Multi-fluid edge plasma transport simulations in the edge and SOL of NSTX

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Proposals:

- **Ly-alpha opacity experiment**
- **Molecular flux experiment**
- **Impurity transport including intermittent convection**
- **Carbon sources in helium plasma**

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Study the effect of deuterium Ly-radiation re-absorption on inner divertor detachment

Peak heat load in ITER must be less than 3 MW/m^2.

Heat load to plate ≈

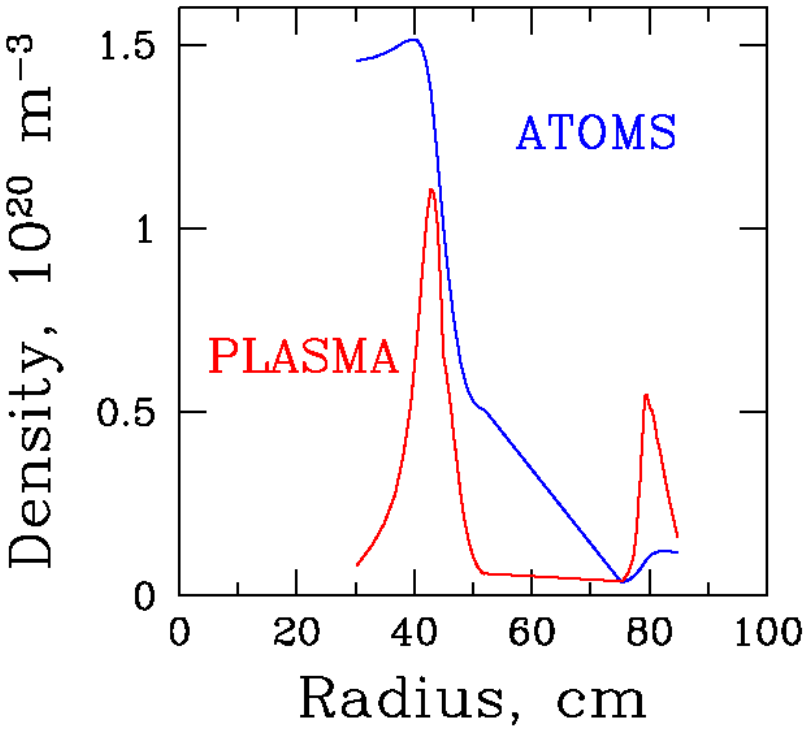
≈ $(8\ T + 13.6eV)\ \Gamma_{sat} + \frac{1}{2}\ (\mathbf{REF}*10.2eV)\ \Gamma_{sat,attach}$.

In detachment $\Gamma_{sat} << \Gamma_{sat,attach}$, and Radiation Escape Factor (REF) should be small for tolerable loads.

However, unloading the strike point, one loads another places (that is, heat profile broadening).

Detached plasmas are strongly opaque (C-Mod), **REF<10^{-4}**.

In NSTX, inner divertor plasma is predicted to be strongly opaque to Ly-α radiation



UEDGE simulations show:

Neutral density is high **$>10^{20}$ m^{-3}**

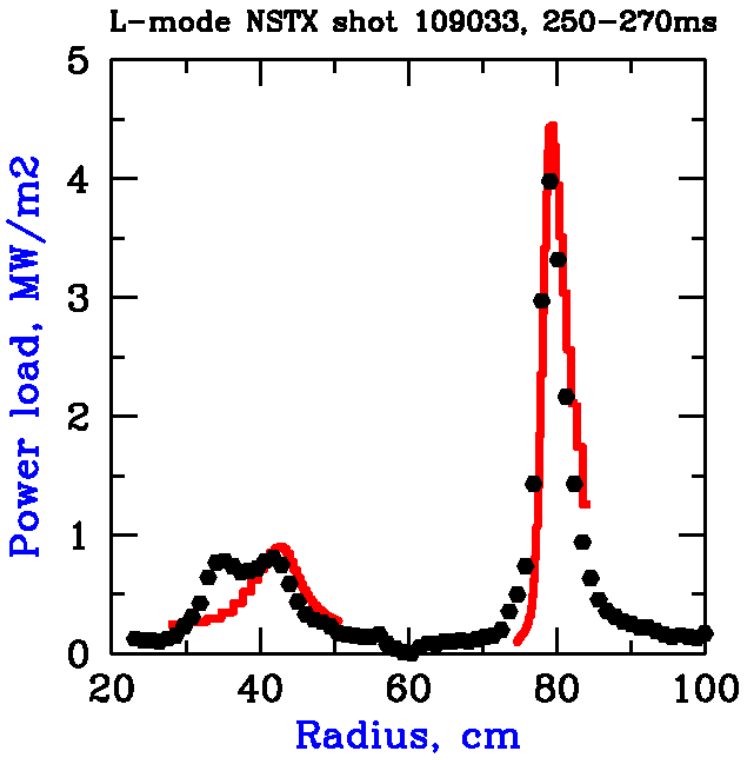
Characteristic size of opaque region L_{or} = **20x5 cm**

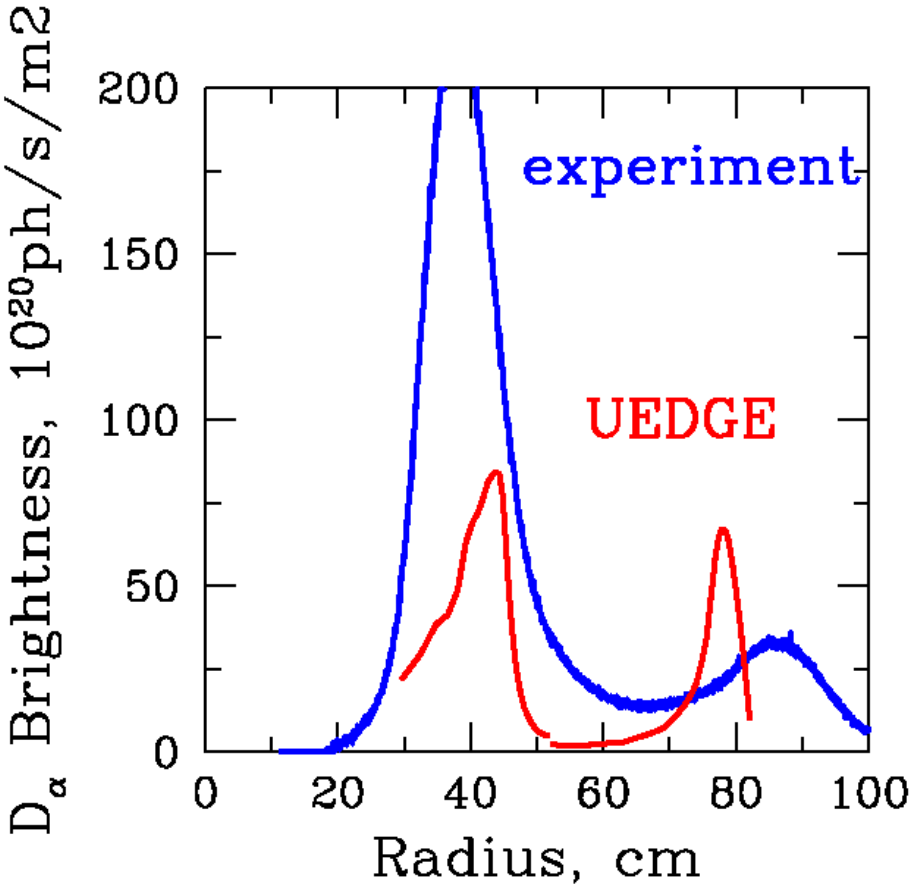
Ly-a photon mean free path λ_{Ly} is **1 mm !!!**

Radiation Escape Factor=π^2 (1/3 λ_{Ly} /L_{or})^2 = **10^{-4}**.

Ly-a radiation is strongly trapped and must have a non-linear effect on the entire edge plasma region

The simulated inboard profiles of heat flux and D-α are much narrower than that measured





Opacity experiment

Provide evidence for opaque plasma conditions occurring in the inner divertor.

For example, measure Ly-α (127nm) profile. Analyze the intensity ratio of Ly-β (102nm) and D-α (656nm) similar to (J. Terry, C-Mod 1999).

Measure plasma temperature, heat load, particle flux, and divertor radiation profiles.

Use UEDGE to simulate the data.

Determine the concentrations of molecules in the divertor

Molecular flux from outer divertor plate may consist of 70% of ion incident flux in L-mode as reported by JET (Pospiesczuck, PSI 2004) and AUX (PSI, 2002).

In H-mode, molecular flux fraction increases up to 95%.

Molecules enhance the recycling and alter the plasma source profile.

Molecules affect the Balmer line emission.

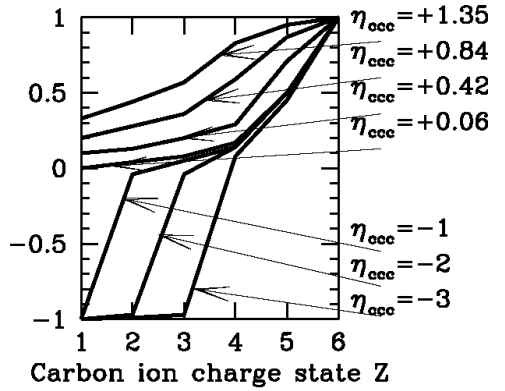
Molecular flux experiment

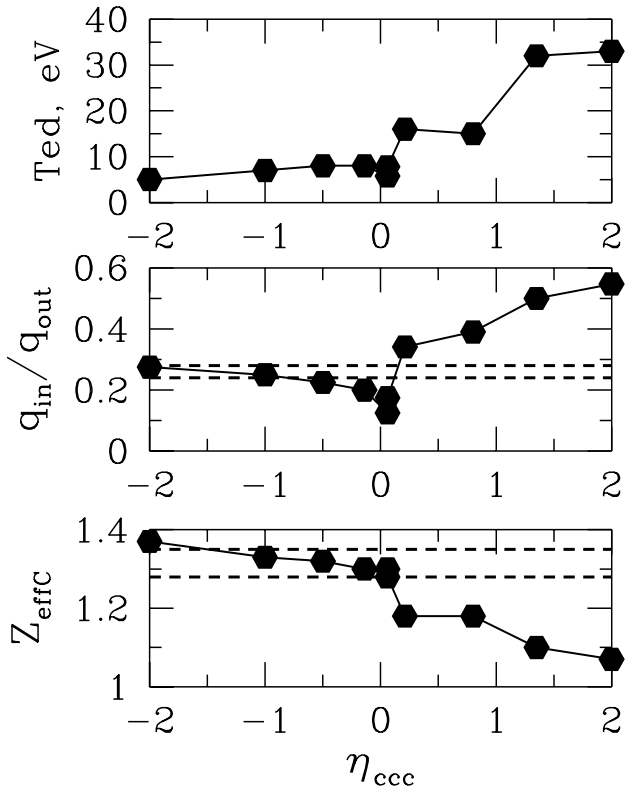
Measure the intensities of Fulcher (P or Q branch) band as well as D-α, D-β, and D-γ in typical L- and H- mode shots.

Use 2-point model and Collisional Radiative model to determine molecular flux.

Use UEDGE code to evaluate the effect of molecules on edge plasmas.

In NSTX, the direction of impurity ion anomalous convection has strong impact on edge plasma





Velocity of impurity ion with charge state z:

$$Vconv(\psi,\theta, z) = V^{[D+]}conv(\psi,\theta)\ A(z)$$

$-1<A<1$ is the amplitude factor, $A(6)=1$

Continuous parameter: $\eta_{CCC}=A(1)+A(2)+A(3)$

Main species ions and highly charged impurity ions are transported toward the wall by density **blobs**.

The lowest impurity charge states can be carried inside the plasma by density **holes**.

Major parameters are matched at

$$-2<\eta_{CCC}<-0.5$$

ie low charge states are convected inward

Density holes

In CII (or CIII) imaging with fast camera: are there intermittent objects moving inside the core from SOL?

Are there any connections between blob and hole?