The BK system: stability and interaction dynamics of the GKP and GNLS solitons

Vasily Yu. Belashov, Kazan Federal University, Russia
Elena S. Belashova, Kazan National Research Technical University named after A.N. Tupolev – KAI, Russia
Oleg A. Kharshiladze, Iv. Javaxishvilis Tbilisi State University, Georgia

Abstract

The Belashov-Karpman (BK) system describes the dynamics of a wide class of multidimensional nonlinear wave processes in complex continuous media and include, on a level with other, the 3D generalized Kadomtsev-Petviashvili (GKP) equation and the 3D generalized nonlinear Schrödinger (GNLS) equation. The generalizations of the equations are relevant to various complex physical media and take into account the effects associated with high-order dispersive ones, influence of dissipation and instabilities, and also nonstationarity and non-uniformity of real physical media. The results of analytical and numerical study of evolution, stability and interaction dynamics of the GKP and GNLS solitons are presented in the paper. This is consistent representation of the both early known and new original results obtained by authors, and also some generalizations in theory of the solitons dynamics in complex nonstationary and nonuniform dispersive media. The analysis of stability of solutions is based on study of transformational properties of the Hamiltonian of corresponding system. The interaction of multidimensional solitons is studied numerically using the highly accurate methods specially developed for the equations of the BK system based on both finite difference and spectral approaches. It is shown that in the BK system the multidimensional (2D and 3D) stable soliton solutions can take place and their collision interaction can be elastic and non-elastic with the N-soliton structures' formation. In some cases the equations of the BK system can have the multidimensional solutions of type of breathers which are stable even at their propagation in nonuniform and nonstationary media. This is in conformity with the stability conditions obtained analytically for the equations of the BK system. The results presented have numerous applications in real physical media and can be useful in investigations in areas such as plasma physics, hydrodynamics, physics of upper atmosphere and nonlinear optics.

Key words: Nonlinear Waves, BK system, GKP equation, GNLS equation, Multidimensional Solitons, Stability, Interaction dynamics, Theory, Numerical Simulation

Image

Figure 1: Interaction of solitons in the BK system: a) the GKP model – formation of bound state – "bi-soliton"; b) the GNLS model – formation of three solitary pulses from two ones.

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.

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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. 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.
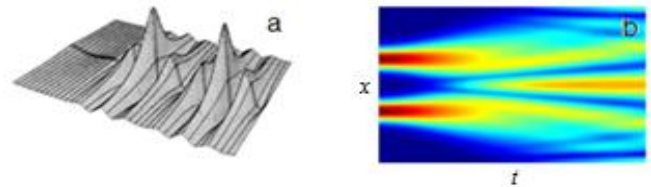
Dr. Elena S. Belashova, PhD (Physics of Atmosphere and Hydrosphere). She is Associate Professor at the Kazan National Research Technical University named after A. N. Tupolev – KAI. She is author of 60 publications. Main book: Solitons: Theory, Simulation, Applications. Kazan Federal University, 2016.

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).

Presenting author details

Vasily Belashov
Kazan Federal University, Russia
Prof

Russia
vybelashov@yahoo.com
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