Xie, Jiangming; Li, Maojun
A fast BDF2 Galerkin finite element method for the one-dimensional time-dependent Schrödinger equation with artificial boundary conditions. (English) Zbl 07705765

Summary: In this paper, we propose an efficient numerical scheme with linear complexity for the one-dimensional time-dependent Schrödinger equation on unbounded domains. The artificial boundary method is used to address the unboundedness of the domain. By applying the two-step backward difference formula for time discretization and performing the $Z$-transform, we derive an exact semi-discrete artificial boundary condition of the Dirichlet-to-Neumann type. To expedite the discrete temporal convolution involved in the exact semi-discrete artificial boundary conditions, we design a fast algorithm based on the best relative Chebyshev approximation of the square-root function. The Galerkin finite element method is used for spatial discretization. By introducing a constant damping term to the original Schrödinger equation, we present a complete error estimate for the fully discrete problem. Several numerical examples are provided to demonstrate the accuracy and efficiency of the proposed numerical scheme.

MSC:

65Mxx Numerical methods for partial differential equations, initial value and time-dependent initial-boundary value problems
35Qxx Partial differential equations of mathematical physics and other areas of application
65Nxx Numerical methods for partial differential equations, boundary value problems

Keywords:
Schrödinger equation; unbounded domains; fast algorithm; Chebyshev approximation; error estimate

Full Text: DOI

References:

[27] Mayfield, B., Nonreflecting boundary conditions for Schrödinger’s equation (1989), University of Rhode: University of Rhode Island, Ph.D. thesis

This reference list is based on information provided by the publisher or from digital mathematics libraries. Its items are heuristically matched to zbMATH identifiers and may contain data conversion errors. It attempts to reflect the references listed in the original paper as accurately as possible without claiming the completeness or perfect precision of the matching.