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Competition and coexistence of multiple mutually pumped oscillations in the visible and infra-red

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Abstract

A photorefractive oscillator, mutally pumped by three wavelengths is presented in various configurations and competition effects demonstrated. The theoretical model used to simulate the behaviour of the oscillation beams is in good agreement with experimental data.

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In recent years the idea of coupling between incoherent beams has attracted a great deal of attention. A number of photorefractive conjugators and oscillators have been proposed [1, 2] with the double-phase-conjugate mirror (DPCM) [3] and its modified version, the double-colour-pumped-oscillator (DCPO) [4], as one of the most popular ones. In both of these configurations, two new beams are simultaneously self-generated due to the interaction of the two mutually incoherent input beams.

Our work has aimed at investigating the full potential of the DCPO as an oscillator for cross-coupling multiple single-frequency waves. The standard configuration has been modified by adding a third incident beam, giving rise to generation, in total, of four new oscillation beams (fig.1). We have investigated different arrangements using either two or three different input wavelengths from Ar^+ lasers and infra-red laser diodes, both with, and without mutual coherence between two of the input beams. The intensity and wavelengths of all interacting beams, have been monitored. Theoretical analysis, based on modified standard four-wave mixing theory [1], has enabled us to calculate the power of the oscillation beams and compare with experimental results.

We have found that the prominent factor in the generation of oscillation beams is the geometry of the interacting waves. It is possible for the three input beams to interact simultaneously to produce four oscillation beams, provided that there are two regions of interaction inside the crystal. Each grating induced in each of these regions is responsible for diffracting only the two respective input beams into the two generated oscillation beams: there is no coupling between the interaction regions. The particular position of the interaction regions in the crystal determines whether a pair of oscillation beams originating from it experiences "competition", i.e. a decrease in power due to the presence of an additional input beam. The other pair, from the other region, can stay relatively unaffected by the presence of additional beams. For example, the power of one of the oscillation beams will increase until saturation with increasing power of one of the input beams creating it (fig. 2). If an additional beam is present, this dependence is the same, but the power of the oscillation beam is lower. Theory and experiment are in good agreement, in this case.

The interesting, fragile coexistence of oscillation beams can be easily destroyed if the input beams overlap, and hence share just one region. According to the theory if there is a single, interaction region for all the beams, all the oscillation beams cannot coexist, i.e. only one pair of oscillation beams can be present at one time.

We have also investigated the stability of oscillation beams using infra-red laser diodes, two of them unisolated, as input sources. It can be observed that the diodes can "lock" to each other via backward propagating oscillation beams. As a result the intensity of the generated oscillation beams can become unstable. The problem of injection locking and mutual coherence between beams is to be a subject of further investigation.

References

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Figure captions

Figure 1 Experimental arranagement of the multiple mutually pumped oscillator pumped oscillator. L's: lenses; $\lambda/2$: half-wave plate; VND: variable neutral density filter; BS: beam splitter; M: mirror.

Figure 2 Example of observed and calculated power (solid lines) of one of the oscillation beams as a function of input power of beam 1. ($*$) and solid curve: additional input beam 2 present; ($\triangle$) and solid thick curve: additional input beam 2 absent.

Fig.1

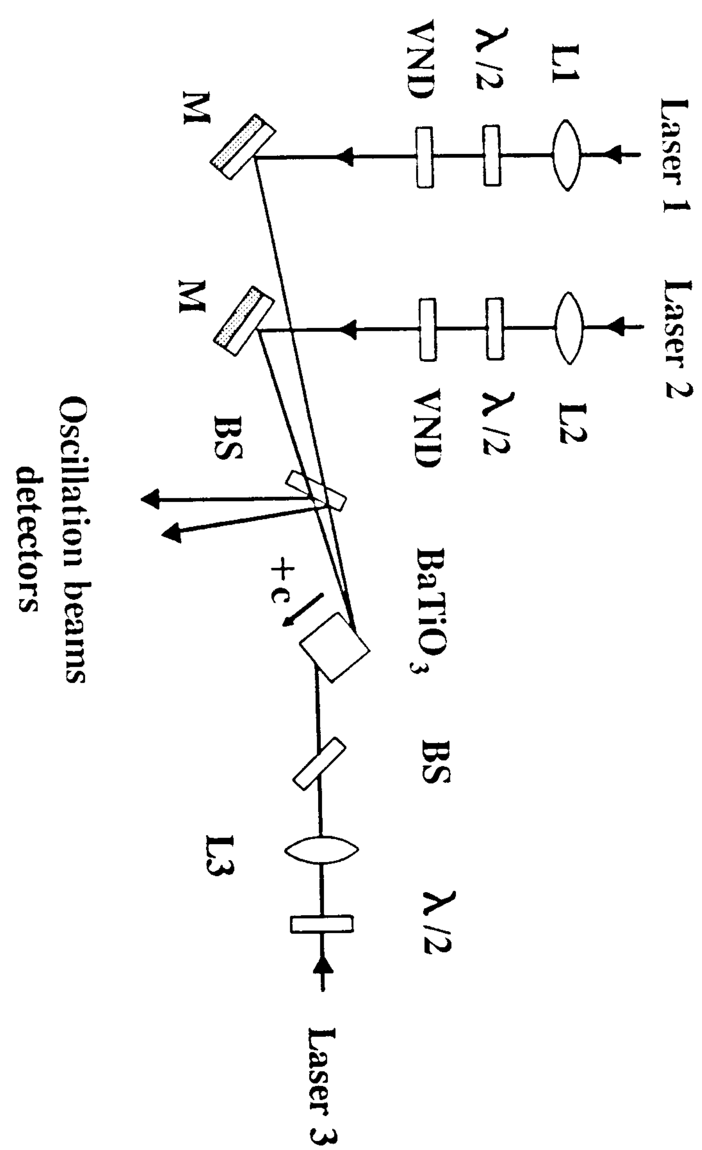
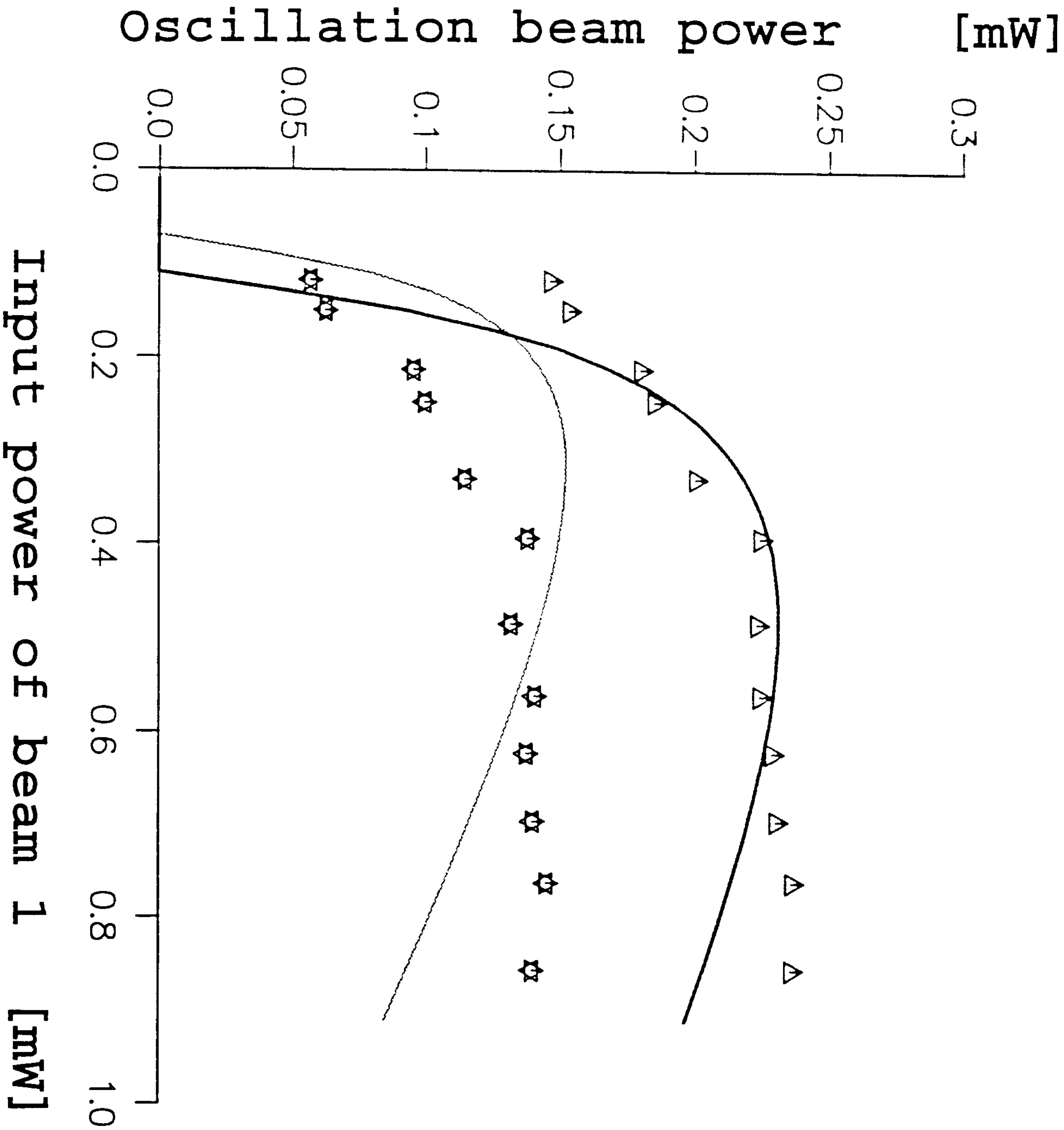

Laser 1
L1
λ/2
VND
M
Laser 2
L2
λ/2
VND
M
BS
Oscillation beams detectors
+c
BaTiO3
BS
L3
λ/2
Laser 3

Fig.2


Oscillation beam power [mW]
0.0
0.05
0.1
0.15
0.2
0.25
0.3
Input power of beam 1 [mW]
0.0
0.2
0.4
0.6
0.8
1.0