Nonautonomous Dark Solitons and Soliton Collisions in a Nonlinear Medium with Linear Potential

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The concept of soliton was first introduced by Zabusky and Kruskal which explains that the nonlinear solitary waves do not disperse during propagation and after a collision [1]-[2]. The optical solitons in fibers presents a beautiful in which the mathematical concept has produced a large impact on the real world of high technologies. The classical soliton concept was developed for nonlinear and dispersive systems that have been autonomous; time has played the role of independent variable [2]. For the nonautonomous system, DS remain a subject of continuing interest. However, it was reported that the study on DS is less investigated though they have great potential applications in nonlinearity management and dispersion management systems. One of the main reasons may be that the exact solution of DS is hard to be constructed and the most advantages of DS have been shown only by numerical simulations. Li et al. presented an approximate solution for DS on a parabolic background, and discussed its motion trajectory. Tenorio et al. obtained the exact analytic DS solutions for the model of nonlinear Schrödinger equation (NLSE) with an external harmonic potential. In most cases, the dynamics of nonautonomous solitons are governed by the generalized nonautonomous NLSE. Luo et al. have found a transformation from some nonautonomous to standard NLS equations. In order to inspire potential applications of DS for diverse systems, it is of key importance to take advantage of the exact solution of generalized nonautonomous NLSE for the management of DS [3].

The generalized nonautonomous NLSE is

$$i\frac{\partial\psi}{\partial t}+D(t)\frac{\partial^2\psi}{\partial x^2}+2R(t)|\psi|^2\psi + [\mu(t)x^2+F(t)x]\psi + i\frac{G(t)}{2}\psi = 0 \qquad (1)$$

Where $\psi(x,t)$ is the wave function, *D(t)* is the dispersion management parameter, *R(t)* is the nonlinear management parameter, $\mu(t)x^2$ is the time dependent harmonic trap, *F(t)x* is the arbitrary time dependent linear potential and *G(t)* denotes the dissipation [$G(t) > 0$] or gain [$G(t) < 0$].

The above equation is solved by Hirota bilinear equation and one and two dark soliton solutions are obtained. The solitons obtained by this method is snakelike and it is oscillating around the central axis. The collision between two dark solitons is elastic. The background, valley and wave central position is also obtained.

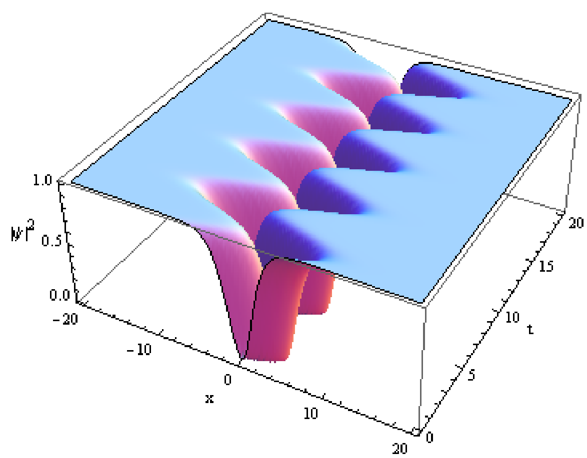

Figure1: (Color Online) Dynamics of one dark soliton with D(t) = 1, μ(t) = 0, G(t) = 0, R(t) = -1/4, f(t) = 3cos1.5t, σ_0 = 1.

In case of fibers, the snakelike 1D soliton and the collision between two solitons are obtained. In case of the collision of two dark solitons, the soliton is breather like and they are oscillating around the central axis.

Reference:

[1] Zhan Ying Yang et al Physical Review E 83: 066602-1-5, 2011

[2] V N Serkin, Akira Hasegawa, T L Belyaeva Physical Review Letters 98: 074102-1-4, 2007

[3] LIU Chong et al *Commun. Theor. Phys.* 59: 703-710, 2013

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