Extraordinary polarised light does not always yield the highest reflectivity from Self-Pumped $BaTiO_3$

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The 'Cat-Mirror' Self Pumped Phase Conjugator, SPPC, has continued to stimulate research since its discovery in 1982[1]. Surgical erasure of photorefractive gratings has been used in attempts to locate principle interaction regions in the conjugator[2,3], and also to control the magnitude and temporal behaviour of the phase conjugate (PC) output[4].

The SPPC has been shown to possess a well defined value of gain-interaction length product[1]. In order to obtain sufficient gain in $BaTiO_3$ it is necessary to access the r_{42} electro-optic coefficient by using an extraordinary ($\hat{e}$) polarised input beam. As the plane of polarization of the input beam is rotated only the $\hat{e}$ component will contribute to the PC output, since the ordinary ($\hat{o}$) component does not see sufficient gain, and is not phase matched to the gratings written by the $\hat{e}$ component. Thus the $\hat{e}$ component, $I_{\hat{e}}$, and hence the PC output, would be expected to follow:

$$I_{\hat{e}}(\theta) = I_{inc} \cos^2(\theta) \qquad (1)$$

$$I^*(\theta) = R_{PC}\, I_{inc} \cos^2(\theta) \qquad (2)$$

where I_{inc} is the input power, $I^*(\theta)$ is the PC output power, R_{PC} is the PC reflectivity and θ is the angle of the plane of polarisation with respect to the extraordinary polarisation direction. Equation (2) would be expected to represent the **upper limit** on the PC output, since the co-propagating (and virtually co-linear) $\hat{o}$ component would be expected to erase the SPPC gratings, thereby reducing the PC output.

Here, however, we will show that for *certain* input geometries it is possible to increase the PC reflectivity (by up to a factor of 2) through the inclusion of an $\hat{o}$ component in the input beam, and that by controlling the $\hat{o}$ component it is possible to achieve optical gain in switching the PC output.

An example of the results obtained is shown in fig. 1 where the PC reflectivity (defined here as $I^*/(I_{\hat{e}}+I_{\hat{o}})$, where I^* is the PC output, and $I_{\hat{e}}$ and $I_{\hat{o}}$ are the intensities of the $\hat{e}$ and $\hat{o}$ components of the input beam) is plotted as a function of the input plane of polarisation, obtained at an angle of incidence of 58° with respect to the normal to the crystal face

The graph shows that the PC output exceeds the expected $\cos^2(\theta)$ dependence at all angles out to $\theta=45°$, and that the inclusion of an $\hat{o}$ polarized component in the input beam produces a 75% enhancement in the PC reflectivity at $\theta=15°$. Observation of the time dynamics of the SPPC process for these geometries has lead to the conclusion that the onset of SPPC is accompanied by a secondary, parasitic, process, of longer time constant, which extracts power from the SPPC geometry. The $\hat{o}$ polarised component of the input beam erases the parasitic gratings, reducing their deleterious effect.

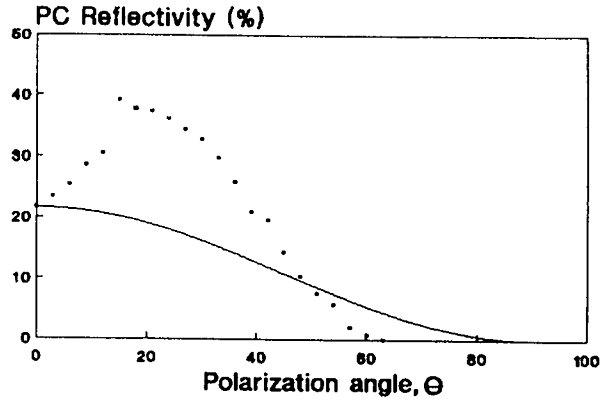

Figure 1: Normalised reflectivity as a function of the input plane of polarisation θ (measured with respect to the extraordinary direction), for an angle of incidence of 58°. The expected $\cos^2(\theta)$ dependence is shown by the solid line.

References

1. J. Feinberg, Opt.Lett. 7, 486 (1982).
2. P.S. Brody, Appl.Phys.Lett. 53, 262 (1988).
3. D.M. Pepper, Phys.Rev.Lett. 62, 2945 (1989).
4. G.J. Dunning, D.M. Pepper and M.B. Klein, Opt.Lett. 15, 99 (1990).