**Title:** A Single-Step Single-Stage High-Order Constrained Transport Method for Magnetohydrodynamic Equations

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**Abstract:**
In this work we develop a high-order numerical scheme for magnetohydrodynamic equations that is single-stage, single-step, and therefore amenable to Adaptive-Mesh-Refinement (AMR). Our scheme is an extension of Picard-Integral-Formulation WENO (PIF-WENO) methods. Here, we use a Taylor discretization of the time-averaged flux, and leverage the Cauchy-Kovaleskaya procedure to convert temporal derivatives into spatial derivatives. A further challenge particular to magnetohydrodynamic equations is the necessity to maintain divergence-free magnetic fields, where failure to do so has been shown to cause numerical instabilities. To overcome this difficulty, we use an unstaggered constrained transport method, where we introduce a magnetic potential, evolve it in time, and correct the magnetic field from the curl of this potential. We use tools from Hamilton-Jacobi solvers to evolve the magnetic potential in order to obtain non-oscillatory magnetic fields. Finally, we include a flux limiter that produces positive density and pressure. Our one, two and three dimensional numerical experiments verify that our scheme is third order in time, fourth order in space, and is able to resolve complex features of several classical test problems including shock-tube Riemann problems, Orzsag-Tang vortex formulations, and cloud shock interactions.