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A space-time discontinuous Galerkin method for seismic wave propagation problems

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The study of direct and inverse wave propagation phenomena is an area of intensive research and finds important applications in different engineering areas including acoustics, aeroacoustics, electromagnetics, and computational seismology. From the mathematical perspective, the physics governing these phenomena can be modeled by means of the wave equation. From the numerical viewpoint, a number of distinguished challenges arise when tackling such kinds of problems, and reflect onto the following features required to the numerical schemes: accuracy, geometric flexibility, and scalability. In recent years, high order discontinuous Galerkin (dG) methods have become one of the most promising tools for the solution of wave propagation problems. Indeed, thanks to their local nature, dG methods are particularly apt to treat highly heterogeneous media, complex geometries and sharp variation of the wave field by allowing for space and time adaptivity within the approximation.

In this work, we present a new space-time dG scheme for second-order elastodynamics problems. The method is a combination of a dG space discretization on general polygonal grids and a dG time integration scheme for second-order differential equations. We show that the resulting discrete formulation is well-posed, stable, and retains a superoptimal rate of convergence with respect to the time discretization parameters, namely the time step and the polynomial approximation degree. We present a wide set of two- and three-dimensional numerical experiments confirming the theoretical bounds and apply the method to realistic geophysical problems. Finally, we analyze the efficiency of the algorithm from the point of view of scalability on HPC machines.

Part of the results can be found in [1].

REFERENCES

[1] P.F. Antonietti, I. Mazzieri and F. Migliorini, *A discontinuous Galerkin time integration scheme for second order differential equations with applications to seismic wave propagation problems*. MOX Reports, 05/2021, 2021.