

Source code documentation of APPM

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Contents

1	Introduction	2
2	Mesh construction	2
2.1	Primal mesh	2
2.2	Dual mesh	2
3	Data output	2
3.1	Mesh	3
3.2	Data	3
4	Visualization	3
5	Testcases	3
5.1	Uniform current, determine magnetic fields	3
6	TODO	3

Todo list

Leapfrog scheme	3
Raviart-Thomas interpolation of magnetic flux B	3
Flow states	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:

$$\partial_t \vec{B} + \nabla \times \vec{E} = 0 \quad (1a)$$

$$\partial_t \vec{D} - \nabla \times \vec{H} = -\vec{J} \quad (1b)$$

$$\nabla \cdot \vec{B} = 0 \quad (1c)$$

$$\nabla \cdot \vec{D} = \rho \quad (1d)$$

(ρ : space charge density)

$$\vec{D} = \varepsilon \vec{E} \quad (1e)$$

$$\vec{B} = \frac{1}{\mu} \vec{H} \quad (1f)$$

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 ParaView¹ or VisIT, using XDMF² for data description and HDF5³ for the heavy data.

Remarks:

- Use ParaView, because VisIT does not support polyhedral cells.
- ParaView has three readers for *.xdmf-files: XDMF Reader, Xdmf3ReaderS, and Xdmf3ReaderT.
- XDMF Reader supports the `GridType="Tree"` tag (i.e., grid of grids), but does not support polyhedrals.
- 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).

¹version 5.6.0, 64-bit

²xdmf.org/index.php/XDMF_Model_and_Format, version 3.

³version 1.10, 64-bit

3.1 Mesh

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

For each face: facettype + list of vertex indices. Except for a polygon: facettype + 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: XDMF 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

Animation View, Time Inspector From the menu bar: View.

5 Testcases

5.1 Uniform current, determine magnetic fields

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

6 TODO

Raviart-Thomas interpolation of magnetic flux B