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LASER COLORATION METHOD IN THE STUDY OF CEP EFFECT ON A SINGLE-CYCLE LIGHT BULLET IN LITHIUM FLUORIDE*

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The filamentation of femtosecond laser pulses under anomalous group velocity dispersion condition is accompanied by the formation of extremely compressed wave packets - light bullets [1], the duration of which is about one period of optical oscillations [2]. Spatiotemporal and energy characteristics of the formed light bullet periodically change during its propagation due to the continuously changing relation between the phases of the carrier wave and its envelope (carrier-envelope phase, CEP). This significantly affects the efficiency of the nonlinear optical interaction of the light bullet with the medium [3]. Consistent experimental study of the effect of CEP on the dynamics of a light bullet is possible only with the use of the laser coloration method [4] in a single-pulse mode.

The report presents the results of a study of the CEP effect on the characteristics of tracks of color centers generated in LiF by a high-intensity light bullet. Experimental registration was carried out in the single-pulse exposure mode, which allowed avoiding errors associated with fluctuations in radiation parameters from pulse to pulse. Analyzing the luminescence of structures induced in LiF by a light bullet at different wavelengths, a periodic modulation of the density of color centers was recorded in the direction of pulse propagation. The modulation depth of the luminescence profiles increases with increasing wavelength (Fig. 1).

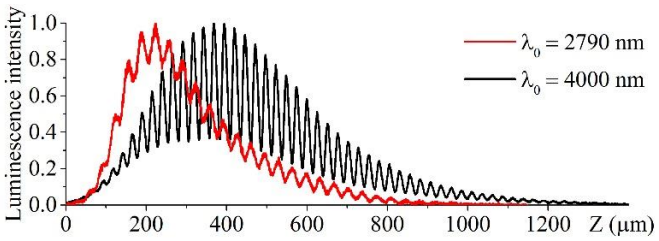

Fig.1. Experimentally measured luminescence profiles on the axis of tracks of color centers induced in LiF by a light bullet at wavelengths (red curve) 2790 nm, (black curve) 4000 nm.

Numerically, by solving the unidirectional pulse propagation equation describing the formation and nonlinear optical interaction of a light bullet with LiF, we found that due to the CEP effect, the electric field strength of a light bullet periodically oscillates during its propagation [3], which leads to a periodic change in the rate of color centers generation and, as a consequence, to modulation of their density along pulse propagation direction. At that, the period of induced structures decreases with an increase in the carrier wavelength due to a change in the ratio between the group and phase velocities of the pulse, and the modulation depth, on the contrary, increases, and is determined by the duration of the light bullet.

The results obtained make it possible to predict the effect of the wavelength of a light bullet on its nonlinear optical effect on a transparent dielectric. This can be used in the currently promising fields of ultrafast metrology and micromodification of materials.

REFERENCES

[1] V.P. Kandidov, E.D. Zaloznaya, A.E. Dormidonov, V.O. Kompanets, S.V. Chekalin, “Light bullets in transparent dielectrics”, Quantum Electronics, vol. 52, no. 3, pp. 233, 2022.

[2] M. Durand, A. Jarnac, A. Houard, Y. Liu, S. Grabielle, N. Forget, A. Durécu, A. Couairon, and A. Mysyrowicz, “Self-guided propagation of ultrashort laser pulses in the anomalous dispersion region of transparent solids: A new regime of filamentation”, Phys. Rev. Lett., vol. 110, pp. 115003, 2013.

[3] E.D. Zaloznaya, V.O. Kompanets, A.D. Savvin, A.E. Dormidonov, S.V. Chekalin, V.P. Kandidov, “Carrier-envelope phase of a light bullet”, arXiv:2201.04357, 2022.

[4] S.V. Chekalin, V.O. Kompanets, “A method of laser coloration in experiments on filamentation of individual impulses and the formation of a light bullet in a homogeneous transparent dielectrics”, Opt. Spektrosc., vol. 127, no. 1, pp. 88, 2019.

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