Abstract

Recent Experiments on coaxial helicity injection (CHI) initiated, inductively sustained plasmas have resulted in more robust plasmas with higher plasma current than previously achieved on the Helicity Injected Torus II (HIT-II) experiment[1]. The multi-Point Thomson scattering (MPTS) diagnostic on the HIT-II experiment, a 6 point ruby system is utilized to characterize the temperature and density profile of these discharges. Results of plasmas initiated and driven by either CHI or transformer operations alone will also be presented. The temperature and density profiles are compared to EFIT results, which will eventually incorporate the Thomson scattering data in Kinetic EFIT reconstructions.

Location of multipoint Thomson field of view
OH Plasma:
Temporal profile of electron temperature

Temperature continues to increase beyond plasma current peak.
The MPTS spatial profile agrees with FIR

Green and black symbols are MPTS data taken at 18ms, HIT-II shots 26686, 26687.

Blue line is an Abel inversion of the FIR measurement for this shot series.

[See R. Griff O’Neill’s Poster QP1.061 for further FIR results.]
During the plasma current rise of the OH plasma:

- Electron temperature increases.
- Density increases and its profile peaks.
During the peak, and in the initial portion of the OH plasma current decay:

- Temperature continues to increase despite onset of reconnection events.
- Density profile peaks between reconnection events.
During the final stages of current decay:

- Temperature and density peak during quiescent periods between reconnection events.
- Temperature and density profiles flatten during reconnection events.
• MPTS profiles during CHI plasma indicate high temperatures at the plasma edge.
• Higher temperatures may be located outside the MPTS field of view at the edge.
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During the current rise of the OH portion of the plasma:
• The temperature rises with a profile similar to that of an OH only plasma despite indications of more magnetic activity at the edge.
• Density profiles are strongly peaked.
OH + CHI startup vs. OH only

OH Only

- Lower peak plasma current for the same transformer volt seconds.[1]
- Plasma performance degrades with every shot.[1]

OH + CHI startup

- OH + CHI startup has the highest demonstrated plasma current on HIT-II (190 kA)
- Density inside MPTS field of view is lower than for OH only shots with otherwise similar parameters.
- Peak temperatures are similar to OH only
- Temperature profile seems to differ from OH only.

OH + CHI Initiation vs. OH only
The resistive heating power (normalized by the electron density) is within the same order of magnitude for CHI and OH plasmas.

Let:

\[ P_{\Omega}(t) = I(t)^2 p R(t) \]

Where:

\[ I_p = \text{Plasma Current} \]

\[ R \approx 5.2 \times 10^{-5} \frac{Z \ln \Lambda}{<T_e>^{3/2}} \]

\[ Z \ln \Lambda \approx 10 \]
Estimated peak beta toroidal

\[ \beta_T = \frac{nk(T_e + T_i)}{B_t^2/2\mu_0} \]

Let \( T_i \approx T_e \)

Where:
- \( T_i \) = ion temperature
- \( T_e \) = MPTS measured electron temperature
- \( n \) = MPTS measured electron density
- \( B_t \) = Toroidal field
- \( \mu_0 \) = permeability

**Note:** Ion doppler spectroscopy measurements indicate that ion temperatures in CHI plasmas may be significantly hotter than electron temperatures. This would increase the CHI beta to about 2%

**OH Plasma:**
- \( T = 354 \text{ eV} \)
- \( n = 3.11 \times 10^{19} \text{ m}^{-3} \)
- (Shot 27517)
- \( \beta_t \approx 6\% \)

**CHI Plasma**
- \( T = 50 \text{ eV} \)
- \( n = 2.5 \times 10^{19} \text{ m}^{-3} \)
- \( \beta_t \approx 0.7\% \)

[See R.Griff O’Neill’s Poster QP1.061 for further Ion Doppler results.]
Summary

- MPTS has been used to measure temperature and density at 5 spatial locations during OH driven plasmas, CHI driven plasmas, and OH driven plasmas with CHI startup. Measurements have been made at various times during plasmas with repeatable performance to study the temperature and density temporal evolution.
- The density profile agrees well with an Abel inversion of FIR measurements for the same plasma profile.
- During OH plasmas the temperature and density rise during the ramp up of the plasma current, and for several milliseconds following the plasma current peak. Between reconnection events, the density profile is peaked.
- During the late stages of plasma current decay, the density profile shows ever increasing peaked profile between reconnection events, and flattens during reconnection events.
• MPTS measurements during CHI plasmas indicate lower temperatures, with highest measured temperatures at the edge. Higher edge temperatures may lie outside the MPTS field of view.

• OH plasmas with CHI startup appear to achieve similar temperature and density magnitudes despite indications of higher magnetic activity during the discharge. The temperature profiles may be different than OH only discharges.

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