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Piston-Driven Shock Wave Test Problem for Validating Magnetohydrodynamic Models in Astrophysics

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Computational magnetohydrodynamics (MHD) provides a powerful framework for modelling matter in extreme environments where both fluid dynamics and magnetic fields are critical. These conditions arise in heavy-ion collisions (HIC) and astrophysical events like core-collapse supernovae (CCSNe). To ensure solver accuracy, we validate our RMHD model using a piston-driven shock wave test problem, ideal for simulating the bounce stage of CCSNe, where a magnetised shock forms and propagates outward. Following validation, a complementary model for HIC will be developed to study early-stage shock evolution. This will enable the investigation of post-shock pressure and density profiles, flow coefficients (notably v2), and CME-induced charge separation. In CCSNe, we explore magnetic versus thermal pressure contributions and gravitational waveforms. Together, these observables allow for a comparative analysis of how magnetic fields influence shock propagation and structure in both astrophysical and high-energy nuclear systems.

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