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基于多辛结构谱元法的保结构地震波场模拟

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Structure-preserving modeling for seismic wavefields based upon a multisymplectic spectral element method

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摘要

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摘要 近年来构造高精度、高效且具有长时程跟踪能力的保结构算法已逐渐成为地震波模拟算法发展的重要方向之一。本文基于谱元法(SEM)进行空间域离散结合新推导的三阶辛算法(NTSTO)进行时间域离散,构造了一种具有时-空保结构特性的新算法。本文给出的多组数值试验对比结果表明,本算法无论在内存消耗、稳定性及计算耗时,还是长时程跟踪能力方面都有上佳的表现;另外,本文给出的起伏地表多层介质模型的数值算例验证了该算法处理复杂几何形状和复杂介质时的有效性。该多辛结构谱元法的发展将为长时程地震波传播的计算及模拟提供更为广泛而有效的选择。

关键词 谱元法, 辛算法, 地震波模拟

Abstract: In recent years, structure-preserving algorithms effective for treating problems of high-precision and long-time tracing have emerged as one attractive topic of the numerical simulation of seismic waves. In this paper, a new kind of time-space structure-preserving algorithm, which combines the spectral element method (SEM) in spatial discretization with a new three-stage third-order symplectic algorithm (NTSTO) in temporal discretization, is designed to simulate seismic wave propagation. The comparisons of numerical experiments show that the NTSTO-SEM algorithm is much superior to the other methods in terms of efficiency, long-time tracing ability, stability, and low storage requirement. Finally, the numerical experiments of a multilayered model with irregular topography are given to illustrate the effectiveness of NTSTO-SEM for handling complex geometry and complex media. These appealing features of the multisymplectic algorithm would make it effective to model the large-scale and long-time seismic wave propagation.

Keywords Spectral element method, Symplectic algorithm, Seismic modeling

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