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A 3D cell-centered Lagrangian scheme for the ideal Magnetohydrodynamics equations on unstructured meshes*

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Abstract

We propose a cell-centered Lagrangian numerical scheme for solving the 3D ideal Magnetohydrodynamics (MHD) equations on unstructured meshes. All the variables are cell-centered and the Lagrangian conservative system of ideal MHD equations are compatibly discretized in this scheme. The geometric conservation law (GCL) requirement is satisfied by using the discrete compatible Lagrangian framework of polyhedral meshes. A nodal solver for MHD equations is then constructed through the nodal pressure flux and magnetic field invoking total energy conservation and thermodynamic consistency. Besides, the magnetic divergence free constraint is fulfilled by a projection method after each time step. Various numerical tests are presented to assert the robustness and accuracy of our scheme.

Keywords: Lagrangian Magnetohydrodynamics, Cell-centered scheme, Unstructured mesh, Projection method

1. Introduction

Numerical simulation of magnetohydrodynamics is widely used in the areas such as celestial physics, confined fusion, high energy density physics and so on, it can give detailed evolution process and clear flow characteristics of plasma which are difficult to obtain by experiments or physical analysis. However, the MHD govern system which combined Naiver-Stokes equations together with the Maxwell equations is nonlinear hyperbolic, and the wave structure is much more complicated than that in hydrodynamic system. For simplicity, researchers usually concern about the ideal MHD equations where the effects of resistivity, thermal conductivity and viscosity are ignored.

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