Optical Solitons for the Higher Order Dispersive Cubic-Quintic Nonlinear Schrödinger Equation

Chao-qing Dai, Jian-ping Meng, and Jie-fang Zhang*

Institute of Nonlinear Physics, Zhejiang Normal University, Jinhua 321004, China
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We present several kinds of optical soliton solutions for the higher order dispersive cubic-quintic nonlinear Schrödinger equation, describing the propagation of optical pulses in a medium that exhibits a parabolic nonlinearity law. Among them, not only some regular fundamental (solitary wave) bright solitons and dark solitons are given, but also a bright and dark soliton and a W-shaped soliton, which describe bright and dark solitary wave properties while their amplitude may approach nonzero when time approaches infinity, are found.

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A fascinating manifestation of fiber nonlinearity occurs in the anomalous-dispersion regime, where the fiber can support optical solitons through an interplay between the dispersive and nonlinear effect. Soliton refers to a special kind of wave that can propagate undistorted over long distances and they remain unaffected after collision with each other.

It is well known that the propagation of a picosecond optical pulse in a monomode optical fiber (not including optical fiber loss) is described by the nonlinear Schrödinger equation (NLSE), although it only includes self-phase modulation (SPM) and group velocity dispersion (GVD) [1]. The possibility of a bright (dark) soliton in optical fibers is due to the exact counter balancing between the effects: anomalous (normal) GVD and SPM. In this article, the propagation of ultrashort light pulses in optical fibers are of particular interest; they have practical value because of their extensive applications to telecommunication and ultrafast signal-routing systems. When short pulses are considered, e.g. up to nearly 50 fs, even below 10 fs, third order dispersion (TOD) and fourth order dispersion (FOD) must be taken into account [2, 3].

Moreover, when the optical field frequency approaches a resonant frequency of the optical fiber material, accounting for higher-order nonlinearities in optical fibers is related to stronger optical fields and the corresponding larger powers launched into them. In the Pusharov *et al.* study [4], they modelled the refractive index nonlinearly, i.e. $n = n_0 + n_2|E|^2 + n_4|E|^4 + \cdots$ (E is the electric field amplitude, $n_2 = 3\chi^{(3)}/(8n_0), n_4 = 5\chi^{(5)}/(16n_0)$, $\chi^{(3)}$ and $\chi^{(5)}$ being the components of the corresponding nonlinear dielectric tensors and n_0 being the linear refractive index coefficient). If the expansion is cut to the fourth order terms with respect to $|E|^4$, then cubic-quintic nonlinearities are introduced into the NLSE.

Extending the NLS equation to the generalized nonlinear Schrödinger (GNS) equations received much attention, due to these models being more realistic and the many important applications of different types of GNS equations. Generally, corrections to the

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