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Uniform strongly interacting soliton gas in the frame of the Nonlinear Schrodinger Equation

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The statistical properties of many soliton systems play the key role in the fundamental studies of integrable turbulence and extreme sea wave formation. It is well known that separated solitons are stable nonlinear coherent structures moving with constant velocity. After collisions with each other they restore the original shape and only acquire an additional phase shift. However, at the moment of strong nonlinear soliton interaction (i.e. when solitons are located close) the wave field are highly complicated and should be described by the theory of inverse scattering transform (IST), which allows to integrate the KdV equation, the NLSE and many other important nonlinear models.
The usual approach of studying the dynamics and statistics of soliton wave field is based on relatively rarefied gas of solitons [1,2] or restricted by only two-soliton interactions [3]. From the other hand, the exceptional role of interacting solitons and similar coherent structures - breathers in the formation of rogue waves statistics was reported in several recent papers [4,5].
In this work we study the NLSE and use the most straightforward and general way to create many soliton initial condition - the exact N-soliton formulas obtained in the theory of the IST [6]. We propose the recursive numerical scheme for Zakharov-Mikhailov variant of the dressing method [7,8] and discuss its stability with respect to increasing the number of solitons. We show that the pivoting, i.e. the finding of an appropriate order for recursive operations, has a significant impact on the numerical accuracy. We use the developed scheme to generate statistical ensembles of 32 strongly interacting solitons, i.e. solve the inverse scattering problem for the high number of discrete eigenvalues. Then we use this ensembles as initial conditions for numerical simulations in the box with periodic boundary conditions and study statics of obtained uniform strongly interacting gas of NLSE solitons.

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