Solitons' dynamics in regions with sharp gradients of basic parameters of propagation medium

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Abstract

We consider the problem of dynamics the multidimensional solitons which are described by the generalized Kadomtsev-Petviashvili (GKP) equation in complex continuous media with the varying in time and/or space dispersive parameters $\beta,\gamma = f(t,\mathbf{r})$. This problem is very interesting from the point of view of its evident applications in physics of the real complex media with the dispersion. For example, such situation takes place at propagation of the 2D gravity-capillary waves on surface of "shallow" water when β and γ are defined as $\beta=(c_0/6)[H^2-3\sigma/\rho g]$ and $\gamma=(c_0/6)[H^2(\frac{2}{5}H^2-\sigma/\rho g)-\frac{1}{12}(3\sigma/\rho g-H^2)^2]$ respectively, and ρ is the density, σ is the coefficient of surface tension of fluid and $H=H(t,x,y)$ is the depth. In this case β and γ also become the functions of the coordinates and time. Similar situation takes place at evolution of the 3D FMS waves in a plasma in case of the inhomogeneous and/or non-stationary plasma and magnetic field when β and γ are the functions of the Alfvén velocity $v_A = f[B(t,\mathbf{r}),n(t,\mathbf{r})]$ and the angle $\theta=(\mathbf{k}\hat{}\mathbf{B})$, namely: $\beta=v_A(c^2/2\omega_{0i}^2)(\cot^2\theta-m_e/m_i)$, $\gamma=v_A(c^4/8\omega_{0i}^4)[3(m_e/m_i-\cot^2\theta)^2-4\cot^4\theta(1+\cot^2\theta)]$. Next interesting example is the dynamics of 2D solitons of the internal gravity waves (IGW) generated at heights of the *F* region of ionosphere by moving fronts of the solar terminator and solar eclipse (SE). In this case dispersive parameters β and γ are functions of the ionospheric parameters such as electron density, temperature, scale heights for the ions and neutral particles etc. which have sharp gradients in these regions.

Here, the problem of study of multidimensional solitons dynamics with $\beta,\gamma = f(t,\mathbf{r})$ was solved in general and for above-mentioned applications. Fig. 1 shows the examples of numerical results for 2D solitons on shallow water with bottom in form of varying in space and time "step" and for 2D IGW soliton at heights of the ionosphere *F* region for such source as SE spot. The interpretation of results obtained is given in detail.

Image

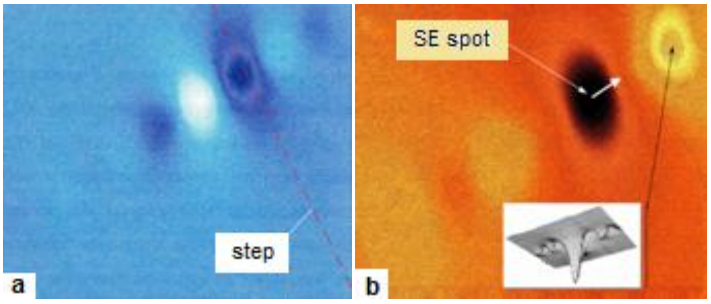

Figure 1: General view of 2D solution of the GKP equation: a) on shallow water with step on the bottom; b) on the frontal region of the SE spot at height of the maximum of the *F* region of ionosphere.

Recent Publications

1. Belashov VYu, Vladimirov SV (2005) Solitary Waves in Dispersive Complex Media. Theory, Simulation, Applications. Springer-Verlag 305.
2. Belashov VYu, Belashova ES (2016) Solitons: Theory, simulation, applications. Kazan, Publishing Center "School" 270.
3. Belashov VYu, Belashova ES (2015) Dynamics of IGW and traveling ionospheric disturbances in regions with sharp gradients of the ionospheric parameters. Adv. Space Res. 56:333–340.
4. Belashov VYu, Belashova ES (2015) Nonlinear dynamics of the 3D Alfven waves in plasma of ionosphere and magnetosphere. J. Atm. and Solar-Terr. Physics 136:150-154.
5. Belashov VYu, Belashova ES (2016) Nonlinear Dynamics of 3D Beams of Fast Magnetosonic Waves Propagating in the Ionospheric and Magnetospheric Plasma. Geomagnetism and Aeronomy 56:716-723.
6. Belashov VYu (2016) Dynamics of Multidimensional Nonlinear Wave Structures of the Soliton and Vortex Types in Dispersive Complex Media. J. Astrophys. Aerospace Technol. 4(3):18.

Biography

Prof. Vasily Yu. Belashov, PhD (Radiophysics), DSci (Physics and Mathematics). Main fields: theory and numerical simulation of the dynamics of multi-dimensional nonlinear waves, solitons and vortex structures in plasmas and other dispersive media. Presently, he is Chief Scientist at the Kazan Federal University. He was Coordinator of studies on the International Program "Solar Terminator" (1987-1992), and took part in Programs WITS/WAGS and STEP. He is author of 288 publications including 6 monographs. Main books: Solitary Waves in Dispersive Complex Media. Theory, Simulation, Applications. Springer-Verlag GmbH, 2005; The KP Equation and its Generalizations. Theory and Applications. Magadan, NEISRI FEB RAS, 1997.

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Notes/Comments: