Direction-Depending Ultrashort Pulses Dynamics In Dispersion Distributed Fibers

A.D.Zverev [1], V.A.Kamynin [1], A.A.Sysoliatin [1], I.S.Panyaev[2], P.A.Itrin[2], D.A.Korobko[2], V.A.Ribenek[2], I.O.Zolotovskii [2], V.B.Tsvetkov [1]

[1]Prokhorov General Physics Institute of the Russian Academy of Sciences, Moscow, Russia

[2]S.P. Kapitsa Scientific Technological Research Institute, Ulyanovsk State University, Ulyanovsk, Russia

Abstract— We demonstrated the realization of different pulse bursts from dispersion distributed fibers depending on the propagation direction and input power. At an average output power level of about 6 mW, it was able to achieve 2 subpicosecond pulses while irradiation injected into the small core side opposite to 3 subpicosecond pulses in case of larger core injection.

Keywords— amplification, ultrashort pulses, composite fibers

I. INTRODUCTION

Optical elements that change transmitted signals properties depending on propagation direction are in great demand. They can be linear such as optical isolators and circulators or nonlinear such as tapered and dispersion distributed fibers (DDF). This type of fibers is distinguished by the fact that it is made on a quartz basis, which facilitates their integration into a laser system based on standard fibers. Additionally, the use of DDF fibers provides efficient radiation conversion due to the compression of the soliton pulse, which will first be located in the zone with anomalous dispersion and then move to zero [1]. The last ones can be used in supercontinuum or wideband generators [2], and signal processing [3]. In our work, we demonstrated the possibility to generate different bursts of subpicosecond pulses depending on propagation direction. In addition to temporal characteristics measurements, we provide spectral and frequency-resolved optical gating of the output irradiation.

II. EXPERIMENTAL SETUP AND RESULT

A series of experiments were carried out in which the radiation from a pulsed master oscillator (MO) was amplified and injected into a nonlinear DDF. The MO generated ultrashort pulses at a central radiation wavelength of 1530 nm with a repetition frequency of 92 MHz. A 50 m DDF fiber with an average coefficient of nonlinearity γ = 10 W-1×km-1 was used as a nonlinear medium. The fiber diameter together with the cladding changed from 120 µm to 150 µm, while the core diameter changed from 6 µm to 9 µm, respectively, and the anomalous dispersion changed linearly along the fiber length from 0 ps/nm×km (d = 120 µm) to 11 ps /nm×km (d = 150 µm) at a wavelength of 1550 nm. Initially, input radiation amplified to Pin 10.5 mW (central wavelength 1530 nm, spectral width 2.31 nm, pulse duration 1.42 ps, TBP 0.42) was introduced into the DDF fiber from the side of the smaller diameter (d = 120 µm). The figure on the left depicts the FROG signal at the output of a DDF with a diameter of 150 µm. The output radiation power Pout in this case was 6.3 mW. Next, Pin was increased to 12.9 mW (central wavelength 1530 nm, spectral width 2.32 nm, pulse duration 1.43 ps, TBP 0.43) and radiation was injected into the DDF from the other side (d = 150 µm). The figure on the right shows the FROG radiation at the output of a fiber with a smaller diameter (d = 120 µm). In this case, Pout was equal to 6.1 mW. The analysis of the FROG shows that in the first case, we observe two pulses at the output of the fiber, and three in the second. This confirms the dependence of the transmitted signal properties on the propagation direction into DDF and input power. In our work, we additionally investigated pulse dynamics at input power levels up to 13 mW and 78 m long DDF.

This work was supported by the Ministry of Science and Higher Education of Russian Federation (grant № 075-15-2020-912) and carried out on the basis of the World-Class Research Center «Photonics».

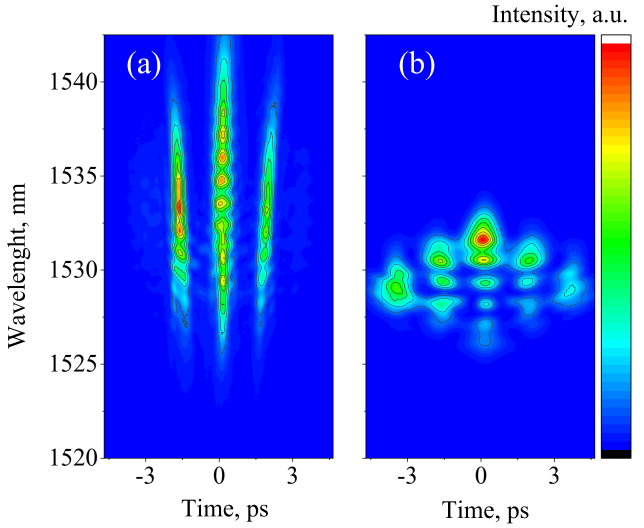

Fig. 1. FROG traces of output signal depending on propagation direction (a) from small to large core diameters (b) from large to small core diameters.

REFERENCES

[1] A.V. Andrianov, S.V. Muraviev, A.V. Kim, A.A. Sysoliatin, "DDF-based all-fiber optical source of femtosecond pulses smoothly tuned in the telecommunication range," Laser Phys **17** (11), 1296-1302 (2007);

[2] M. Nakazawa, K. Tamura, H. Kubota, E. Yoshida, "Coherence degradation in the process of supercontinuum generation in an optical fiber, " Optical fiber technology **4**(2), 215-223 (1998);

[3] A.A Sysoliatin, D.A. Nolan, "Optical signal processing in dispersion varying fiber," Journal of Nonlinear Optical Physics & Materials **16**(02), 171-184 (2007)

2022 International Conference Laser Optics (ICLO) | 978-1-6654-6664-6/22/$31.00 ©2022 IEEE | DOI: 10.1109/ICLO54117.2022.9839699