Development of an Exploding Wire Plasma System for Studying Magnetic Reconnection

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Why Study plasma?

- Plasma is the most energetic and most abundant state of matter (over 99% of the matter in the visible universe).
- It couples strongly to magnetic fields causing them to be frozen in and move in unison with the matter.
- Consequently, magnetized plasmas can form large scale structures such as prominences and flares.
Magnetic Reconnection

- Magnetic reconnection is a mode of magnetic energy dissipation
- Occurs at the boundaries of magnetic domains where the field strength approaches zero
- Transfers magnetic energy to plasma particles which leads to particle ejection
- Plays an important role in space weather phenomena and fusion energy research
- Can be induced by $\vec{F} = \vec{J} \times \vec{B}$ forces
Magnetic Helicity

- Magnetic helicity is the measure of the topological interlinkage of magnetic field loops

\[ H = \int_V A \cdot B \, dV = \int_V A \cdot (\nabla \times A) \, B \, dV \]

  - \( H \) is the helicity of the entire magnetic field
  - \( B \) is the magnetic field strength
  - \( A \) is the vector potential of \( B \) which is \( B = \nabla \times A \)
  - \( dV \) is the differential volume element

- It is conserved during magnetic reconnection while energy may be transferred between the magnetic field and the plasma

\[ 2 + (-2) = 0 \]

\[ 1 + 1 = 2 \]
J. F. Hansen, S. K. P. Tripathi, P. M. Ballan Experiment

Single prominence

Co-helicity

Counter-helicity

<table>
<thead>
<tr>
<th>Main capacitor charging voltage (kV)</th>
<th>Single prominence x-ray emission (mV)</th>
<th>Co-helicity x-ray emission (mV)</th>
<th>Counter-helicity x-ray emission (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.00</td>
<td>0.6±0.3</td>
<td>0.8±0.6</td>
<td>0.5±0.2</td>
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<tr>
<td>4.00</td>
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<td>1.1±0.6</td>
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<tr>
<td>6.00</td>
<td>7.8±5.7</td>
<td>3.6±1.6</td>
<td>176.3±100.6</td>
</tr>
</tbody>
</table>
Experimental Design
Vacuum Chamber
Pulse Power System

High voltage power supply

Capacitor: 30kV @ 2μF

Ignitron: high voltage switch

High voltage diode
Diagnostics

Ultra-High-Speed Framing Camera

Voltage Divider

Rogowski Coil

Shunt Resistor

Voltage Measurement
Summary

Completed
• Vacuum chamber
• Sample holder

In progress
• Pulse power system
• Diagnostics

Looking forward
• Quadrupole pulse magnets
• Soft X-ray array diagnostics
• In chamber magnetic diagnostics
References


