Spectral broadening of femtosecond optical vortices under filamentation in a medium with anomalous group velocity dispersion

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Filamentation of femtosecond optical vortex at central wavelengths of 1800 nm and higher in fused silica and fluorides was experimentally and numerically studied. The features of broadening of frequency and frequency-angular spectra are considered.

Keywords - filamentation, femtosecond pulse, anomalous group velocity dispersion, fused silica, fluorides, light bullet, optical vortex, self-focusing, supercontinuum.

I. Introduction

Propagation of powerful femtosecond pulses is accompanied by formation of long and thin filaments with high intensity of radiation [1]. In the case of filamentation of vortex beams, an even higher fluence can be observed in the focal spot, resulting in significant spectral broadening [2]. Filamentation of femtosecond optical vortex in a medium with anomalous group velocity dispersion is of considerable interest, since in such media the pulse self-compression in time occurs simultaneously with the beam self-focusing in space, resulting in formation of so-called light bullets [3].

II. Filamentation of Optical Vortices

Filamentation of femtosecond optical vortex at central wavelengths of 1800 nm and higher in a sample of fused silica and LiF crystal was experimentally and numerically studied. Spectra of the supercontinuum of the optical vortex in the IR range are obtained (Fig. 1).

A characteristic feature of the frequency-angular spectrum of a compressed optical vortex is the presence of dark bands along the wavelength axis, which are observed both in the main part of the spectrum and in the Stokes and anti-Stokes regions that appear during filamentation. The intensity of the Stokes components is higher than the anti-Stokes ones. The striped structure of the angular spectrum can be explained in terms of the interference model, according to which it arises because of destructive interference of antiphase coherent radiation sources formed during nonlinear pulse propagation. A comparative analysis of the spectra of an optical vortex and a Gaussian beam was performed. The width of the frequency spectrum of the optical vortex is less than the width of the spectrum of a Gaussian beam with approximately the same excess of the peak pulse power over the critical one at the beginning of the stable filamentation regime. The relative intensity of the spectral components in the anti-Stokes wing of the spectrum is higher for the annular beam with phase dislocation.

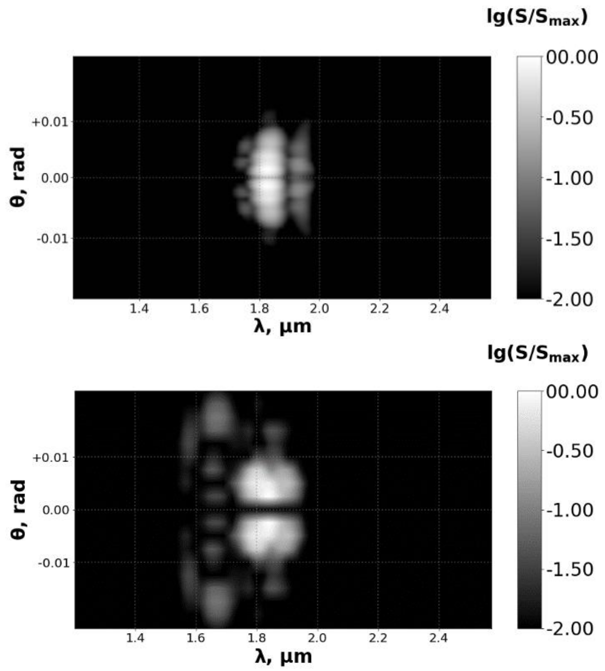

Fig. 1. Experimental (top) and numericall (botton) frequency-angular spectrum of the femtosecond optical vortex at the wavelength of 1850 nm after nonlinear broadening in fused silica.

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