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Simulation of the interaction of solitons by the Monte Carlo method

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The rapidly increasing demand on communication speed is exerting great pressure on the networks infrastructure at every scale, which explains the real motivation behind all optical communications research. Since the introduction of fiber-optic communications in the late 1970s, many technological advances, such as erbium-doped fiber amplifiers, wavelength division multiplexing (WDM), dispersion management, forward error correction, and Raman amplification, have been developed to enable the exponential growth of data traffic. However, the continuing bandwidth demand is pushing the required capacity close to the theoretical limit of the standard single-mode fiber (SSFM), which is imposed by the fibers nonlinearity effects (Kerr effect) [1]. In recent years, there have been extensive efforts in attempting to surpass the Kerr nonlinearity limit through various nonlinearity compensation techniques. However, there are still many limitations and challenges in applying the aforementioned nonlinear compensation methods, because the transmission technologies utilized in optical fiber communication systems were originally developed for linear (radio or open space) communication channels. Therefore the true limits of nonlinear fiber channels are yet to be found.

The interaction and propagation of optical signals in fiber can be accurately modelled by the nonlinear Schrodinger equation (NLSE) [1], which describes the continuous interplay between dispersion and nonlinearity. It is well known that the NLSE (without perturbation) belongs to the class of integrable nonlinear systems. In particular, this means that the NLSE allows the existence of a special type of solutions: highly robust nonlinear waves, called solitons. Solitons were proposed as the information carriers for the high-capacity fiber-optic communications. In this article we use super(multicore) computing to modell the soliton interaction where the number of nuclei runs into hundreds of thousands puts forward Monte Carlo methods (MCM) the most adapted to parallel calculations, both from the point of view of the simplicity of parallelizing the algorithms and the necessity of carrying out a huge number of identical calculations. The highest efficiency of using MCM in parallel calculations is achieved on modeling long term random processes, in particular, the solutions of stochastic differential equations. By modeling on supercomputer independent from each other trajectories of the solutions of SDE, one can evaluate any required functionals from the solutions with an assigned accuracy. We present the investigation of pulse power of solitons at distances of 6-10 km when a random heterogeneous medium passes through and the results of

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high-frequency interactions of solitons arising at maximum loads of optical fiber lines.

The calculations were carried out on the cluster of NCC-30T of Siberian Supercomputer Center at the ICM&MG SB RAS.

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