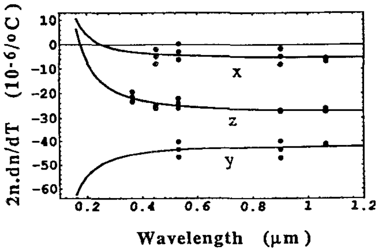

FM2 Fig. 1. 2 $n(dn/dT)$ versus wavelength for LBO crystal: curves are the computed values; solid circles are the experimental data[2] at 20°C.

terials even for limited data.[3] The optimum fitted constants G and H are shown in Table 1 along with the other physical parameters at 20°C. The experimental points and the fitted curves are shown in Fig. 1. All the quoted values including precision are used. It is interesting to note that the fit gap E_{ig} is close to the XPS valence band peak positions 'D', as denoted by French et al.[5] These optical constants are capable to interpret the existing NLODs, particularly the recently introduced femtosecond traveling-wave parametric generations.

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FM3 **1400**

Efficient phase conjugation using four-wave mixing in a broad-area laser diode

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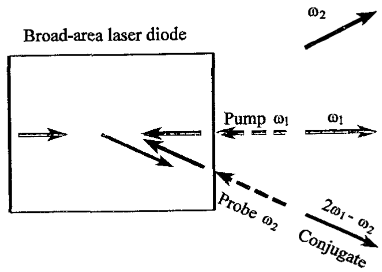
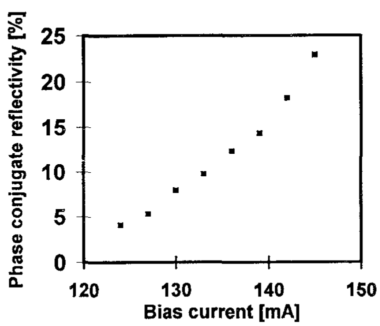
There is now a strong interest in developing fast, efficient phase conjugators for a variety of applications. Here, we focus on a phase conjugation scheme where two external fields are injected into a broad-area laser diode using a spatially nondegenerate mixing geometry (Fig. 1). Our approach has the advantage of providing a phase conjugate mirror with nanosecond response times restricted only by the carrier lifetime inside the laser diode. This compares favorably with more conventional schemes for phase conjugation using photorefractive materials.

The scheme presented in Fig. 1 has already been shown to work in principle.[1,2] However, the observed phase conjugate reflectivities (defined as the ratio of the phase conjugate signal power to the input probe power) were rather low, less than 3%. We achieve higher reflectivities by operating the laser diode above the free-running laser threshold.

For a phase conjugator we use a broad-area laser diode with a 50 μm wide emission stripe and reflectivities of 15% and 95% at the front and rear facet, respectively. A pump beam is injected colinearly to the laser axis and a probe beam is injected at an angle of 5.2° to the axis. The pump frequency ω_1 and probe frequency ω_2 are tuned 200 MHz apart. The phase conjugate reflectivities are measured by spectrally resolving the far field of the light emitted by the laser diode. This is done by scanning the far field with an optical fiber whose output is analyzed with a Fabry-Perot etalon. At the frequency $2\omega_1 - \omega_2$ we observe the phase conjugate signal propagating counter to the input probe beam.



FM3 Fig. 1. Two external fields (dashed lines) are injected into the broad-area laser diode. A carrier density grating is generated by pump and probe beams traveling to the left inside the broad-area laser diode. The pump beam reflected from the rear facet is scattered by this grating to produce a conjugate beam counterpropagating to the incident probe beam. In the far field we observe the amplified pump and probe beams, and the phase conjugate signal.



FM3 Fig. 2. Dependence of the phase conjugate reflectivity on the bias current of the broad-area diodelaser. At input powers of 390 μW for the pump and 280 μW for the probe and laser diode can be operated at a current of 10% above threshold (133 mA) in an injection-locked regime.

We increase the bias current of the broad-area laser above threshold operating it in the injection-locked regime. The phase conjugate reflectivity is strongly dependent on the bias current as shown in Fig. 2. The lasing threshold is 133 mA. We operate between 124 mA and 145 mA where the conjugate reflectivity ranges from 4% to 23%. For bias currents above 145 mA, injection-locking deteriorates and free running modes of the laser diode are observed, reducing the stability and efficiency of the phase conjugate process.

The observed phase conjugate reflectivity of 23% is considerably more than results previously reported. This suggests that the broad-area laser diode is an interesting candidate for phase conjugation applications where a fast time response is needed. An example might be the linewidth reduction of laser diodes using phase conjugate feedback.[3]

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FM4 **1415**

Arch double phase conjugation in photorefractive $BaTiO_3$ crystal

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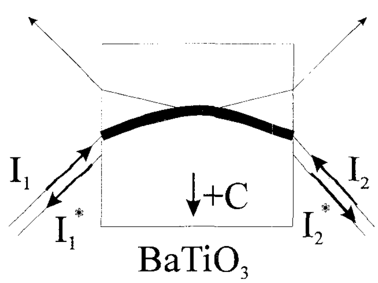
The double phase conjugate mirror (DPCM) couples two incoherent beams and has been demonstrated in a variety of materials and geometries.[1–5] It has applications in optical processing, laser phase locking and optical neural networks. Two phase conjugate outputs are produced simultaneously in the interaction of the two mutually incoherent laser beams within the photorefractive crystal by four-wave mixing (FWM). The DPCMs reported to date can be categorised by the number of internal reflections the beams experience before emerging; zero (double phase conjugation and modified bridge)[1,2] one (bird-wing),[3] two (mutually incoherent beam coupling; MIPC)[4] and three (frog-legs).[5]

In this paper a novel DPCM geometry, the "arch" (shown in Fig. 1), in photorefractive $BaTiO_3$ crystals is demonstrated. Both incident beams make an acute angle with the negative, −C, crystal axis. This leads to an effective mutual interaction as the two fans emanating from the input beams have a large region of overlap and do not suffer from Fresnel losses at internal reflections. The new DPCM exhibits phase conjugation with zero internal reflections. Qualitatively, it appears to ex-

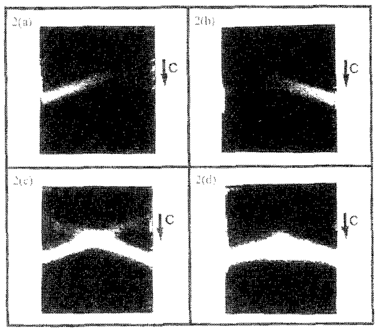


FM4 Fig. 1. Schematic of interaction geometry for the Arch-DPCM.

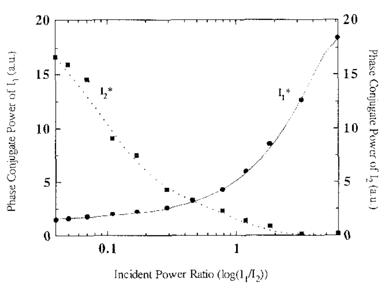
perimentally verify recent theoretical predictions.[6]

The geometry of the Arch-DPCM is shown in Fig. 1. When only one beam was incident on the crystal (Figs. 2(a) & (b)), apart from the directly propagating beam, a divergent fan of beams was established. When two beams were simultaneously incident on the crystal (Fig. 2(c)) we observed that they began to branch out and bend toward the +C axis, and an arch shape began to form. A steady arch was observed to be complete after 1.5 seconds (Fig. 2(d)). The dependence of the phase conjugate reflectivities of each beam as a function of the input beam power ratio is shown in Fig. 3.

The two incident beams enter the crystal (Figs. 2(a) & (b)), and produce strong photorefractive beam fanning towards the +C axis. The two input beams have the same wavelength but are mutually incoherent. Each incident beam interferes with its own scattered light from scattering centres within the crystal and writes a set of fan gratings. A set of identical gratings with similar phase, period and position, occurring in both fans add constructively. The fanned light resulting from one beam Bragg diffracts from the fan gratings formed by the other beam to



FM4 Fig. 2. A temporal sequence of photographs illustrating the formation process of the Arch DPCM, taken from above the $BaTiO_3$ crystal for 60° angle of incidence for both beams. (a) only the left beam incident, (b) only the right beam incident, (c) immediately after both beams are incident, (d) 1.5 seconds after both beams are incident showing the arch.



FM4 Fig. 3. Plot of the phase conjugate powers, I_1^* and I_2^*, as a function of the beam power ratio, I_1/I_2, between two beams.

generate the phase conjugate beam by FWM. As a result, the fans couple and bend into each other, to form the arch.

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FM5 **1430**

Studies of a new mechanism of self-pumped phase conjugation in photorefractive crystals

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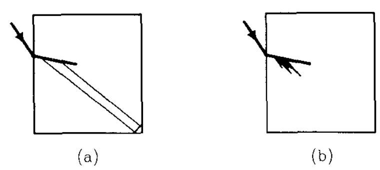
Traditionally, two typical mechanisms for internal self-pumped phase conjugation (SPPC) generation in photorefractive crystals have been identified. One is stimulated photorefractive backscattering (SPB).[1] The other is total-internal-reflection (TIR).[2] SPPC generation with the former depends on SPB interaction. With the later, SPPC generation depends on four-wave mixing (FWM) and total internal reflections. In this case, optical path loop(s) exists in the crystal [Fig. 1(a)].

In this paper, we mainly present our studies on a new SPPC generation mechanism in photorefractive crystals, stimulated photorefractive backscattering and four-wave mixing (SPB-FWM). This mechanism was first observed in 0.4 wt% Fe-doped $KTA_{0.52}Nb_{0.48}O_3$ (KTN:Fe) at 514.5 nm.[3] Where SPPC is also established with FWM interactions. However, one of the pump beams for FWM interactions, i.e., beam that propagates backward to the FWM regions, is produced through SPB amplification of backscattering light by the fanning beam. Thus the SPPC establishment does not require the



FM5 Fig. 1. Schematic optical beam patterns that can be observed in an internal self-pumped phase conjugator when the SPPC mechanism is (a) total-internal-reflection and (b) stimulated photorefractive backscattering and four-wave mixing.

internal reflections by the crystal faces. Typical beam patterns are schematically shown in Fig. 1(b). This mechanism is also found to dominate in various Ce-doped $BaTiO_3$ phase conjugators in almost the whole visible wavelength region. SPPC reflectivity as high as 80% has been obtained in these phase conjugators.

In both KTN:Fe and $BaTiO_3$:Ce crystals, it has been observed that, in a fixed beam/crystal geometry, a transition between SPB-FWM and TIR happens with varying wavelength.[4,5] At short wavelengths, SPB-FWM dominates in the SPPC production. At long wavelengths, TIR will be responsible for the SPPC production. At medium wavelengths, various beam patterns different from that as shown in Fig. 1 can be observed. The phenomenon of mechanism transition with wavelength is found to result from the fact that the contra-directional two-wave mixing gain coefficient γ_{2K} decreases with increasing wavelength. And thus it should be quite general in photorefractive crystals. This phenomenon can be explained in theory.

Phase conjugators working with SPB-FWM mechanism has two main advantages over that working with TIR mechanism: (a) only the incidence face needs to be polished; (b) dimensions of the phase conjugator could be small. The transition property of SPPC mechanism make it possible for us to choose the mechanism of a phase conjugator by varying the wavelength.

It should be noted that SPB interaction in photorefractive crystals can be strengthened by doping. As doped crystals become more easily available, it is expected that SPB-FWM mechanism should become more common and important in SPPC generation with photorefractive crystals.

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FM6 **1445**

Two possibilities of self-pumped phase conjugation of the laser beams in an inverted laser crystal with a feedback loop

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The effect of self-pumped phase conjugation (SPPC) was observed recently in the inverted Nd:YAG-rod with the loop schemes.[1,2] Two possibilities of this effect realization were discussed: first is the formation of PC-wave in the resonator with the holographic mirror (RHM-scheme) induced in an inverted laser crystal by interference field of the pumping waves; second is the simultaneous stimulated resonant scattering (SRS) of two intersecting (in the general case noncoherent