Effect of Imposed Magnetic Fields on Hot-spot Shape

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3 perturbation types:
• Fill-tube ➔ HDC
• Radiation asymmetry ➔ High-foot
• Multi-mode ➔ All ICF

3 field strengths:
• 0T ➔ Unmagnetised base case
• 5T ➔ Similar to OMEGA shots
• 50T ➔ Predicted best improvement

3 Magnetic Effects:
• Thermal conduction
• Magnetic pressure ➔ 50T only
• Magnetised α transport ➔ 50T only
Chimera:

- 3-D Extended-MHD
  - OMEGA experiments matched well- ask for more info

- Anisotropic thermal conduction

- Radiation transport (non-diffusive)

- Magnetised α-transport (PIC)

- Synthetic diagnostic suite
$B_0 = 0T$, $5T$, $50T$

$T_i$ keV contours:

Magnetised thermal conduction only
Magnetised thermal conduction

$B_0 = T_i$ keV contours:

Magnetic Pressure

Magnetised thermal conduction
$T_i$ keV contours:

Magnetic force
Magnetisation of $\alpha$-particles does not change shape, but does increase temperature.
t = Peak Burn

\[ B_0 = 5T \]
t = Peak Burn + 20ps

\[ B_0 = 5T \]
Magnetised thermal conduction only

Density (kg/m^3)

- Increased heat flow
- Decreased heat flow

0T
5T
50T

$B_0$
$B_0 = 50T$

Magnetic Pressure

Magnetised thermal conduction
Magnetised thermal conduction only

\[ B_0 = 0 \text{T}, \ 5 \text{T}, \ 50 \text{T} \]

Magnetised thermal conduction only
$B_0 = 50T$

**Magnetic Pressure**

- **No Lorentz Force**
  - Vortices suppressed by Lorentz force

- **With Lorentz Force**
  - Magnetised thermal conduction
\( B_0 = 50T \)

No Lorentz Force

With Lorentz Force

Magnetic Pressure

Magnetised thermal conduction
Summary – Hot-spot Shape

Magnetised thermal conduction

- Hot-spot elongation
- Increased penetration $\parallel B$
  - Reduced ablative stabilisation
  - Pinching around waist
- Reduced penetration $\perp B$
  - Increased ablative stabilisation
  - Increases high-mode structure

Magnetic Pressure

- 50T only
- Reduced penetration $\parallel B$
- Prevents hot-spot severing at waist
- Suppresses vortices $\Rightarrow$ mix?

Magnetised $\alpha$-transport

- 50T only
- Negligible effect on shape
- Increases temperature & yield
Comparing fill-tube orientations

Fill-tube $\perp$ to field:

Fill-tube $\parallel$ to field:
Tent + radiation asymmetry

0T

5T

50T

Magnetic Field Magnitude (T)

0.0e+00  2000  3000  4000  5000  6000  7000  8000  1.0e+04

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The images illustrate the effect of magnetic field strength on radiation asymmetry with three different field strengths: 0T, 5T, and 50T. The plot shows the magnitude of the magnetic field, with the scale indicating the range from 0 to 10000 Tesla. The radiation asymmetry appears to increase with the magnetic field strength, as indicated by the more distinct and pronounced patterns in the higher field images.
Experiments on OMEGA

Flux Compression:

- Gorgon replicates peak proton deflection and therefore peak field strength

Fusion Performance:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>$T_i$ % Change</th>
<th>Yield % Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment</td>
<td>+15</td>
<td>+30</td>
</tr>
<tr>
<td>3-D Gorgon</td>
<td>+11</td>
<td>+33</td>
</tr>
</tbody>
</table>


Chang et. al. PRL (2011)