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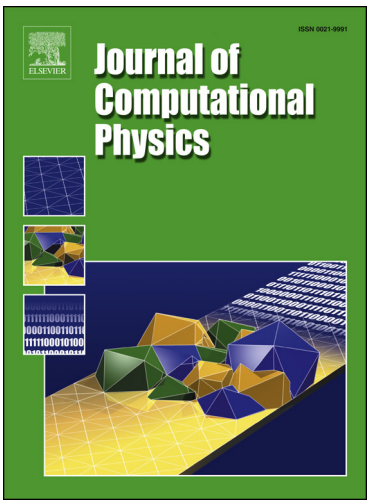

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The arbitrary order mimetic finite difference method for a diffusion equation with a non-symmetric diffusion tensor

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Abstract

We present the arbitrary order mimetic finite difference (MFD) discretization for the diffusion equation with non-symmetric tensorial diffusion coefficient in a mixed formulation on general polygonal meshes. The diffusion tensor is assumed to be positive definite. The asymmetry of the diffusion tensor requires changes to the standard MFD construction. We present new approach for the construction that guarantees positive definiteness of the non-symmetric mass matrix in the space of discrete velocities. The numerically observed convergence rate for the scalar quantity matches the predicted one in the case of the lowest order mimetic scheme. For higher orders schemes, we observed super-convergence by one order for the scalar variable which is consistent with the previously published result for a symmetric diffusion tensor. The new scheme was also tested on a time-dependent problem modeling the Hall effect in the resistive magnetohydrodynamics.

1 Introduction

The last decade has seen a development of a large number of discretization methods that work on unstructured polytopal (polygonal or polyhedral) meshes. Such meshes are in high demand in various engineering applications due to a critical flexibility they provide for working with complex geometries (e.g. subsurface flows). They appear as a result of mesh refinement, de-refinement, reconnection and other optimizations. They may also appear in multi-physics applications as dual to simpler meshes (e.g. Voronoi mesh as dual to a triangular mesh). In this time period, many discretization methods on polytopal meshes were extended to higher order. Higher-order schemes reduce significantly numerical diffusion which is critical for a number of multi-physics applications, e.g. for problems with dominated vorticity.

In this paper we present a new arbitrary order mimetic finite difference (MFD) method for diffusion problems with non-symmetric tensorial coefficients written in a mixed form.