Sawteeth in MST

Magnetic reconnection occurs at sawtooth bottoms called sawtooth crashes. Higher magnetic field gradients lead to larger reconnection fluxes, whereas heating events are reduced. Reconnection points produce magnetic islands where amplitudes increase during a sawtooth event. Core reconnection modes with n = 3, 4 are associated with an increase in sawtooth crash time. Energy is stored in the plasma and thermal energy.

Dynamo generates toroidal field

Reconnection condition

\[ \frac{d B_{\phi}}{dt} = \frac{\alpha B_{\phi}}{r} \]

\[ \alpha = \frac{v_r \frac{d v_r}{dt}}{B_r} \]

Dynamo-dominated regime

Magnetic reconnection rate

\[ \frac{d B_{\phi}}{dt} = \frac{\alpha B_{\phi}}{r} \]

\[ \alpha = \frac{v_r \frac{d v_r}{dt}}{B_r} \]

Energy is released and converted to plasma kinetic and thermal energy. By studying the sawtooth dynamics very quickly released and converted to plasma kinetic and thermal energy. During these events, fluctuation levels increase to many measurable quantities and lead to the transport of particles, momentum, and energy. The sawtooth flow dynamics during these events and how to build better understanding of reconnection, control the instabilities that lead to sawtooth crashes, and reduce the frequency of sawtooth crashes, which remain important in transport and are heated faster than classical collisional arguments.

MST is a toroidal plasma confined by a set of nested poloidal field coils. In MST, the toroidal magnetic field is directed by the "inner surface" of the plasma.

Plasma Parameters

To be able to make probe measurements, MST was operated at lower plasma currents. Typical discharge events 76 - 84 MA with a density of 0.5 - 1.5 MA/m^2. The plasma current is driven and sustained, and energy is stored in the plasma and thermal energy.

Velocity [km/s]

<table>
<thead>
<tr>
<th>Time [s]</th>
<th>Velocity [km/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>0.1</td>
<td>0.6</td>
</tr>
<tr>
<td>0.2</td>
<td>0.7</td>
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</tbody>
</table>

Fluctuation-induced particle transport is enhanced at the sawtooth crash

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time at crash [s]</td>
<td>0.1</td>
</tr>
<tr>
<td>Toroidal field [T]</td>
<td>0.5</td>
</tr>
<tr>
<td>Poloidal field [T]</td>
<td>0.2</td>
</tr>
<tr>
<td>Plasma pressure [Pa]</td>
<td>1000</td>
</tr>
<tr>
<td>Plasma current [A]</td>
<td>50</td>
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</tbody>
</table>

Fluctuation-induced particle transport increases at the sawtooth crash.

Fluctuations are enhanced at the sawtooth crash.

Core mode/amplitude begin increasing before the crash

Core mode amplitude increases before the crash.

Core mode amplitude begins to increase before the crash.

Mode structure rotates past a single point probe measurement, but when higher-order modes are included, the O-point vanish.

Magnetic fluctuations are small.

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Measured non-axisymmetric flow profiles are inconsistent with standard reconnection picture

Expected flow patterns:
- Coupling propagating vortices
- Magnetic structure remains a single-growth probe measurement, but the toroidal plasma provides a reference.
- Ions are frozen in with electrons.

Turbulent stresses are much larger than inertial changes but balance each other

Turbulent stresses are much larger than inertial changes but balance each other.

Ions are hotter that can be explained by collisions with electrons.

Measurements of the m=0 components of \( \delta \) show inward flow at the 3/4 point and outward flow at the O-point. In agreement with simulations, these regions show the flow transitions to a different phase relationship compared to simulation.

EDD simulations show one flow pattern that flow through the O-point and back out through the D-point.

EDD simulations show one flow pattern.

EDD simulations show one flow pattern, where higher-order modes are included, the D-point is suppressed.

IDS probe locally measures line emission

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Fluctuation-induced particle transport is enhanced at the sawtooth crash.

Fluctuation-induced particle transport increases at the sawtooth crash.

Fluctuation-induced particle transport increases at the sawtooth crash.

Conclusions and future work

Ion flow phenomena are not related to magnetic islands. The analysis of edge and core transport are not related to magnetic islands. The analysis of edge and core transport are not related to magnetic islands. The analysis of edge and core transport are not related to magnetic islands. The analysis of edge and core transport are not related to magnetic islands.

The model structure of velocity, temperature, and density gives rise to transport. Fluctuation-induced particle transport increases exponentially during a sawtooth event, reaching a 100 x-particles.

Reconnection and turbulence are not measured. However, the flow field has been much larger than the scale of change in reconnection events, approximately in balance with each other.

1st Townsend force is not a sawtooth structure.

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