Progress in understanding flows and electric field in HSX

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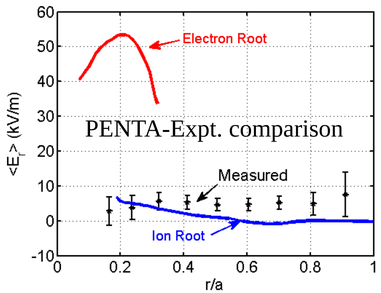
Experiments in the past could not reproduce flows and E_r calculated by the PENTA code.



(A. Briesemeister et al.)

- Previous carbon flow measurements using charge exchange spectroscopy (CHERS). Radial electric field (E_r) calculated from force balance.
- No indication of large positive electron root E_r at the core calculated by PENTA.

Improvements in measurements and modeling are being undertaken to understand this discrepancy

I. E_r can be determined from Pfirsch-Schlüter (PS) flows.

Advantage: avoids perpendicular flow measurements that are difficult to make, especially near the core

Total parallel ion flow

$$v_{||i} = \underbrace{v_{||i}(\psi)}_{\text{flux surface averaged}} + \underbrace{v_{PS}}_{\text{local}}$$

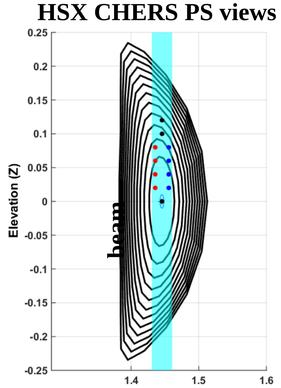
$$v_{PS} = \left(\frac{d\phi}{d\psi} + \frac{1}{en_i Z_i}\frac{dP_i}{d\psi}\right) h\vec{B}, E_r = -\frac{v_{PS}}{h\vec{B}}$$

PS factor $h\vec{B}$ is defined by

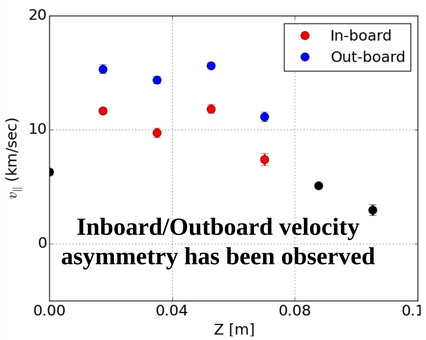
$$\vec{B}.\nabla h = -2\frac{(\vec{B}\times\nabla B).\nabla\psi}{B^3}, < hB^2 >= 0$$

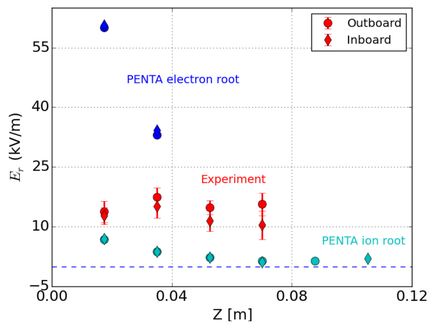
The $h\vec{B}$ and $\nabla\psi$ are calculated at the measurement locations. The v_{PS} is obtained from CHERS measurements.

HSX CHERS PS views



Flow measurements are made in 100 kW Methane plasma.

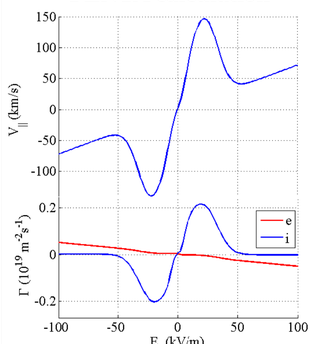




The E_r calculated from PS flows is between Electron and Ion roots calculated by PENTA, higher than that previously obtained from radial force balance.

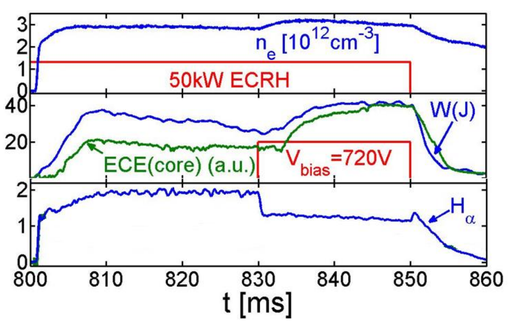
II. Biased electrode experiments trying to detect the ion resonance effect.

PENTA calculation



Helical resonance would appear as a sudden change in electrode current and parallel velocity.

Typical biased discharge. Graphite tipped electrode inserted at the edge of the plasma

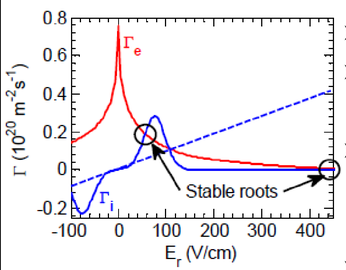


Biased electrode discharges in HSX show H-mode like characteristics. However, expected change in electrode current and large change in parallel flow haven't been observed during bias.

III. Motional Stark Effect polarimetry is used for direct measurement of E_r

- A dual Photo Elastic Modulator Motional Stark Effect (MSE) polarimetry has been designed, being built. Initial characterization of the diagnostics is underway.
- E_r as small as 1.5 kV/m can be detected with careful selection of sightlines
- See poster CP12.00082 T. Dobbins et al.

IV. Modeling is being improved.



- Large E_r is due to large ion flux at helical resonance.
- PENTA assumes that particle energy is constant – this assumption is invalid at resonance.
- We are bench-marking PENTA results with SFINCS and FORTEC-3D, which do not have mono-energetic assumption.
- Also investigating the effect of impurities in the calculated E_r and velocities.

Summary

- Improvements in experiment and modeling are underway to understand the discrepancy between neoclassical modeling and experiment
- Pfirsch-Schlüter flows have been measured, the E_r has been calculated.
- Experiments with biased electrode and MSE polarimetry are progressing.
- Benchmarking the E_r calculated by SFINCS and FORTEC-3D to the PENTA results is underway to understand the effect of monoenergetic assumption.

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