Source code documentation of APPM

Roman Fuchs

December 2, 2019

Contents

Todo list

Output file (*.xdmf) must be written separately for primal and dual mesh. As of now, Paraview supports EITHER a spatial collection of grids OR a temporal grid of a single mesh. It does not support multiple grids AND time variations. – No, it does! (the time value tag was at wrong place) 3

Leapfrog scheme 3

Raviart-Thomas interpolation of magnetic flux B 3

APPM: asymptotic preserving plasma model.

1   Introduction

Aim of the code: show the feasibility of a plasma model that is based on the Maxwell Grid Equations (see Finite Integration Technique) for electromagnetism and the Navier-Stokes equations for the fluid.

Maxwell equations:

$$\partial_t \vec{B} + \nabla \times \vec{E} = 0 \tag{1a}$$

$$\partial_t \vec{D} - \nabla \times \vec{H} = -\vec{J} \tag{1b}$$

$$\nabla \cdot \vec{B} = 0 \tag{1c}$$

$$\nabla \cdot \vec{D} = \rho \tag{1d}$$

(ρ: space charge density)

$$\vec{D} = \varepsilon \vec{E} \tag{1e}$$

$$\vec{B} = \frac{1}{\mu} \vec{H} \tag{1f}$$

2   Mesh construction

Why a primal and dual mesh?

2.1   Primal mesh

How it is defined.

2.2   Dual mesh

How it is defined.

3   Data output

The data is visualized in ParaView[1] or VisIT, using XDMF[2] for data description and HDF5[3] for the heavy data.

Remarks:

- Use ParaView, because VisIT does not support polyhedral cells.

- ParaView has three readers for *.xdmf-files: XMDF Reader, Xdmf3ReaderS, and Xdmf3ReaderT.

- XDMF Reader supports the `GridType="Tree"` tag (i.e., grid of grids), but does not support polyhedrals.

---

[1] version 5.6.0, 64-bit
[2] `xdmf.org/index.php/XDMF_Model_and_Format`, version 3.
[3] version 1.10, 64-bit

- Xdmf3ReaderS supports polyhedrals, but does not support `GridType="Tree"`.

- Therefore, the mesh data is split into two xdmf files: one that has vertex, edge, and surface data (that can be read with XDMF Reader); and a separate one for volume data (that can be read with Xdmf3ReaderS).

3.1 Mesh

Definition of cells and faces as given in the XDMF format.

For each face: facetype + list of vertex indices. Except for a polygon: facetype + number of vertices + list of vertex indices.

For each cell: celltype + list of vertex indices. Except for a polyhedral: celltype + number of faces + description of each face.

3.2 Data

4 Visualization

- Use ParaView

- Open file `appm.xdmf`

- Select Reader `XDMF Reader` (other options: XMDF Reader S, XDMF Reader T; they do not work)

- To visualize data on a given mesh: add Filter, extract Block.

Vectors:

- Add Filter -> Glyphs

- Orientation array = . . .

- Scale array = . . .

- Masking / Glyph mode = All points

5 Testcases

5.1 Uniform current, determine magnetic fields

Define current density in z-direction, at radius $r < r_0$.

6 TODO

Leapfrog scheme

Raviart-Thomas interpolation of magnetic flux B

Flow states