OPTICS AND LASER PHYSICS LAB #6

PHOTOREFRACTION & OPTICAL PROCESSING

Use of Photorefractive Material for Optical Processing

Photorefractive crystals are nonlinear materials whose index of refraction changes after light of a specific polarization and orientation enters the sample. These materials are known for the ability to produce a phase conjugate beam in various geometries. One geometry is known as the double phase conjugator or mutually pumped phase conjugator (DPPC or MPPC). This particular geometry is interesting because two input beams introduced into opposite sides of the photorefractive sample will interact with their beam fans and each other to produce phase conjugates of both inputs.

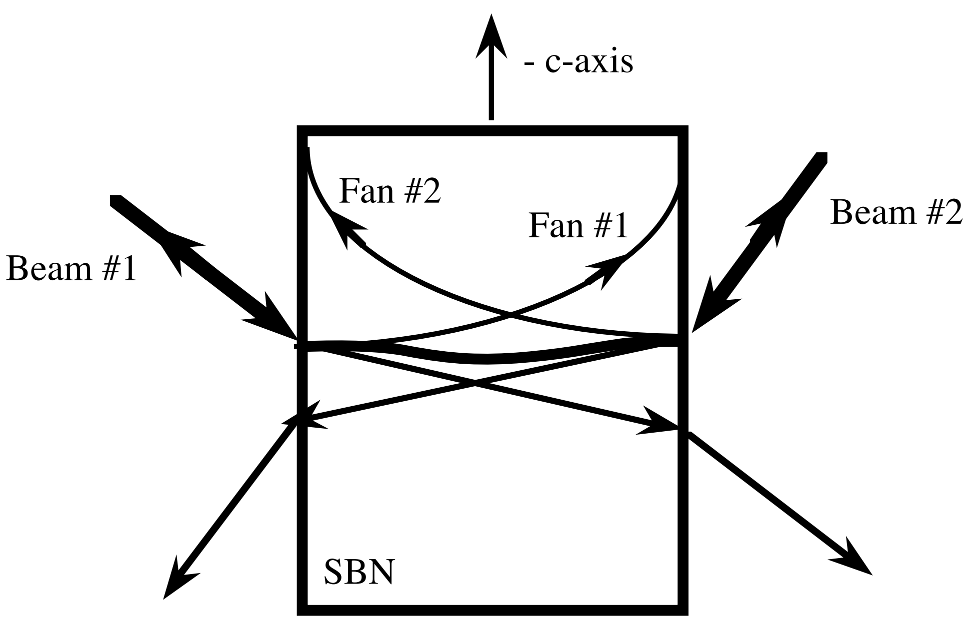

Figure 1. Diagram of Bridge Configuration of Mutually Pumped Phase Conjugation

Mutually Pumped Phase Conjugators

The generic experimental set-up for mutually pumped phase conjugation is based upon the introduction of two mutually incoherent optical beams into a photorefractive crystal in various geometries. Each of the beams produce a fan which then makes a number of reflections within the sample ranging from zero to three depending on the MPPC geometry. The end result of the two beams' and their associated fans' interactions is the production of two phase conjugates of the

input beams. The geometry of the experiments on which we report is known as the bridge conjugator. In the bridge conjugator no internal reflections are necessary for production of the two phase conjugate beams. For example in Figure 1, one beam entering from the left side of the crystal (Beam #1) is scattered, creates index gratings via photorefraction, and finds itself fanning toward the -c-axis (SBN has negative charge carriers). This fan #1 writes index of refraction gratings with the initial refracted beam in the crystal. Then the fan #2 from the oppositely directed beam (Beam #2) reads these gratings, thus in some characteristic time forming a phase conjugate beam of the initial beam #1 which then exits the crystal. This process occurs in reverse for Beam #2 with the fan of Beam #1 reading the gratings formed by Beam #2's fan and its initially refracted beam. Both beams are necessary for either conjugate to exist since the energy for one conjugate is supplied by the other and vice versa. No cross talk is observed between the two conjugates once
they reach steady state. If spatial or temporal information is placed on either Beam #1 or #2 (or on
both beams), then the phase conjugates of these beams will also carry this information as the index gratings which are written by the respective fans and refracted beams contain this information.

High Resolution Edge Enhancement

Once the MPPC has established its two phase conjugate beams, image processing can be performed on the beams. Only one beam is manipulated (beam #1); the other beam is not changed. Both beams are image bearing beams having passed through a positive resolution chart or mask which was placed at a 45^{o} angle to eliminate the preferential effects of beam fanning on the normally horizontal components in the bar pattern. Edge enhancement of the full image (all edges regardless of orientation) is seen when a low frequency spatial filter is placed in any of the six Fourier planes.

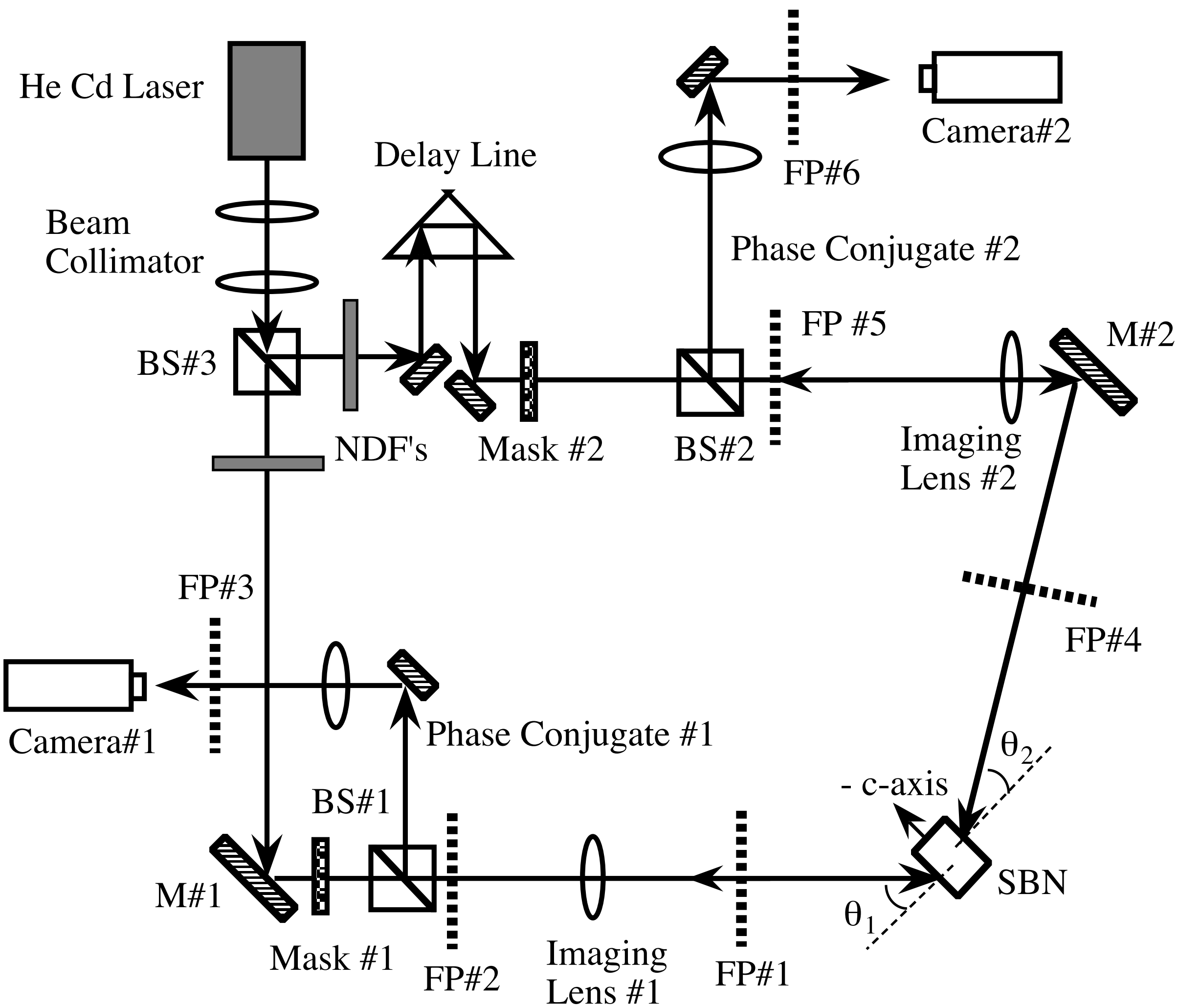

Figure 2. Mutually Pumped Phase Conjugate Geometry. Two phase conjugate image-bearing beams are created in the photorefractive SBN crystal. Imaging lenses #1 and #2 are placed in a 2f-2f system so that masks are 2f away from lens and crystal is 2f away as well. Focal lengths of imaging lenses are Lens #1, f=17.5 cm and Lens #2, f=25 cm. Neutral density filters, NDF's, are used to tailor the beam ratios. Beam splitters (BS) #1 and #2 are used to separate the phase conjugates from the input beams and the conjugates are subsequently imaged into two cameras. The six Fourier planes in which spatial filtering can be accomplished are denoted as FP#1-6.

Amplified Edge Enhanced Imaging

There are two geometries in which an amplified edge enhanced image can be created. In the first case, a phase conjugate image is formed at the CCD camera. It then undergoes spatial filtering via the 1 mm filter placed in the Fourier plane #3.

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When a second spatial filter is placed in the central beam spot at either Fourier plane #1 or between the mask and beam splitter #1, the already edge enhanced image becomes amplified.

Rview the experimental set-up already in place in the lab. Explore the edge enhancement and high frequency filtering capabilities of the optical system both at the lens and after the image bearing mask. Create an amplified edge enhanced image. Then create an amplifed edge enhanced image.

Q. 14 When compared to the image processing available with an image bearing beam and a simple lens, what advantages do you see with the DPPC set-up?

Q. 15 Why is the amplification of the enhanced image significant?

Q. 16 What real-life situations would you see as being affected by this capability?