Magnetic reconnection plays an important role in particle transport, acceleration, and energization in space, astrophysics, and laboratory plasmas. In MST reversed field pinch plasmas, discrete magnetic reconnection events release large amounts of energy from the equilibrium magnetic field, resulting in non-thermal ion heating. However, Thomson Scattering measures a decrease in the thermal electron temperature. Recent tail x-ray data measures a decrease in high energy x-ray flux during reconnection, where the coupling between edge and core modes is increased. Electron acceleration mechanism is determined by measuring high energy tail spectral index, which is fit with a power law to quantify high energy electron tail generation.

### ABSTRACT

Magnetic reconnection plays an important role in particle transport, acceleration, and energization in space, astrophysics, and laboratory plasmas. In MST reversed field pinch plasmas, discrete magnetic reconnection events release large amounts of energy from the equilibrium magnetic field, resulting in non-thermal ion heating. However, Thomson Scattering measures a decrease in the thermal electron temperature. Recent tail x-ray data measures a decrease in high energy x-ray flux during reconnection, where the coupling between edge and core modes is increased. Electron acceleration mechanism is determined by measuring high energy tail spectral index, which is fit with a power law to quantify high energy electron tail generation.

### TEARING MODE RECOVERY IN MST

- Stored magnetic energy grows during plasma discharges until tearing mode instabilities are driven away.
- Plasma undergoes reconnection process where magnetic energy is released suddenly, generating large pulsed electric fields within switchboard crashes.
- Twinning instabilities and nonlinear coupling results in multiple magnetic reconnection sites.

### MOTIVATION - PARTICLE HEATING & ENERGIZATION

- Large proportion of magnetic energy transferred to ions, resulting in T_e. Thomson Scattering measures a decrease in the thermal electron temperature. Parallel E-field exerts force that accelerates electrons.
- Expect energetic electrons to be lost faster than thermal electrons, may mask electron transport.
- Minority ions: Heated more strongly perpendicular to B. Electron heating dependent on charge mass ratio. Increased energetic electrons accelerated parallel to B-field.
- Diminished heating when weak coupling between core & edge modes.
- High energy tail develops in majority ion energy distribution. Relaxed fit by power law.
- Decrease in indicative generation of high energy tail.

### POSSIBLE ELECTRON ENERGIZATION MECHANISMS

- Increase in high energy x-ray flux during reconnection events not due to thermal emission.

### TARGET EMISSION

- If target emission is responsible for increased high-energy x-ray flux at reconnection events, emission will increase with Moly probe inserted in plasma.
- No increase in x-ray emission during reconnection events with probe inserted compared to when probe is completely reflective.

### COLLISIONS

- Before reconnection event, ions remain constant, but varies for different n_0 (I_e/3 m = 0 amplitude very small compared F = 0).
- Allowing x-ray emissions for increased high-energy tail generation during reconnection compared to before event.

### RELEASED MAGNETIC ENERGY

- J_e is a measurement of how much of magnetic tail generated during reconnection compared to before event.
- Effects of parallel reconnection: Plasma parameters change between edge and core modes.

### ENERGY SPECTRA & TAIL CALCULATION

- Due to high temporal resolution, x-ray flux can be calculated for time windows as short as 20 μs.
- X-ray flux shows increase in energetic electrons at reconnection events, similar to measurements of energetic ions.

### PARALLEL ELECTRIC FIELD & ELECTRON RUNAWAY

- Parallel E-field exerts force that accelerates electrons.
- Frictional drag force due to Coulomb collisions with background distribution opposes acceleration.
- Fast electrons experience less collisional acceleration than thermal electrons.
- Electrons runaway if no other damping mechanism.
- Discharge field is maximum E-field for thermal runaway.
- In previous experiments, injected fast ions gain energy at reconnection events, consistent with runaway acceleration.

### DIRECTIONAL DEPENDENCE - PARALLEL TO B

- More substantial tail generated perpendicular to core B-field than parallel direction.
- J_e indicates energetic electrons more strongly emitted perpendicular to B-field than to ion heating.

### SUMMARY

- Reconnection events in MST characterized by bursts of tearing mode activity.
- Non-collisional ion heating & energization observed at reconnection events, but cooling of thermal electrons observed.
- Non-classical electron energization observed during reconnection events in MST.
- Enhanced generation of energetic tail that is greatest for largest amount of energy released from equilibrium magnetic field.
- Coupling between edge and core heating modes essential for energization.
- No clear dependence of tail generation on parallel E-field, ruling out runaway acceleration as dominant mechanism in energization process.
- Electrons energized more strongly in directions perpendicular to B-field.
- Characteristics of non-classical electron energization consistent with those of ion heating & energization, indicating similar mechanisms.

### FAST-X-RAY DETECTOR ON MST

- FXR detector has radial view through core of plasma.
- Measures bremsstrahlung emission perpendicular to B-field.
- X-ray flux shows a characteristic pulse.

### INITIAL MEASUREMENTS - PERPENDICULAR TO B

- Shows with same conditions are correlated to calculate total x-ray count rate at reconnection events.

### ENERGY SPECTRA & TAIL CALCULATION

- Total x-ray flux normalized by plasma volume through which detector views & number of events to compare data taken in different discharges.

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