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Periodic problem for the nonlinear Schrödinger equation by the Riemann-Hilbert approach

We develop the Riemann-Hilbert (RH) approach to the construction of periodic finite-band solutions to the focusing nonlinear Schrödinger (NLS) equation $iq_t + q_{xx} + 2|q|^2 q = 0$. We show that a finite-band solution to the NLS equation can be given in terms of the solution of an associated RH problem, the jump conditions for which are characterized by specifying the endpoints of the arcs defining the contour of the RH problem and the constants (so-called phases) involved in the jump matrices. Moreover, in the case when the finite-band solution of the NLS is periodic in x, we solve the problem of retrieving the phases given the solution of the NLS equation evaluated at a fixed time (as a function of x on the periodicity interval). Our findings are corroborated by numerical examples of phases computation, demonstrating the viability of the method proposed.

[1] Shepelsky D., Karpenko I., Bogdanov S., Prilepsky J.E. Periodic finite-band solutions to the focusing nonlinear Schrödinger equation by the Fokas method: inverse and direct problems. Proc.R.Soc.A 480 (2024), 20230828.

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