Bi-solitons on the surface of a deep fluid : IST perturbation theory approach

Andrey Gelash[1], Sergey Dremov[2], Rustam Mullyadzhanov[3,4], Dmitry Kachulin[2,3]

[1] Laboratoire Interdisciplinaire Carnot de Bourgogne UMR6303 CNRS- Université Bourgogne Franche-Comté, Dijon France
[2] Skolkovo Institute of Science and Technology, Moscow, Russia
[3] Novosibirsk State University, Novosibirsk, Russia
[4] Institute of Thermophysics SB RAS, Novosibirsk, Russia
Andrey.Gelash@u-bourgogne.fr

We apply the Inverse Scattering Transform (IST) to analyze the bound state coherent structures (bi-solitons) discovered previously in the free surface deep water models, see [1,2]. We consider the Dyachenko–Zakharov equation together with fully nonlinear equations, and present them as the one-dimensional focusing nonlinear Schrödinger equation (NLSE) plus a right-hand side. When the impact of the right-hand side is small compared to the NLSE part, one can use the IST perturbative approach to analyze the scattering data of the wavefield. We compute the right-hand side numerically for the bi-solitons and ensure that the perturbation theory is valid in this case. Then we compute trajectories of the soliton eigenvalues during the bi-soliton evolution and find that they are in good agreement with predictions of the IST perturbation theory. Based on the obtained results, we conclude that the IST perturbation theory can justify the existence of the bound state coherent structures on the surface of deep fluid. Finally we discuss the general perspectives of applications of the IST perturbations theory in combination with efficient numerical IST tools [3,4] in various studies of coherent structures, soliton gases and integrable turbulence.

Références

1. D. Kachulin, A. Dyachenko & S. Dremov, Multiple soliton interactions on the surface of deep water, *Fluids*, **5(2)**, 65 (2020).
2. D. Kachulin, S. Dremov & A. Dyachenko, Bound coherent structures propagating on the free surface of deep water, *Fluids.*, **6(3)**, 115 (2021).
3. A. Gelash & R. Mullyadzhanov, Anomalous errors of direct scattering transform, *Phys. Rev. E*, **101(5)**, 052206 (2020).
4. D. Agafontsev, A. Gelash, R. Mullyadzhanov & V. Zakharov, Bound-state soliton gas as a limit of adiabatically growing integrable turbulence, *Chaos, Solitons and Fractals*, **166**, 112951 (2023).