Introduction

- The behavior of particle and impurity density profiles in electron heated Ohmic, ECH and ECCD L-modes and H-modes as well as eITB’s is investigated on TCV in view of developing physics understanding for a predictive capability for a-heated, ignited reactor conditions.

- The TCV (R0=0.88 m, a=0.25 m, BT<1.5 T, Ip<1.1 MA) ECRH system includes six gyrotrons for heating at the second and third harmonic of the electron cyclotron resonance (2.7 MW at 82.7 GHz + 1.5 MW at 118GHz).

- Database study included about 2000 electron density profiles and transport relevant plasma parameters taken in stationary phases of Ohmic and ECRH discharges.

Particle transport in L-mode plasmas

- Density peaking depends on the peaking of the current profile
- No dependence on ne(0), Te, collisionality, shape or Vloop

Density gradient in steady state

\[ \frac{\nabla n}{n} = \frac{1}{D} \left( \frac{\Gamma_{\text{source}}}{n} + \frac{\nabla V_{\text{wave}}}{q} + C_{\text{T}} \frac{V T}{T} - C_{\text{q}} \frac{\nabla q}{q} \right) \]

- Particle source
- Neoclassical
- Ware Pinch
- Thermodiffusion
- Turbulent
- Equi-partition

- In plasmas with full sustained current drive density profiles are still peaked
- Regressions show no evidence of correlation between density peaking and loop voltage

Particle source

- In He neutral penetration by successive CX reactions is quenched because of the low cross section for double CX
- Electron density in D and He discharges are very similar therefore neutral penetration is not responsible for the density peaking

Neutral penetration calculation were performed using the KN1D and DOUBLE-TCV 1D codes

Experimental density profiles are too peaked to be explained by edge fuelling and diffusive particle transport alone

- Peaked density profiles can only be explained by anomalous processes

Density profile peaking

- Density usually flattens when ECRH is applied
- Density peaking depends mainly on the edge safety factor
- Significant scatter indicates the importance of other parameters

- Deposition location has an effect on density peaking

Two and three parameters regression did not show any other significant dependencies

Scaling in TCV ECRH discharges for P_{ECRH}>0.45 is expressed as:

\[ \frac{n_{\text{d}}}{<n_\text{e}>} \approx 0.9 < j > / (j_0 d_0) - 0.2 \rho_{\text{dep}} + 0.44 \]

Transition from Ohmic to high power ECRH

- A series of power scans in L-mode with additional power changing from 0.18 MW to 2 MW at \( \rho_{\text{dep}}=0.35 \)
- The final level of the peaking depends on the deposition location

The dominant edge safety factor dependence observed in L-mode is supportive of TEP

Although core flattening by ECH is in qualitative agreement with drift wave turbulence theory, the power saturation is not predicted by theory.
Particle transport in eITB

- Density peaking is increased inside the barrier despite the shear reversal
- An effect on the density profile is observed only for strong eITBs ($H_{\text{pol}}>3$)

Scaling

- Peaking during strong eITB departs from the general scaling for ECRH discharges
- There is no dependence on current profile peaking for strong eITBs
- As strength of the barrier increases the density gradients start to correlate with the temperature gradients
  \[ R/L_{\text{pol}} \approx (0.4 \pm 0.5) R/L_T \]
- The link between $L_{\text{pol}}$ and $L_T$ remains when the q profile inside the barrier is modified by small current perturbations

H - mode

- Purely electron heated H-modes
- EC heated H-modes with $\beta<2$ and $T_e/T_i<2$ have been obtained on TCV using 3rd harmonic ECRH
- Density profile in Ohmic and ECRH phases remains the same or flattens modestly

Conclusions

- Moderately peaked electron density profiles are observed in virtually all plasma conditions in TCV
- There is a clear difference in the particle transport, between L-mode discharges and eITB discharges
- In L-mode discharges density peaking depends mainly on current profiles whereas in the regions of strong eITB density profile are coupled with electron temperature profiles
- A direct proportionality between temperature and density gradients in eITB indicates the domination of thermodiffusive type of turbulence with small contribution of TEP. In contrast, in L-mode discharges the scaling of the density peaking with the width of the current profile is consistent with TEP.
- Measurements of steady state carbon profiles indicate that peaked density profiles in L-mode plasma are accompanied by peaked carbon profile with clear anomalous origins of the underlying transport

This work was partly supported by the Swiss National Science Foundation