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Spatial switching and spatial steering of quadratic solitons in a PPLN film waveguide with short pulse duration

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Abstract: We experimentally and numerically investigated spatial switching and steering of a soliton beam in PPLN film waveguides. We demonstrated the operation of an ultra-fast spatial switch based on the non collinear excitation at a repetition rate of 125Gbit/s.

Introduction: Soliton collision between two quadratic spatial solitons in 1D or 2D was widely studied by many groups around the world. It was already demonstrated that spatial 1D [1] and 2D [2] quadratic solitons interactions may lead to spatial repulsion, fusion or mutual steering. These nonlinear behaviours are then employed to realize ultra-fast all optical switching and addressing devices.

In this paper we investigated, for the first time to our knowledge, a new device to realize spatial switching and spatial steering of a trapped beam in a PPLN film waveguide with short pulse duration. We show that, in spite of the group delay mismatch between the fundamental and the SH waves widely larger than the pulse duration, it is possible to realize an ultra-fast addressing based on soliton propagation in the non collinear excitation regime. The spatial switching and the spatial steering are controlled by the phase relationship between the input waves. Nonlinear interactions between two input beams at different wavelengths are also demonstrated.

Experimental set-up: In the experiments we used an all fiber laser source delivering 4ps (@1548nm) pulses duration with a repetition rate of 20MHz and a maximum peak power of 7kW. A Michelson-type interferometer split the fundamental beam into two separate waves with identical polarisations. The two waves are further focused to 50 µm spots onto the entrance face of the PPLN waveguide. The non linear medium is a 58mm long PPLN with a micro domain structure of 16.92µm periodicity. The sample is inserted in a temperature stabilized oven to allow operation at elevated temperatures (phase matching temperature: 160°C@ 1548nm).

Results: We launched simultaneously the two incident beams with two different directions in the device. The overlapping of the two waves gave birth to spatial fringes due to the interference between the waves. The transverse position of the maxima and minima depended on the phase relationship between the two beams. For a zero phase difference between the two input waves, the profile of the input field exhibited a main central peak. A single soliton is then excited in that case by fusion of the two input beams.

The propagation direction corresponded to the median direction between the two initial directions of the input beams. Slight steering of the output position of the trapped waves is obtained by the introduction of a small phase difference between the input beams. For a phase difference of π the interference field was double peaked. Two separate solitons are then excited. The behaviour derived from numerical simulations appeared similar to those obtained in practice and confirmed the phase dependence of the output patterns.

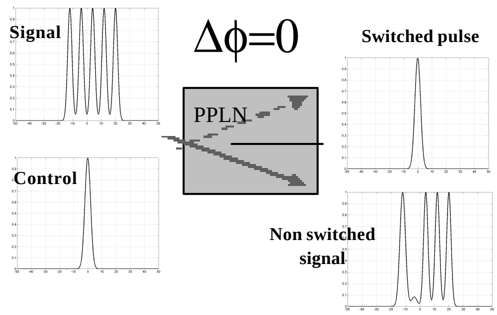

Fig.1: pulse profile of the input and output signals in the case of spatial switching at 125GBit/s.

To demonstrate the efficiency of this new switching device, we realized the spatial switching of one pulse in a packet of 5 pulses at a variable repetition rate. The device operated successfully up to a data rate of 125Gbit/s (figure 1). Almost 90% of the input signal was routed to a different output port. The rejection ratio between the switched and non-switched output is of the order of 20 dB in our experimental arrangement.

Conclusion: We investigated numerically end experimentally spatial switching and spatial steering of a soliton beam in a PPLN film waveguide in a non collinear excitation regime. We demonstrated that in spite of the shortness of the pulse light we obtained spatial addressing with high efficiency at a repetition rate of 125Gbit/s. The spatial switching was also obtained with two input beams with separate central wavelengths. The numerical simulations developed to describe the phenomenon are in good agreement with the experiments.

[1] R. Schiek, Y. Baek, G. Stegeman, W. Sohler: Opt. Quantum Electron. **30**, 861-879 (1998).
[2] B. Costantini, C.De Angelis, A. Barthélémy, B. Bourliaguet, V. Kermene: Opt. Lett. **23**, 424-426 (1998).