ABSTRACT:
Magnetic reconnection plays an important role in particle transport and energization in space, astrophysical, and laboratory plasmas. Strong ion heating and energetic ion tail formation are observed in MST plasmas at the time of reconnection events. The present study is the result of an attempt to understand the energetic electron population and the heating of electrons in space, astrophysical, and laboratory plasmas. The presence of energetic electrons in reconnection plasmas is of utmost importance as they provide insight into the generation and acceleration processes of these particles. This study aims to explore the characteristics of energetic electrons in MST plasmas and investigate the mechanisms governing their formation and acceleration.

RECONNECTION EXPERIMENTS:
- Stored magnetic energy grows during plasma discharges until it is then released as sudden reconnection events.
- Neams undergoes relaxation processes where magnetic energy is released slowly, generating large pressure-induced electric fields during sawtooth crashes.
- Sensitive high-speed measurements of the electron energy distribution in plasma plasmas at the time of reconnection events will be compared to determine if a tail population of electrons exists.
- Strong ion heating and energetic ion tail formation are observed in MST plasmas.
- Electrons accumulate more thermal energy during plasma decay.

RUNAWAY ELECTRON ONSET:
- Lees energetic electrons dominated by collisional drag.
- More energetic electrons accelerated when E-field larger than collisional drag.
- E < 15 keV for energetic electrons that are accelerated.
- Electrons runaway to speeds much greater than thermal velocities.

RUNAWAY ELECTRON EXPERIMENTS:
- RE onset threshold (Black line): $E_{onset} = 2.345 \times 10^7$ V/m.
- RE onset threshold (red line): $E_{onset} = 0.17 \times 10^7$ V/m.
- Increase in $n_e$ shot by shot increasing the net energy gain. Increase of a factor of 2 to 3.

EXPERIMENTAL PARAMETERS:
- Bt (avg): 1200 Gauss
- Ne (m): ~ 10^19 m^-3
- E = By / (B^2)
- PhotoSax of Samples: 90\%.

RUNAWAY ELECTRON SUPPRESSION:
- RE experiments need to be mitigated during discharges.
- Increasing RE yields the collisional cooling rate, which can suppress the growth of a RE population.
- In experiments, X-ray flux and E-field in order to suppress RE in MST tokamak plasmas.

Electron energization experiments:
- A fast x-ray detector is used to study electron energization at reconnection events in 500 keV standard plasmas.
- The time evolution of photon flux shows an increase in high energy photons at the time of the sawtooth crash.
- Energy distributions are calculated for 20 ms time intervals, ranging from -1 to +1 ms around reconnection events.
- An increase in $E_{onset}$ observed just before crash time, indicating there may be the formation of an energetic electron tail at reconnection events.
- The threshold for suppression of RE is ½ of the onset threshold.

FUTURE WORK:
- Target emission: The m = 0 crash is required for electron energization.
- In ion energization experiments, when m = 0 crash was not present, but a crash in the poloidal loop voltages was observed, no ion energization was observed.
- In future experiments, X-ray flux data will be gathered with and without the m = 0 crash to rule out target emission as a possible cause of energetic electron generation.
- Study reconnection events occurring at the high confinement regime.
- Study the substantial electron energization during 1.5 mode growth of SXR plasmas with the mode locked at different poloidal locations.

Electron Energie Distributions:
- Energy distributions are calculated for 20 ms time intervals of $E_{onset}$ to $E_{onset}+90\mu$s.
- The m = 0 crash is required for electron energization.
- No definitive evidence that formation of energetic tail is dependent on the crash amplitude.
- The amount of energization does not appear to depend on the crash amplitude.
- The free energy available to accelerate electrons and generate a significant population is proportional to the change in magnetic energy.
- Energy distributions for each crash amplitude range are calculated for three time ranges.
- $E_{onset}$ is relatively small, but generates more flux of all energies per crash than smaller amplitudes.
- The free energy available to accelerate electrons and generate a significant population is proportional to the change in magnetic energy.
- Based on photon PFs and the increase in $E_{onset}$ for increasing sawtooth amplitude, expect $E_{onset}$ to scale with $I_t$.
- The amount of energization does not appear to depend on the crash amplitude.

ENERGETIC TAIL DEPENDNCE ON SAWTOOTH CRASH AMPLITUDE:
- Sawtooth crashes with amplitudes $\geq 15$ – $35$ keV most probable in standard plasmas, but generate very few photons with E $\lesssim 15$ keV.
- $\sim 10^5$ keV photons are seen in the electron tail population.
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ENERGIZED PHOTON COUNTS:
- Photon pulses from Fe55 source.
- Calculated photon pulse duration.
- Photon energy spectrum: 0.141 V corresponds to 5.889 keV.
- Previous experiments on MST have focused on ion energization. (E. Scime 1992, R.M. Magee 2011, S. Eilerman 2014)
- Indicative of magnetic reconnection, leading to energization of electrons.
- Stored magnetic energy grows during plasma decay.

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