유도브릴루앙산란 위상공액거울을 이용한 두 빔의 자체 위상잠금

self-phase locking of two beams using stimulated Brillouin scattering phase conjugate mirrors

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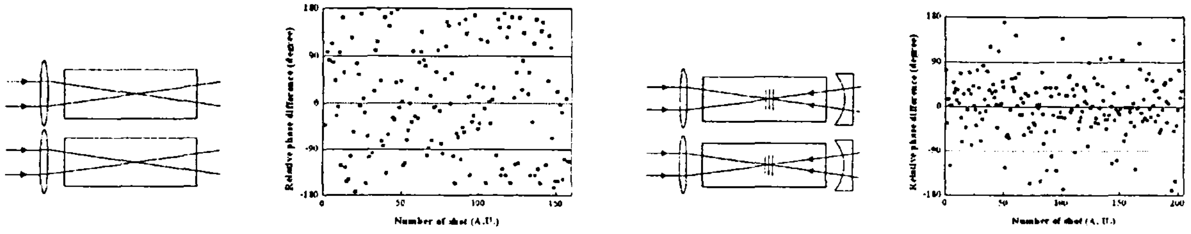
For achieving a high repetition rate of the high power laser system, several methods have been investigated by many researchers such as the beam combination technique, the diode pumped laser system with gas cooling, the electron beam pumped gas laser, and the large sized ceramic Nd:YAG [1-5]. We believe the beam combination method is one of the most practical techniques. The laser system using the beam combination technique, in which a laser beam is divided into several beams and recombined after separate amplification does not need a large gain medium. Hence, it can operate at a repetition rate exceeding 10 Hz regardless of the output energy and is easily adaptable to the modern laser technology. Kong et al. (ref. 2) proposed a promising beam combination laser system using a stimulated Brillouin scattering-phase conjugate mirror (SBS-PCM) whose the output energy can be unlimitedly scaled up by increasing infinitely the numberof separate amplifiers. In addition, the SBS-PCM not only produces a phase conjugate wave beam to compensate for system aberrations, but also couples the outputs from many separate amplifier channels to produce a single large-aperture beam. However, it is necessary to lock the phase of the each backward Stokes beam in order to achieve the coherent single beam with a uniform phase after they retrace their separate paths [2-5]. Since the SBS originates from the random acoustic noise, the phase of the reflected beam is naturally random value. There have been several works to lock the phases of the laser beams for the beam combination with the SBS-PCM and some of them were very successful [3-5]. By overlapping the laser beams at one focal point, the phases are almost locked. However, since all the beams must be focused at one point, the energy scaling is limited and the alignment is also difficult. The back seeding of the Stokes beam overcomes the above drawbacks, but the phase conjugation is incomplete if the injected Stokes beam is not completely correlated [6].

Figure 1(a) shows the scheme and the experimental results for the unlocked case when the energy of each incident beam is ~9 mJ. Each point in fig. 1 (a) represents one of 160 laser pulses. As naturally expected, the relative phase difference has random values and the standard deviation is ~0.295λ. This implies that the two beams are independent and absolutely unlocked. The SBS is generated from the random acoustic noise, implying that the time and the position of a moment when the Stokes beam reflects are not fixed, which gives rise to the random phase fluctuation. We have fixed the position and time of the SBS reflection by inducing the weak density modulation in the SBS cell. Figure 1(b) shows the proposed scheme and the experimental results for the self-phase locking. The pump beam is reflected by the uncoated concave mirror (~4% reflection) with R = 300 mm and then injected into SBS-PCM to build up the standing wave which can induce the density modulation by electrostriction. The energy of each incident beam was 13 mJ and 203 laser pulses were examined. The standard deviation is ~ 0.165. Furthermore, 88% of the data points is contained within the range of ±λ/4. This implies that the phases of two beams are considerably locked.

In this paper, we have proposed and demonstrated a new phase locking technique, the self-phase-locking wherein each beam is focused at the separate focal points without using any backward Stokes seed beams and hence, the energy scaling is not limited and the phase conjugation is not disturbed.



(a) (b)

Fig. 1. a) The scheme and relative phase difference for the unlocked case. b) The proposed scheme and relative phase difference for the self-phase locking case

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