



# Stability problem and simulation of interaction of the multidimensional NLS solitons in non-uniform and nonstationary media

Vasily Yu. Belashov, Kazan Federal University, Russia  
Oleg A. Kharshiladze, Iv. Javakishvilis Tbilisi State University, Georgia  
Jemal Rogava, I. Vekua Institute of Applied Mathematics, Iv. Javakishvilis Tbilisi State University, Georgia

## Abstract

Investigation of dynamics of multidimensional electromagnetic (EM) waves in a plasma, such as 2D and 3D envelop solitons, is very actual problem. The interaction sufficiently changes the characteristics of the waves and background EM field in the region of interaction. Problem of the dynamics and stability becomes more complicated if it is necessary to take into account an influence of different dispersive and nonlinear inhomogeneities and nonstationary parameters of medium on the soliton structure and evolution. In this case the problem reduces to the generalized nonlinear Schrodinger (GNLS) equation for the amplitude of the EM field with coefficient functions having spatial and temporal inhomogeneities. The analysis of stability of the multidimensional GNLS solitons was based on the method of study of transformational properties of the Hamiltonian of the system developed by authors earlier for the BK class of the equations. As a result we have found the conditions of existence of the multidimensional stable GNLS soliton solutions. At simulation the Fourier splitting method for the GNLS equation was used 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 modeling showed that inhomogeneity of medium changes the amplitudes of solitons and nonlinear EM waves, their velocities of propagation, their quantity that is caused by their nonelastic interaction in inhomogeneous medium. Nonstationary medium changes a form of impulse 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.

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

## Biographies

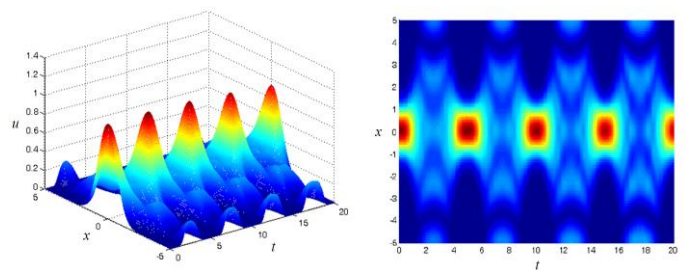
**Prof. Vasily Yu. Belashov**, PhD (Radiophysics), DSci (Physics and Mathematics). He is Chief Scientist and Professor at the Kazan Federal University. He is author of 340 publications including 8 monographs. Main books: Solitary Waves in Dispersive Complex Media. Theory, Simulation, Applications. Springer-Verlag GmbH, 2005; Solitons: Theory, Simulation, Applications. Kazan, Kazan Federal University, 2016.

**Prof. Oleg Kharshiladze** is associated professor at physics department of Iv. Javakishvili 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).

## Presenting author details

Vasily Belashov  
Kazan Federal University, Russia  
Prof  
Russia  
vybelashov@yahoo.com  
<https://appliedphysics.physicsmeeting.com/>

## Image



**Figure 1:** Strong stable pulsations of breather type in non-stationary medium with negative nonlinearity

## 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.

Oral presentation

Theory and modeling of nonlinear wave processes and solitons in complex dispersive media