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Evolution of Self-Similar Pulse in Telluride-based Microstructured Fiber

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***Abstract*—Ultrashort pulse has important applications in supercontinuum spectrum, frequency comb generation , bioimaging and so on, therefore it becomes more and more popular. Self-similar pulse can be compressed and the high quality and high power ultrashort pulse can be achieved. In this paper, we research the generation and evolution of self-similar pulses in gain-containing Telluride-based microstructured fiber. These results are in favor of studying the high power and ultrashort pulse laser and high-speed optical communication syste.**

***Keywords*—telluride-based fiber; self-similar; ultrashort pulse**

I. Introduction

Nowaday, the high power and ultrashort pulse laser is widely used in mechanical processing industry , material handling, packaging , automotive applications, high energy laser weapon, optical sighting systems ,laser range finding and so on.Confronting such a mass need for high power and ultrashort pulse, it is difficult to obtain the corresponding lasers as it is limited by the current development of lasers[1-4].There is an effective solution whic is to get the corresponding narrow pulse through the design of medium. Telluride has higher non-linear refractive index ($10\text{-}50*10^{-20}$m2/W) than traditional quartz glass optic fiber, which can enhance the non-linear effect in the pulse transmission process[5,6]. Telluride has more stable properties and is less affected by temperature. In this paper, the generation and evolution of self-similar pulses are studied in Telluride-based microstructured fiber.

II. Theoretical Model

Considering the characteristic of the Telluride-based microstructured fiber, the theoretical model is generalized Ginzburg-Landau equations(NG-LE)[5,6] for ultrashort optical pulses propagating in a gain-containing Micro-nano fiber.

Based on split-step Fourier method, the NG-LE is solved and simulated.

$$\frac{\partial\Psi(z,t)}{\partial z}+i\frac{\beta_2(z)\,\partial^2\Psi(z,t)}{2\partial t^2}-\frac{g(z)}{2}-\frac{g(t)}{2\Omega^2}\frac{\partial^2\Psi(z,t)}{\partial^2 t}=i\gamma(z)\left|\Psi(z,t)\right|^2\Psi(z,t)-i\gamma(z)\,\tau_R\Psi(z,t)\frac{\partial\left|\Psi(z,t)\right|^2}{\partial t} \quad (1)$$

where $\Psi(z,t)=\left|\Psi(z,t)\right|\exp(i\phi(z,t))$ is the complex amplitude of pulse envelope in moving coordinate frame; z is the axial distance of pulse evolution, $\beta_2(z)$ is group velocity dispersion (GVD) with z, $g(z)$ is gain coefficient with z; Ω is the gain bandwidth of Telluride-based microstructured fiber; $\gamma(z)$ is nonlinearity coefficient with z; τ_R is associated with intrapulse Raman scattering(IRS).

Chirp is as follows[5,6]

$$\delta\omega(t)=-\frac{\partial\phi}{\partial t} \quad (2)$$

III. Numerical Simulation Results

The Gaussian pulse for the input field, which is λ_0=1550nm, and the energy is 80pJ with T_0 of 0.2ps. And fiber length is 5m. $\beta_2(z)=\beta_2=0.04\,ps^2m^{-1}$, $g(z)=g_0=0.5/m$, $\Omega=20\times10^2\,ps^{-1}$, $\gamma(z)=\gamma=4\times10^{-3}W^{-1}m^{-1}$, $\tau_R=3.2fs$.

NG-LE is solved numerically and the evolution diagrams of time-domain and frequency-domain transmission can be obtained in Telluride-based microstructured fiber.

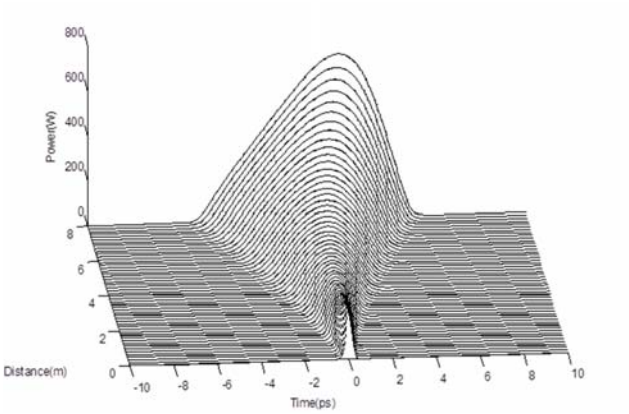
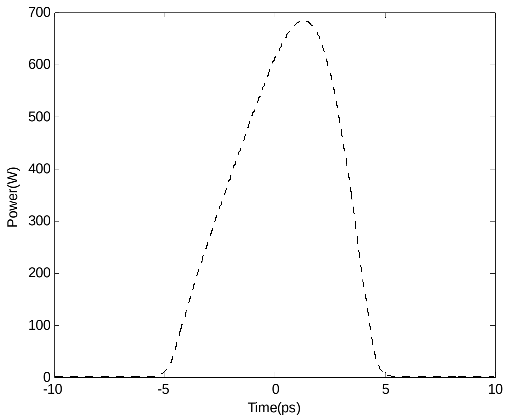


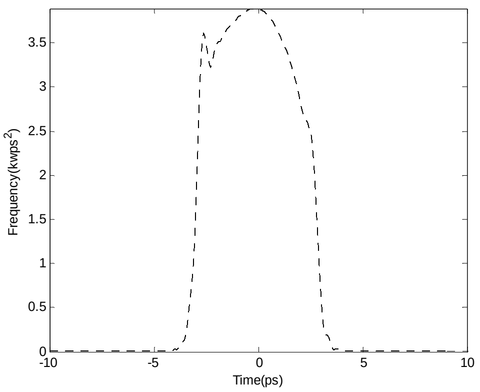
FIGURE I. WAVEFORM EVOLUTION OF SELF-SIMILAR PULSE

Figure1 shows the generation and waveform evolution of self-similar pulses in the gain-containing Telluride-based microstructured fiber. The pulses center shift to right remarkably.

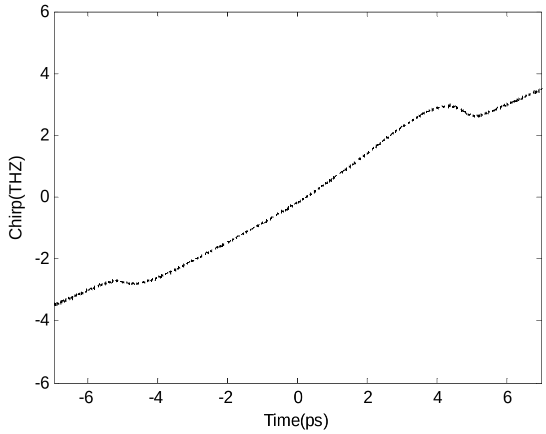
From Figure 2, the self-similar evolutions of waveform (a), frequency (b) and chirp(c) are obvious. The pulse center shifts to right (Figure 2.a); the frequency (Figure 2.b) and chirp (Figure 2.c) appear oscillatory.



(a) waveform

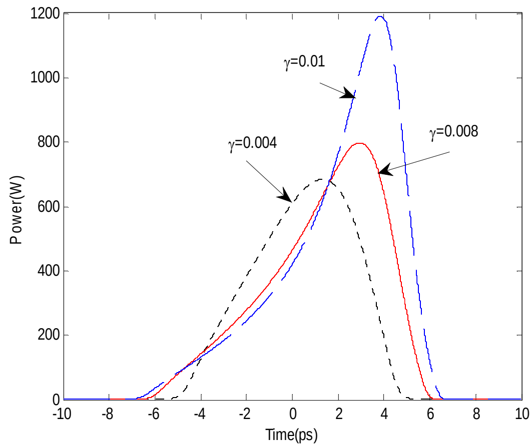


(b) frequency

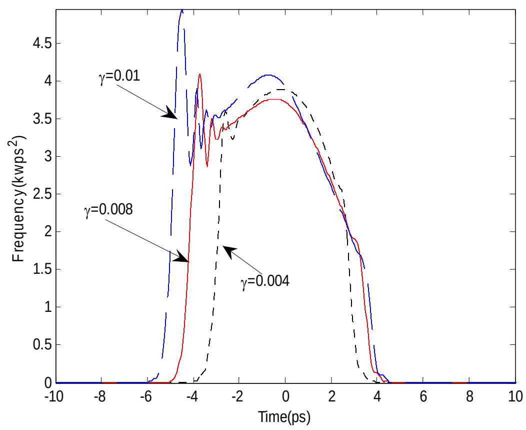


(c) chirp

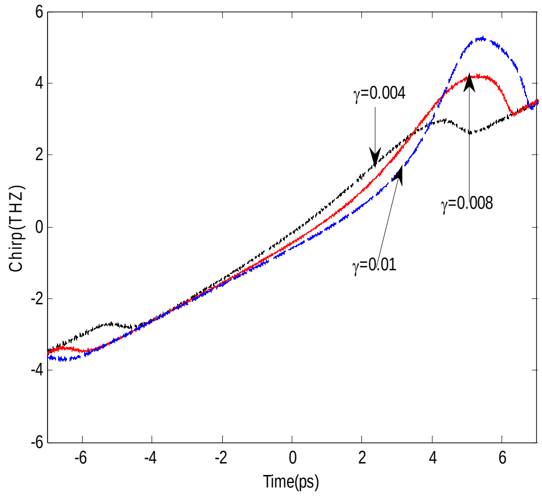
FIGURE II. THE EVOLUTION OF SELF-SIMILAR PULSE (A)WAVEFORM, (B) FREQUENCY(C) CHIRP



(a) waveform



(b) frequency



(c) chirp

FIGURE III. THE EVOLUTION OF SELF-SIMILAR PULSE WITH γ (A) WAVEFORM, (B) FREQUENCY, (C) CHIRP

From Figure 3.a, with the increase of γ, we can see a considerable pulse center shifting, and the frequency jitters on the edge in Figure 3.b. Figure 3.c shows the chirp become greater linearity which is helpful for pulse compressed and high power ultrashort pulses can be obtained.

IV. CONCLUSION

In summary, the properties of self-similar pulse for generation and evolution in Telluride-based microstructured fiber have been studied. Non-linear effect plays a important role with the increase of distance. We can gain the high quality linear chirp which is useful for pulse compressed. The results are critical to the self-similar pulse which has high stable output power and high beam quality.

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REFERENCES

[1] F.O.Ilday, J.R.Buckley, W.G.Clark and F.W.Wise, Self-similar Evolution of Parabolic Pulse in a Laser, Phys. Rev. Lett, 2004, 92(21): 213902(1-4).

[2] C.K.Nielsen, B.Ortac, T.Schreiber, and J.Limpert, Self-starting Self-similar All-polarization Maintaining Yb-doped Fiber Laser, Opt. Lett, 2005, 13(23): 9346-9351.

[3] Feng Jie, Du Guoping, Zhu Ruixing, Huang Lei, Progress of Ultra-Short Self-Similar Pulse Optical Fiber Lasers[J] , Laser&Optoelectronics Progress(2011), 48 , 081409 : 1-15.

[4] Samuel E P , Yan X , Liao M , et al. Phase matching in tellurite/ phospho-tellurite hybrid microstructured optical fiber[J]. 2012.

[5] LIU Wei-Ci, XU Wen-Cheng, FENG Jie, CHEN Wei-Cheng,LI Shu-Xian, LIU Song-Hao. Higher-order Effects on Self-Similar parabolic Pulse in Microstructured Fiber Amplifier, Chin. Phys. B 2008,17(3): 1025-1028..

[6] G.P. Agrawal. Nonlinear Fiber Optics (Academic, San Diego, Calif, 1995)