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High-Order Finite Element Framework for Drift-Reduced MHD
MILAN HOLEC, CHRIS J. VOGL, ILON JOSEPH, ANDRIS DIMITS, BEN ZHU, Lawrence Livermore National Laboratory, BEN SOUTHWORTH, University of Colorado — The high-order MFEM finite element framework, which provides state-of-the-art numerical techniques for discretization and meshing, is used to efficiently solve the drift-reduced extended magnetohydrodynamics physics equations. By eliminating the fast compressional Alfven and sound waves, these models efficiently describe turbulence driven by drift wave instabilities and magnetic reconnection mediated by the shear Alfven wave. The discretization is based on finite element exterior calculus, which mimics the fundamental theorems of vector calculus. By utilizing the extensive set of high-order finite element spaces, such as H1, Nedelec, Raviart-Thomas, and Discontinuous Galerkin, one can achieve desirable numerical properties such as the ability to prescribe divergence-free magnetic fields, incompressible flows, and conservation of energy to machine accuracy. In addition to providing greater numerical accuracy, the high-order elements also provide curved meshes that can be aligned with magnetic flux surfaces. We illustrate these capabilities through applications to edge plasma physics examples and explore the use of advanced meshing techniques for improving accuracy near X-points caused by divertors and magnetic islands. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344 and was supported by LLNL Laboratory Directed Research and Development project 20-ERD-038.

Milan Holec
Lawrence Livermore National Laboratory

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