Error estimates of numerical methods for the nonlinear Schrödinger equation with low regularity potential and nonlinearity

Chushan Wang
National University of Singapore, Singapore
E0546091@u.nus.edu

We prove optimal error bounds of time-splitting methods and the exponential wave integrator for the nonlinear Schrödinger equation (NLSE) with low regularity potential and nonlinearity, including purely bounded potential and locally Lipschitz nonlinearity. Arising from different physical applications, low regularity potential and nonlinearity are introduced into the NLSE such as some discontinuous or disorder potential widely used in the physics literature or the non-integer power nonlinearity in the Lee-Huang-Yang correction which is adopted in modelling and simulation of quantum droplets. Most of the classical numerical methods can be directly extended to solve the NLSE with the aforementioned potential and nonlinearity. However, the performance of these methods becomes very different from the smooth case and the error estimates are subtle and challenging.

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