Soliton Pulse Compression in Self-Similarly Designed Erbium Photonic Crystal Fiber

Poster Presentation

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We numerically investigate the amplification and compression of chirped solitons in Er-doped tapered photonic crystal fibers (TPCFs) at 1550 nm. Generation of low pedestal, high power femtosecond pulses based on self-similar analysis requires proper control over the variation in β_2 and the nonlinearity coefficient γ along the fiber length. To model the evolution of such pulses in the PCF, one needs to solve the generalized nonlinear Schrödinger equation (GNLSE). The GNLSE with distributed gain coefficient, higher-order dispersive, and nonlinear effects is given by [1].

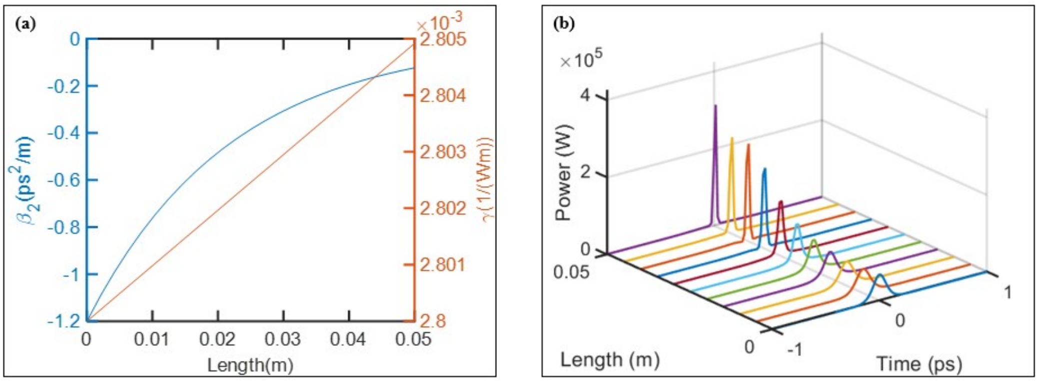

Figure 18: (a) Change in dispersion and nonlinearity along the TPCF (b) Evolution of the compressed pulse

$$\frac{\partial U}{\partial z} = \frac{g(z)}{2}U - \left[\sum_{n\geq 2}\frac{i^{n+1}}{n!}\beta_n(z)\frac{\partial^n U}{\partial t^n}\right] + i\gamma(z)(\omega_0)\times\left[\left(1+\frac{i}{\omega_0}\frac{\partial}{\partial t}\right)U\int_{-\infty}^{\infty}R(t)\left|U(z,t-t_0)\right|^2 dt\right] \tag{2}$$

By neglecting higher-order dispersion effects, the analytic solution of Eq. (1) is obtained as,

$$U(z,t) = \left[\frac{P_0}{1-\xi D(z)}\right]^{1/2}\operatorname{sech}\left[\frac{t-t_0}{T_0(1-\xi D(z))}\right]\times\exp\left[\frac{i\xi(t-t_0)^2}{[1-\xi D(z)]}\right]\exp\left[\frac{G(z)}{2}\right] \tag{3}$$

This solution is possible only when we design the fiber condition satisfies $\beta_2(z) = \beta_2(0)\exp(-\sigma z)$ and $\gamma(z) = \gamma(0)\exp(\rho z)$. To satisfy this condition, we try to determine the proper path variation of fiber parameters such as pitch(Λ) and diameter of the air hole 'd' of PCF. The calculated β_2 and γ variation for the total length of the fiber is drawn in Figure 18(a). Here the exponentially decreasing dispersion profile with high Kerr nonlinearity makes the propagating pulse to amplify for obtaining high-quality pulses as shown in Figure 18(b). Outcomes show a 140 fs pulse compression to 11.2 fs with a compression factor of 12.5 and pedestal energy of 0.42 %. The quality factor of the compressed pulse is calculated to be 0.99.

References

[1] Lidiya, A. E., Raja, R. V. J., and Srinivasan, B., "Generation of high power ultrashort pulses in tapered yb-doped pcf through self-similar compression," IEEE Journal of Quantum Electronics 58(5), 1–8 (2022).