An Approximate Harten-Lax-van Leer Riemann Solver for Relativistic Magnetohydrodynamics

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Abstract An approximate Riemann solver for the equations of ideal relativistic magnetohydrodynamics is presented. The solver belongs to the so-called Harten-Lax-van Leer (HLL, [1]) family of solvers where an initial guess to the characteristic wave speeds is given without any knowledge a priori of the solution. Our proposed method of solution generalizes to the relativistic case the classical five-wave HLLD Riemann solver initially developed by Miyoshi & Kusano [6] for the equations of classical ideal magnetohydrodynamics. The solution to the Riemann problem is approximated by a five-wave pattern, comprising two outermost fast shocks, two rotational discontinuities and a contact surface in the middle, [3]. The proposed scheme is considerably more elaborate than in the classical case since the normal velocity is no longer constant across the rotational modes. Still, proper closure to the Rankine-Hugoniot jump conditions can be obtained by solving a single nonlinear scalar equation in the total pressure variable which, for the chosen configuration, has to be constant over the whole Riemann fan. The accuracy of the new Riemann solver is validated against one-dimensional tests and multidimensional applications. It is shown that our new solver considerably improves over the popular Harten-Lax-van Leer solver and the similar, less accurate, HLLC schemes [5, 4, 2].

References


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