Measurement of higher order chromatic dispersion in a photonic bandgap fiber: comparative study of spectral interferometric methods

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Chromatic dispersion of a 37 cm long, solid-core photonic bandgap (PBG) fiber was studied in the wavelength range of 740–840 nm with spectral interferometry employing a Mach–Zehnder interferometer and a high resolution spectrometer. The interferometer was illuminated by a Ti:sapphire laser providing 20 fs pulses. A comparative study has been carried out to find the most accurate spectral phase retrieval method that is suitable for measuring higher order chromatic dispersion. The stationary phase point, the minima–maxima, the cosine function fit, the Fourier transform, and the windowed Fourier transform methods were tested. It was shown that out of these five techniques, the Fourier-transform method provided the dispersion coefficients with the highest accuracy, and it could also detect rapid phase changes in the vicinity of leaking mode frequencies within the transmission band of the PBG fiber.

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1. Introduction

Nowadays, there are numerous applications of optical fibers, and the demand for further development is continuously growing. The attempt to extend the current limits of performance drew interest toward new alternatives. By moving away from constraints of conventional fiber optics, Bragg-type [1,2] and photonic crystal fibers [3–10] have created new opportunities and acquired respectable attention due to their unique dispersion, birefringent, nonlinear, and guiding characteristics, which can be tailored by the proper design of their geometrical structure.

As one enticing feature of photonic crystal fibers is the feasibility of dispersion-free propagation, a lot of effort is made to develop appropriate geometries that satisfy such requirements [3–5,7–10]. For instance, nearly zero dispersion over a large bandwidth can be realized in hollow-core, air-silica photonic bandgap (PBG) fibers or solid-core Bragg fibers with step-index profile by introducing resonant structures in the fiber cladding [10]. These fiber constructions might have interesting applications in nonlinear wavelength conversion systems or fiber delivery systems for femtosecond pulses. According to the uncertainties in modeling and manufacturing, for practical fiber laser systems it is necessary to characterize the chromatic dispersion of the realized fiber samples as accurately as possible in assistance to their further development or quality testing.

There are several dispersion measurement methods, such as the time of flight, the modulation phase shift, and the interferometric technique [11,12]. The former two methods require long lengths of fiber, which is not a desirable feature if specialty fibers

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