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Towards Stable Propagation of Parabolic Pulses through Tapered Bragg Fiber

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1. Introduction

Parabolic optical pulses with their characteristic linear chirp have profound importance in nonlinear optics as they have immense capability to withstand strong nonlinearity which prevents wave-breaking. Moreover, their evolution is self-similar, hence they are typically known as *similaritons*. Such wave-breaking free parabolic similaritons are widely applicable in all-fiber based devices like, high energy fiber laser sources, bio/chemical sensors, supercontinuum generators, bio-medical imaging and non-invasive surgery tools and so on. To date, theoretical and experimental formation of PPs have been reported for both active and passive optical fibers where PPs are asymptotic solutions of nonlinear Schrodinger equation (NLSE) [1]. It is clearly reported that PPs in active fibers are highly stable and evolve *self-similarly* over longer propagation distance whereas, passive formation of PPs are a mere *intermediate transient state* of propagation and with further evolution it becomes unstable [2]. In this context, another two types of similaritons (bright and dark) have been reported which are exact solutions of NLSE and found to propagate self-consistently against their asymptotic counterpart [3]. While encountering the stability issue of PPs in passive medium, it has been seen that high values of dispersion are being detrimental leading to wave-breaking. Hence some dispersion managed schemes have reported that effectively suppresses the excessive dispersive phase accumulation and stabilize the pulse over a few meters [4]. In this paper, we report formation and stable propagation of PPs over few hundreds of meters through a soft glass based tapered Bragg fiber. Instead of employing any dispersion managing technique, we simply have exploited the self-consistent nature of a bright (sechyperbolic) and dark (tanhyperbolic) similaritons and formed parabolic pulses in a decreasing dispersion profile.

2. Theory, fiber design and results

In passive medium based fibers, PPs are formed in a dispersion decreasing landscape and NLSE have been modified accordingly. Numerical computation of NLSE have been carried out by employing split-step fourier method (SSFM).

We have designed a Bragg fiber with a cladding structure made of 6 bi-layers of soft glasses – SF6 (high index) and LLF1 (low index) surrounding a 7.5 μm core optimized for fundamental mode only. The values of fiber parameters at initial cross-section are: $\beta_2 = 9 \times 10^{-3}$ ps^2/m and $\gamma = 1.7 \times 10^{-3}$W/m. Starting with the initial cross-section, the fiber is down-tapered in a way to make the dispersion profile hyperbolic [5]. At the input end of the fiber a Sechyperbolic pulse (peak power=100 W, FWHM=3.0 ps) and a tanhyperbolic pulse with finite Gaussian background (peak power=3 W, $\text{FWHM}_{\text{gaus}}$=3.0 ps, $\text{FWHM}_{\text{tanh}}$=0.3 ps) have fed simultaneously. During propagation down the fiber, both pulses interact through cross-phase modulation and gradually evolves into a parabolic pulse with linear chirp across its width that propagates stably up to $0.5L_D$ where L_D is the dispersion length of the fiber. Further, we have compared the simulated results with another PP formed from a single Sechyperbolic input with same parameters. All the results are presented at the operating wavelength of 980 nm.

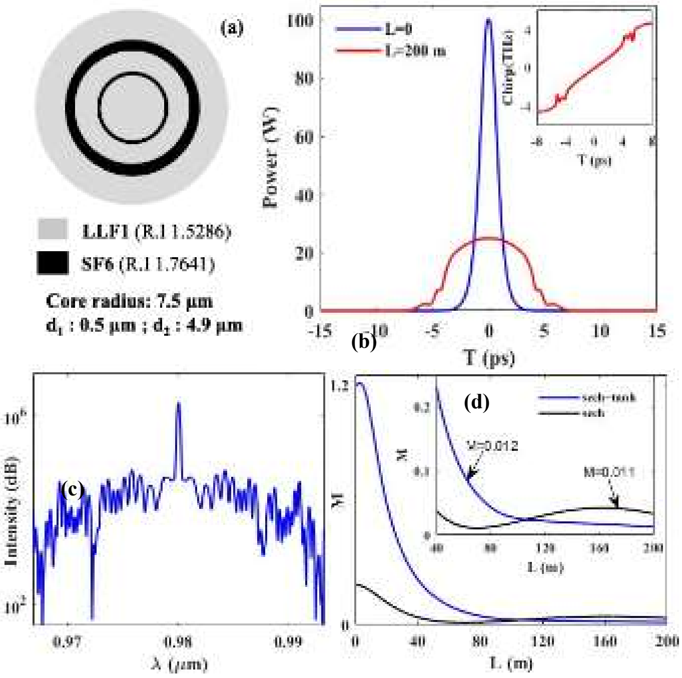

Fig. 1. (a) Cross-section of the Bragg fiber. (b) Time domain profile of input sech+tanh (blue) and output parabolic (red). Output chirp as inset. (c) Output spectral profile. (d) Evolution of misfit parameter M with fiber length for sech+tanh input (blue) and sech only (black). $M < 0.04$ is considered as cut off. Zoomed view as inset.

3. Conclusions

We have reported stable propagation of parabolic pulses formed from two input pulse forms (one bright and one dark) over a longer propagation length of the designed tapered Bragg fiber. The technique and results presented here are new to the best of our knowledge.

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