General Fusion (GF) is working to build a magnetized target fusion (MTF) power plant based on compression of magnetically-confined plasma by liquid metal. GF is testing this compression concept by collapsing solid aluminum liners onto plasmas formed by coaxial helicity injection in a series of experiments called PCS (Plasma Compression, Small).

**INTRODUCTION**

MHD SIMULATION WITH VAC

Shock capturing Eulerian Finite volume code by Gábor Tóth.

In-house modifications:

- Improvements for strong toroidal fields (e.g., slope-limiting instead of $B_\phi$

- Coupling MHD to external circuit models

- Independent ion and electron temperatures

- Classical parallel heat transport

Transport:

- Spitzer temperature dependent resistivity

- Various models for radial heat transport

- Constant viscosity for simplicity

**Equations of the model**

\[
\frac{\partial p}{\partial t} + \nabla \cdot (p \mathbf{v}) = 0
\]

\[
\frac{\partial \mathbf{v}}{\partial t} + \mathbf{v} \cdot \nabla \mathbf{v} = -\nabla p + \frac{\mathbf{J} \times \mathbf{B}}{\mu_0} + \nabla \cdot \mathbf{F}
\]

\[
\frac{\partial \mathbf{B}}{\partial t} = \nabla \times \mathbf{E} + \mathbf{J}
\]

\[
\frac{\partial n_e}{\partial t} = \nabla \cdot (n_e \mathbf{v})
\]

\[
\frac{\partial T_e}{\partial t} = \nabla \cdot (\mathbf{v} T_e) + \nabla \cdot (\lambda_e \nabla T_e)
\]

\[
\frac{\partial T_i}{\partial t} = \nabla \cdot (\mathbf{v} T_i) + \nabla \cdot (\lambda_i \nabla T_i)
\]

**Numerical Experiment**

Compression ratio $\frac{R_0}{R_t} = \frac{2 \pi r_0 B}{B_0}$

Constant shaft current $t_{\text{comp}} = t_i$

Ramped shaft current $t_{\text{comp}} = \frac{1}{10} t_i$

**Simulation of PCS14**

PCS 14 Compression: ramping shaft current

- Torcher Lines: with 3D Simulation Timing Lines: MHD Adjustment

**Stabilization by Ramping Shaft Current**

- Compress current to $t_{\text{comp}}$

- Torcher Lines: with 3D Simulation Timing Lines: MHD Adjustment

**Summary**

- Shaft current ramp:
  - MHD simulations showed stabilizing effect
  - motivated inclusion in PCS14 experiment
  - compression was stable at least to $R_0/R = 2.5x$

- Modeling PCS14:
  - MHD simulation initialized to conditions of PCS14
  - Matches decay of plasma current prior to compression
  - Matches compression increase of plasma current until a compression ratio of about 1.7x, then experiment falls below simulation.

- Numerical experiment:
  - Assume edge cooling, model by increased edge transport
  - Core temperature, pressure remain relatively high

- Simulation prospects for PCS15:
  - AXUV diode x-ray thermometers
  - Additional Mirnov probe for better initialization

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