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A Moving Discontinuous Galerkin Finite Element Method with Interface Condition Enforcement for Unsteady Flows with Discontinuities

Andrew D. Kercher*, **Andrew Corrigan and David A. Kessler**

Laboratories for Computational Physics & Fluid Dynamics, U.S. Naval Research Laboratory, 4555 Overlook Ave SW, Washington, DC 20375

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The Moving Discontinuous Galerkin Method with Interface Condition Enforcement (MDG-ICE), introduced by the present authors [1], can accurately and stably compute flows with interfaces, including both shocks and material interfaces, without relying on interface or shock capturing. It does so within a unified formulation, by enforcing the conservation law and its interface condition simultaneously while treating the discrete domain geometry as a variable. Preliminary test cases demonstrated that the method can be used to compute both steady and unsteady flows with a priori unknown interface topology and point singularities using higher-order elements in arbitrary-dimensional spaces.

In order to further assess the scope and robustness of the proposed method, the present work will apply MDG-ICE to unsteady flow problems with discontinuous interfaces of significantly increased complexity than previously presented. The focus of this work will be the application of MDG-ICE to the standard benchmark case of a Mach 3 flow through a wind tunnel with a step, popularized by Woodward and Colella [2]. In this case, this two-dimensional unsteady shocked flow, is formulated as a three-dimensional spacetime flow. This problem will assess the ability of MDG-ICE to compute unsteady flows with dynamic, curved shock geometry and non-trivial topology, while resolving the corner singularity. The solutions will be computed without shock capturing, using $\mathcal{P}_2$ and higher-order three-dimensional elements. The accuracy will be assessed in comparison to highly resolved solutions computed using standard DG methods.

REFERENCES

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