Nonlinear dynamics of the 3D solitary Alfvén waves in the ionospheric and magnetospheric plasma

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Abstract

The nonlinear dynamics of the 3D solitary Alfvén waves propagating nearly parallel to the external magnetic field in plasma of ionosphere and magnetosphere, which are described by the model of the 3-DNLS equation, is studied analytically and numerically. Under the assumption of negligible dissipative effects the analytical estimates and the sufficient conditions for the stability of 3D solutions of the 3-DNLS equation are obtained, based on the transformational properties of the system's Hamiltonian for the whole range of the equation coefficients. On the basis of asymptotic analysis the solutions asymptotics are presented. To study the evolution of the 3D Alfven solitary waves including propagation of the Alfven waves' beams in a magnetized plasma the equation are integrated numerically using the simulation codes specially developed. The results show that the 3-DNLS equation in non-dissipative case can have the stable 3D solutions in form of the 3D Alfvén solitons (Fig. 1), and also on a level with them the 3D solutions collapsing (Fig. 2) or dispersing with time. In terms of the self-focusing phenomenon the results obtained can be interpreted as the formation of the stationary Alfvén wave beam propagating nearly parallel to magnetic field, or Alfvén wave beam spreading, or the self-focusing of the Alfvén wave beam. The influence of the dissipation in the medium on structure and character of evolution of 3D Alfvén waves is studied.

Image

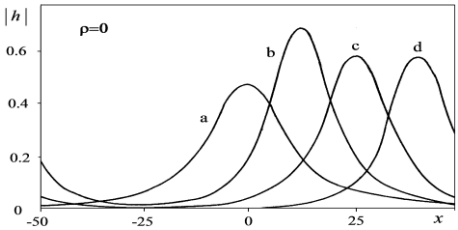

Figure 1: Evolution of a 3D right circularly polarized nonlinear pulse in stability case: a) *t*=0, b) *t*=25, c) *t*=50, d) *t*=75.

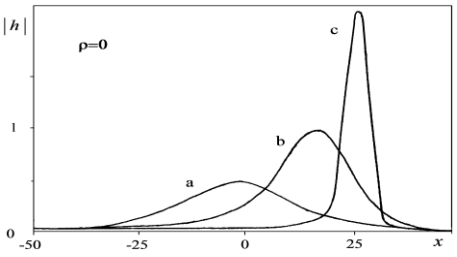

Figure 2: Wave collapse of a 3D right circularly polarized nonlinear pulse: a) *t*=0, b) *t*=25, c) *t*=30.

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) Nonlinear dynamics of the 3D Alfven waves in plasma of ionosphere and magnetosphere. J. Atm. and Solar-Terr. Physics 136:150-154.
4. 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.
5. 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.
6. Belashov VYu (2016) Nonlinear wave structures of soliton and vortex types in complex continuous media. J. Astrophys. Aerospace Technol. 4(3):52.

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 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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Biography

Dr. Elena S. Belashova, PhD (Physics of Atmosphere and Hydrosphere). Main fields: numerical simulation of the dynamics of nonlinear waves and solitons in complex dispersive media. Presently, she is Associate Professor at the Kazan National Research Technical University named after A. N. Tupolev – KAI. She is author of 50 publications including 2 monographs. Main books: Solitons: Theory, simulation, applications. Kazan, Publishing Center "School", 2016; Solitons as Mathematical and Physical Objects. Kazan, KSPEU, 2006.

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Notes/Comments: