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Structure-preserving modeling of elastic equations with damping

Xiaofan Li (1,2), Bingfei Li (1,2), Jiege Si (1,2)

(1) Key Laboratory of Earth and Planetary Physics, Chinese Academy of Sciences, Beijing, China (xflee@mail.iggcas.ac.cn),
(2) University of Chinese Academy of Sciences,Beijing 100049, P.R. China

In general, seismic waves propagating in the soild earth are approximated by using elastic waves. High-precision modeling of elastic waves at the global scale high-precision and involves long-time computation of waves propagation, it is essential to studies of the earth. For long-term simulations of seismic wave (e.g. Earth's free oscillations modelling and global-scale seismic wave propagation modelling), the high-precision and long-time calculations of elastic waves with damping is very important.

Modeling elastic waves with damping in the time domain using direct methods involves discretization of wave equations. Because the traditional methods (nonsymplectic schemes) for time discretizations are not structure-preserving algorithm, it is quite difficult to avoid accumulated errors in long-time numerical computation for partial differential equations using such approaches. Although some structure-preserving methods for modeling seismic waves have developed recently, such methods are only suitable for undamped waves. Actully, however, seismic waves, more or less, are damped waves.

In this study, a structure-preserving method for modeling damped elastic wave is presented. For the time discretization, a second-order symplectic scheme is given. The spatial discretization is implemented by using the spectral element scheme. The performance of the proposed method has been tested and verified using numerical modeling of elastic wave equation with damping. Elastic wavefield modeling experiments on a heterogeneous medium with both damping and high parameter contrasts shows the advantageous performance of the method presented for suppression of numerical dispersion. Also, long-term computational experiments in this study display the excellent capability of the method presented for long-time simulations of damped wave equations.

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Key words: Structure-preserving modeling; damped elastic waves; long-term simulations; Earth's free oscillations modelling