17.15 **QWF6**

All-Optical Signal Regeneration using Parametric Soliton Switch

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Multi-dimensional parametric solitons have been the subject of considerable interest recently Because they rely on a second order rather than a third order interaction they have lower formation energies and shorter interaction lengths than their Kerr counterparts, thus making them suitable as the basis for an all-optical logic switch, or other photonic applications requiring THz bandwidths

A photonic switch in the form of a *logical* AND *gate* within a planar waveguide has been proposed by Drummond et.al [1], and is shown again in Figure 1

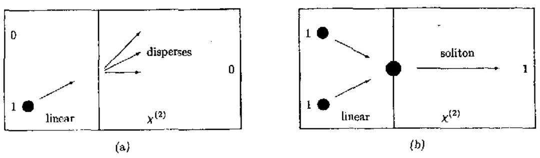

Fig 1 Schematic of proposed AND gate implementation: (a) Logic: 1 & 0 ↦ 0; (b) Logic: 1 & 1 ↦ 1

Figure 1a depicts only one pulse being injected into the waveguide and its subsequent dispersion Figure 1b depicts two pulses arriving simultaneously, with subsequent soliton formation through type II interaction It is also clear that when no pulse arrives at either input then there will be no output pulse In this fashion AND gate logic operation *is achieved For such* 2+1D *solitons* to form the basic requirements are anomalous dispersion and (nearly) matched group velocities at the fundamental and second harmonic frequencies Last year, 2+1D solitons in parametric media were experimentally observed[2]

One of the key factors determining the feasibility of the proposed implementation is its energy transmission (when logic TRUE output is expected) as a function of perturbations in the critical input parameters In the case of type II interaction probably the three most important input parameters are:
1) time separating the arrivals of the individual pulses,
2) their initial transverse separation when they enter the $\chi^{(2)}$ section of the planar waveguide, and
3) the relative energy balance between the input pulses

Investigations by numerical simulation have been performed with two very interesting results Firstly, the switch displays a highly digital response with respect to perturbations in the first two parameters, and secondly the switch continues to perform well with relative energy imbalances of up to a *factor of 2 Thus* not only could this switch be used very effectively as an all-optical AND logic gate, but by combining a signal with a well timed clock pulse-train, time domain multiplexing, de-multiplexing, and signal regeneration in both pulse timing and pulse energy can be performed

Finally it is of note that when using realistic values for nonlinearity, dispersion, and fundamental wavelength we find *that this device would be capable of order* 10^{12}–10^{14} operations per second

References

1 P D Drummond, K V Kheruntsyan, and H He, "Novel solitons in parametric amplifiers and atom lasers", J Opt B 1, 387-395 (1999)
2 X Liu, L J Qian, and F W Wise, "Generation of optical spatio-temporal solitons", Physical Review Letters Volume 82 Issue 23, 4631-4634 (1999)

17.30 **QWF7**

SIGNAL-IDLER SELF-PHASE LOCKING IN A TYPE II OPTICAL PARAMETRIC OSCILLATOR

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SUMMARY

When an Optical Parametric Oscillator (OPO) is above threshold, the oscillator frequencies of the signal and idler modes are determined by the phase-matching condition, which is satisfied in a rather broad frequency range, and by the resonances of the cavity, which change with the cavity length. Consequently, in OPOs, the exact oscillation frequencies cannot be controlled very precisely, which can be a serious drawback. For example, the regime in which the signal and idler modes have exactly the same frequency, equal to half the pump frequency, is obviously very important to reach in metrology, but also in quantum optics where degenerate OPOs have many interesting quantum properties.

Recently, Mason and Wong(1) demonstrated experimentally that one can force the signal and idler modes of an OPO to oscillate at the same frequency by inserting a quarter-wave plate inside the OPO cavity that contains a type II phase-matched nonlinear crystal (with orthogonally polarized signal and idler). The aim of this presentation is to give a detailed theoretical analysis of this phenomenon(2).

A birefringent plate inserted in the cavity induces a linear loss-free coupling between the two polarizations which competes with the interaction induced by the pump in the nonlinear crystal : in most cases the OPO oscillates on signal and idler modes with different frequencies and elliptical polarizations. We show that there exist some experimental conditions for the birefringent plate for which the system suddenly locks at exact frequency degeneracy within a given range of cavity detunings. This phenomenon is quite reminiscent of the locking mechanism occurring in ring gyrolasers where the linear coupling induced by back-scattering induces a phase-locking phenomenon between the two counterpropagating modes. The signal-idler phase difference is then fixed at a value which depends on the operating point within the locking range. There are actually two possible locking modes, with different thresholds and phase properties.

We will also compare these predictions with the experimental observations and discuss possible applications to metrology and quantum optics.

(1) E.J Mason, N.C. Wong, Optics Letters **23** 46 (1998)
(2) C Fabre, E.J. Mason, N.C. Wong, Optics Communications 170 299 (1999)

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