MHD Simulations of Jets with Applications to the Sun

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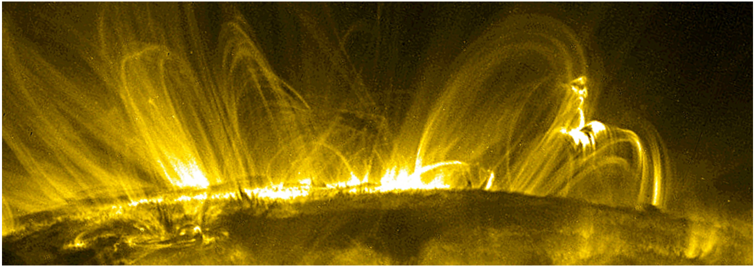
Overview

Coronal Heating

- From the core of the sun to the photosphere the temperature decreases.
- Corona is 200 times hotter than the Sun's photosphere.
- This contradiction is referred to as the coronal heating problem.
- One of the main candidates for heating the solar corona is through wave heating.



Solar Jets

- give overview.

TRQ

- Explain the what it is
- Include images from scullions thesis

Scientific Goal

- Clearly state the problem you are investigating
- Why should they care or what the use in it?

History

- VAC was developed as a flexible software focused on implementing shock capturing numerical schemes (e.g. FCT, TVD, ect).
- Aimed at solving, primarily hyperbolic partial differential equations.
- MPI-AMRVAC is a parallel open source code (On Github: https://github.com/amrvac/amrvac).
- Written in Fortran using a pre-processor which allows to program in any dimensional matter (LASY-syntax).

AMR

- Block based refinement strategy used.

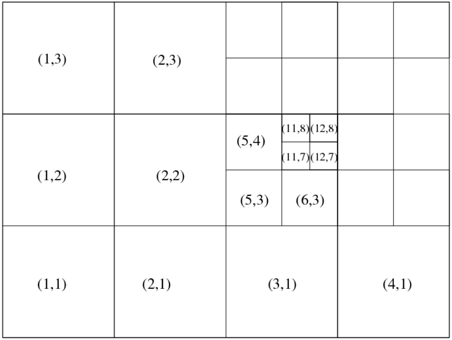


Figure: Describe

Examples of Results of Using AMR

- Example of AMR with 4 levels.
- Example of HD supersonic jet with gravity acting agiant the direction of flow.
- Example of Rayleigh Taylor simulation.

Why use AMR

Uniform Mesh:

- High resolution required for handling difficult regions (discontinuities, steep gradients, shocks, ect).

Adaptive Mesh Refinement:

- Start with a course grid.
- Identify regions that need finer resolution.
- Superimpose finer sub-grids only those regions.
- Increased computational saving over a static grid approach.
- Track features much smaller than overall scale of the problem providing adequate higher spatial and temporal resolution where needed.

Local Error Estimation

Outline AMR criteria.

MHD Module

$$\partial_t \rho + \nabla \cdot (\mathbf{v}\rho) = 0 \tag{1}$$

$$\partial_t (\rho \mathbf{v}) + \nabla \cdot (\mathbf{v}\rho\mathbf{v} - \mathbf{B}\mathbf{B}) + \nabla p_{tot} = 0, \tag{2}$$

$$\partial_t e + \nabla \cdot (\mathbf{v}e - \mathbf{B}\mathbf{B} \cdot \mathbf{v} + \mathbf{v}p_{tot}) = \nabla \cdot (\mathbf{B} \times \eta \mathbf{J}), \tag{3}$$

$$\partial_t \mathbf{B} + \nabla \cdot (\mathbf{v}\mathbf{B} - \mathbf{B}\mathbf{v}) = -\nabla \times (\eta \mathbf{J}). \tag{4}$$

Where:

$$p = (\gamma - 1)\left(e - \frac{\rho \mathbf{v}^2}{2} - \frac{\mathbf{B}^2}{2}\right), \tag{5}$$

$$p_{tot} = p + \frac{\mathbf{B}^2}{2}, \quad \mathbf{J} = \nabla \times \mathbf{B}. \tag{6}$$

- Explain why the equations are in this conservative form.
- Explain the addition of source terms (i.e. gravity).

Set up

- Show line plots of profiles used. Compare against VALC data (see Ronnie PhD student thesis plots).
- Explain the BC conditions you are using.
- Video of the background being stable.
- Explain the driver of the jet.

Results

MOVIES

Conclusion

Future Plans