretched by COPS, is shown in Fig. L.9.3(b). COPS has increased the $1/e^2$ width of the laser pulse from 40 ns to 55 ns without loss of energy, i.e. the COPS has reduced the peak power from 53.57 to 38.96 kW without reducing average power. The pulse shape of the stretched pulse is different from that of the original pulse. The pulse shapes and temporal widths of the simulated stretched pulse, Fig.L.9.2(g) and experimentally observed laser pulse, Fig. L.9.3(b) are matching well within the experimental limits.

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