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Self-trapping of short pulses in Ti:PPLN waveguides at 1550 nm

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Abstract: We experimentally and numerically studied the excitation of quadratic spatially self-trapped beams in a Ti:PPLN film waveguide in presence of large group velocity mismatch.

In this paper, we present an experimental and numerical study of quadratic spatial self-trapped propagation with a pulse duration significantly shorter (5.4 times) than the temporal walk-off between the fundamental (FF) and the second harmonic (SH) waves, with only the FF wave in input at 1548nm. We succeeded in spite of the large group velocity mismatch (GVM) to excite a spatial self trapped beam but only for positive phase mismatch values. The threshold intensity obtained for spatial trapping was 66 MW/cm² which is the lowest value ever reported. We also observed a temporal locking between FF and SH, which showed the GVM compensation during the quasi-soliton propagation.

We performed our experiments in a 58 mm long Ti:PPLN z-cut planar waveguide (3.2 times the diffraction length of the input beam) with a poling period of 16.92 µm. We used for the soliton excitation an all fiber laser system which delivered 4 ps pulses (FWHMI) at 1548 nm. The laser beam was shaped in an elliptical gaussian spot to have an efficient coupling in the waveguide. The sample was inserted in an oven to operate at elevated temperature to reduce photorefractive effects. By temperature tuning, we changed the phase mismatches conditions.

We studied, experimentally and numerically, the spatial profiles evolution of the FF output beam versus the input intensity for different phase mismatches (ΔkL). By increasing the incident intensity, the non linear self focusing balanced the effect of diffraction up to the point where the output beam width was equal to the input one (figure 1). The lowest intensity for reaching this regime was 66 MW/cm² and was obtained for a phase mismatch of 9π. For intensities up to 200MW/cm² this self-trapping effect was maintained, but for higher intensities the output beam width broadened.

In the limit of the available intensity, it was not possible to observe self-trapping in close vicinity of perfect phase-matching ($\Delta kL=0$) measured to be at T=160°C. Spatial trapping started to appear at a sample temperature of 151°C ($\Delta kL\sim 9\pi$) and was maintained down to T=114°C ($\Delta kL\sim 46\pi$). We studied the intensity threshold evolution for reaching spatial trapping versus phase mismatch (figure 2).

Despite the strong temporal walk-off, when spatial trapping occurs, the pulse at FF and a consistent contribution at SH overlapped in time and locked together; this condition was necessary to guarantee an appreciable cascading self focusing effect. Numerics and experiments confirmed this behaviour. FF numerical pulse envelope also revealed a small self steepening effect due to the trapping with SH wave.

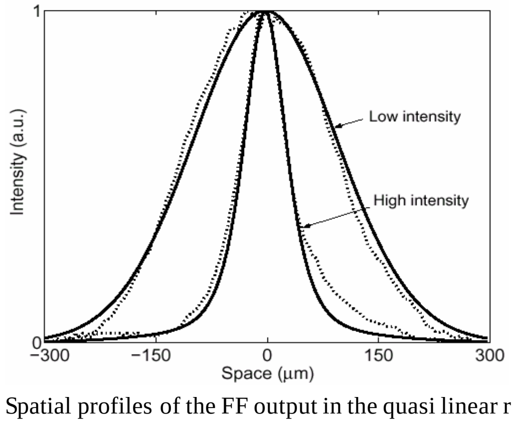

Fig.1: Spatial profiles of the FF output in the quasi linear regime and in the self-trapped regime (I=66MW/cm^2); Experimental data (dot) and numerical simulations (bold).

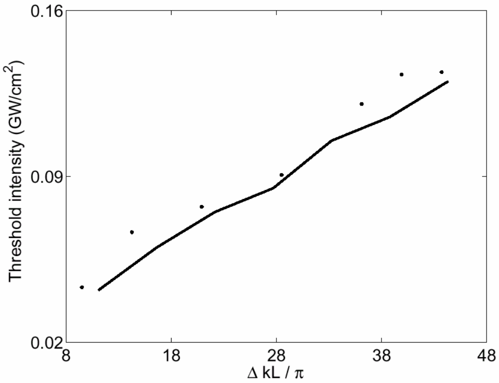

Fig.2: Intensity threshold of self trapping versus phase-mismatch. Dots refer to experimental data, solid line to numerical simulations.

Conclusion: We clearly demonstrated the generation of self-trapped beams in Ti:PPLN slab waveguides despite a pulse duration shorter than the temporal walk-off, only for sufficient positive phase mismatch. We also noticed a temporal trapping of the FF and the SH pulses accompanying the spatial trapped regime.