Numerical study of evolution and collisional interaction of the GNLS solitons in nonstationary and non-uniform media

Oleg A. Kharshiladze, Iv. Javaxishvilis Tbilisi State University, Georgia
Vasily Yu. Belashov, Kazan Federal University, Russia

Abstract

The generalized nonlinear Schrödinger (GNLS) equation is a partial case of the Belashov-Karpman (BK) system and describes the dynamics of 2D and 3D envelop waves and solitons in a plasma and in optical fibers and planar waveguides. The interaction of such solitons is rather complicated and can change the characteristics of the waves and background field in the region of their interaction. Moreover, if medium is non-uniform and nonstationary, it is necessary to take into account spatial and temporal changes of the medium parameters which influence on structure and evolution of the waves, and we should consider more complex GNLS model with coefficient functions having spatial and temporal inhomogeneities. The analysis of stability of the multidimensional GNLS solitons was made earlier in our previous works. We have found there the conditions of existence of the multidimensional stable GNLS solutions of both soliton and breather types. Here we present the results of numerical study of evolution and collisional interaction of the GNLS solitons. For simulation we used the Fourier splitting method developed by us earlier taking into account the inhomogeneities of coefficient functions of the equation. Implicit scheme of finite-difference method was used for investigation of soliton propagation in non-uniform and nonstationary medium. Numerical simulation showed that inhomogeneity of medium changes the parameters of solitons and nonlinear waves such as their amplitudes and velocities at propagation in inhomogeneous medium. Nonstationary medium changes a form of pulses and affects its spectral features. Changes of modulation of the parameters of medium make possible variation of character of nonelastic interaction at solitons attraction-repulsion. In some cases formation of breathers can be observed. The results presented have numerous applications in real physical media and can be useful in investigations in areas such as plasma physics, physics of ionosphere and magnetosphere, and nonlinear optics.

Key words: Nonlinear Waves, Multidimensional Solitons, NLS Equation, Non-uniform and Nonstationary Media, Numerical Simulation

Image

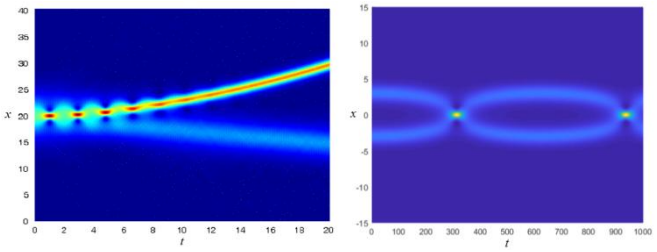

Figure 1: The results of simulation: evolution of a Gaussian envelop pulse in nonstationary medium (left picture) and collisional interaction of two solitary pulses with breathers formation (right picture).

Recent Publications

1. Belashov V Yu, Vladimirov S V (2005) Solitary waves in dispersive complex media. Theory, simulation, applications. Springer Verlag 292.
2. Belashov V Yu, Belashova E S, Kharshiladze O A (2018) Nonlinear wave structures of the soliton and vortex types in complex continuous media: Theory, simulation, applications. Lecture Notes of TICMI. Tbilisi University Press 18:90.
3. Belashov V Yu, Belashova E S (2018) Hamiltonian analysis of stability and classification of multidimensional nonlinear wave structures of soliton type in space plasma. J. Astrophys. Aerospace Techn. 6:19.
4. Belashov V Yu, Kharshiladze O A, Rogava J (2018) Interaction of the multidimensional NLS solitons in non-uniform and nonstationary medium: modeling and stability problem. J. Astrophys. Aerospace Techn. 6:38.
5. Belashov V Yu, Belashova E S, Kharshiladze O A (2018) Problem of stability of multidimensional solutions of the BK class equations in space plasma. Advances in Space Research 62:65-70.

Biographies

Prof. Oleg Kharshiladze is Associated Professor at Physics Department of Iv. Javakhishvili Tbilisi State University. He is involved in international scientific group, working on analytical and numerical analysis of ionospheric and magnetospheric processes (turbulence, shear flows, BBF and others).
Prof. Vasily Yu. Belashov, PhD (Radiophysics), DSci (Physics and Mathematics). He is Chief Scientist and Professor at the Kazan Federal University. He is author of 360 publications including 8 monographs. Main book: Solitary Waves in Dispersive Complex Media. Theory, Simulation, Applications. Springer-Verlag, 2005.

Presenting author details

Oleg Kharshiladze
Iv. Javaxishvilis Tbilisi State University, Georgia
Associate prof

Georgia
oleg.kharshiladze@gmail.com
Plasma Science & Modern Physics
Oral presentation
Analytical and numerical analysis of processes in the ionosphere, magnetosphere and other complex dispersive media

https://www.researchgate.net/profile/Oleg_Kharshiladze2
1959