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Effects of dispersion on nonlinearity measurement of optical fibers ☆

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Abstract

We analyze the effects of dispersion in the determination of nonlinearity of optical fiber by combining the method of continuous-wave self-phase modulation with numerical simulations. The relevance of the measurement results is studied as a function of the wavelength difference of the dual-frequency beat signal and the fiber length. It is observed that dispersion can have a significant impact on the nonlinearity measurements. We propose a means to take the effects of dispersion into account.

Keywords: Nonlinear optics, fiber; Nonlinear refractive index; Optical fibers; Optical fiber dispersion

1. Introduction

The nonlinearity of optical fiber has become an important parameter to be characterized, as ever higher optical powers and bit rates are utilized in long haul optical transmission networks. One of the most significant nonlinear effects is the intensity dependence of the

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refractive index of the optical fiber. Several techniques have been proposed for accurate determination of this parameter. Of these the direct continuous-wave self-phase modulation (CW SPM) method [1,2] is the most applied one. The appropriate conditions for measuring the nonlinear refractive index with this method have earlier been studied experimentally and by numerical simulations for various single-mode fibers. In these studies dispersion has been found to set limitations for the nonlinearity measurement [3] and simulations have also been used to find the suitable fiber length to meet the phase-matching conditions of four-wave mixing process [4].

In this article, we present an analysis of the effects of fiber dispersion on the measurement results obtained using the CW SPM method. We have performed experimental and simulated nonlinearity measurements for various types of optical fibers, and investigate here a large variety of different factors contributing to the final results. We show how the wavelength difference of the dual-frequency beat signal and the fiber length affect the measured values in the presence of dispersion. The measurements are found to be in a good agreement with the numerical simulations of the CW SPM method. When large wavelength differences or long fibers are used in the measurement, the obtained values for the nonlinear coefficient become significantly fallible. We propose a means to take the effects of dispersion into account in the analysis of the results.

2. Nonlinearity measurement

In our measurements, we utilized the CW SPM method as outlined in Fig. 1. Two continuous-wave external cavity diode lasers were operated at around 1550 nm. The output beams were set to have the same linear polarization using polarization controllers and a

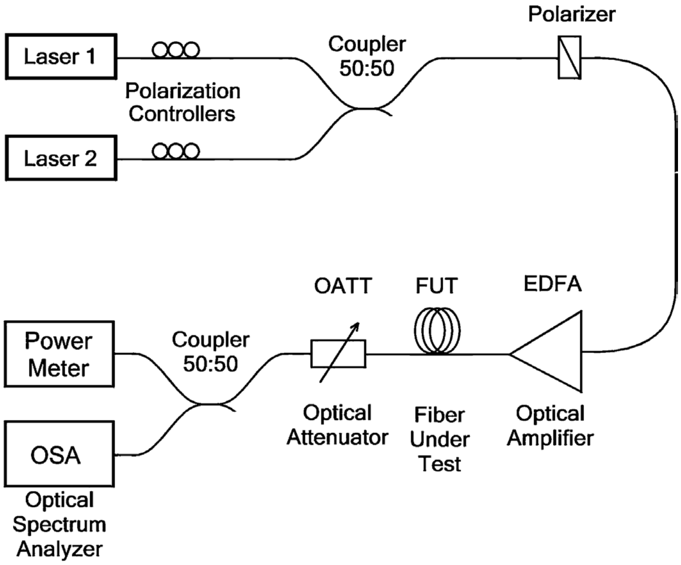

Fig. 1. Measurement setup of CW SPM method.