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An all-speed projection method for magneto-hydrodynamics[1]
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We present an all-speed algorithm for magneto-hydrodynamics (MHD) similar to the work of Colella & Pao (J. Comput. Phys. 1999) for low speed hydrodynamics. The method is based on an asymptotic ordering of scales relevant for tokamak MHD physics. The central idea is to Hodge decompose the velocity, and a splitting of the magnetic guide field analogous to the pressure splitting in low Mach number hydrodynamics into a thermodynamic and an incompressible part. We present the derivation of the ideal MHD equations into slow (advective), intermediate and fast scales. The algorithm treats the slow advective scales using a Godunov-procedure while the intermediate and fast scales are treated implicitly using backward Euler. Results from numerical tests such as the MHD Kelvin-Helmholtz instability, magnetic reconnection and others will be presented. We will highlight the challenges of designing solvers for the intermediate scales.

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