§3. Profile Shaping Experiments: Pellet Injection Studies

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Stellarator-Heliotron fusion reactor operation will require approaches for (quasi) steady-state heating and fuelling. Respective operation scenarios need to be developed and it is expected that fuelling of reactor-scale plasmas is affected by particle transport mechanisms. A basic understanding of underlying transport is therefore required to gain predictive capabilities. Furthermore, an assessment of possible transport-related control parameters opens the door for the detailed examination of possible reactor scenarios.

Transport mechanisms being explored for their relevance at reactor-grade plasma parameters are of neoclassical and turbulent origin. For electrostatic turbulence, the particle transport is intrinsically ambipolar while charge dependent neoclassical fluxes lead to a radial electric field

$$\vec{E}_r = \frac{T_i}{Ze}\left(\frac{\nabla n}{n} + \delta_{12}^{i}\frac{\nabla T_i}{T_i}\right) \quad (1)$$

with usual symbols and δ_{12}^{i} being the ratio of the ion thermodiffusion coefficient and particle diffusivity [1] being valid for prevailing ion transport.

For negative gradients (monotonically outward decreasing profiles) the resulting radial electric field becomes negative. On the other hand, positive density gradients counteracted opposite temperature gradients and could be employed to manipulate the radial electric field. A change in the radial electric field, however, has large impact on the ion transport.

In LHD, the density gradient can be changed by means of fuelling actors. In pellet injection experiments, different gradient lengths also changing the sign of the density gradient can be attained.

Fig. 1 doc uments the capability of changing the density gradient in pellet injection experiments. The magnetic configuration was chosen to be the R_{ax} = 3.75m configuration. Full available NBI heating power was applied with available ECRH heating. The spatio-temporal evolution of the thermodynamic forces during the pellet injection phase and the density decay (t>4.3s) has been documented for different heating conditions and different pellet injection schemes. In general, particularly without additional ECRH, no change in the radial electric field evolution has been found despite substantial changes in the local density gradients. However, due to the substantial density increase during the pellet injection, the signal-to-noise ratio of CXRS measurements suffer from beam attenuation at high densities. In Fig. 1, however, it is clearly seen that the ion temperature gradients are kept stably negative while slightly increasing in magnitude while the density gradient goes from substantially positive to almost zero. A reaction in the radial electric field measurements is indicated but noisy.

As an interim result, the measurements, nevertheless, do not indicate an increase of E_r as suggested by Eq. 1.

1) Maaßberg. H. et al.:*Plasma Phys Contr. Fusion* **41**, 1135 (1999)

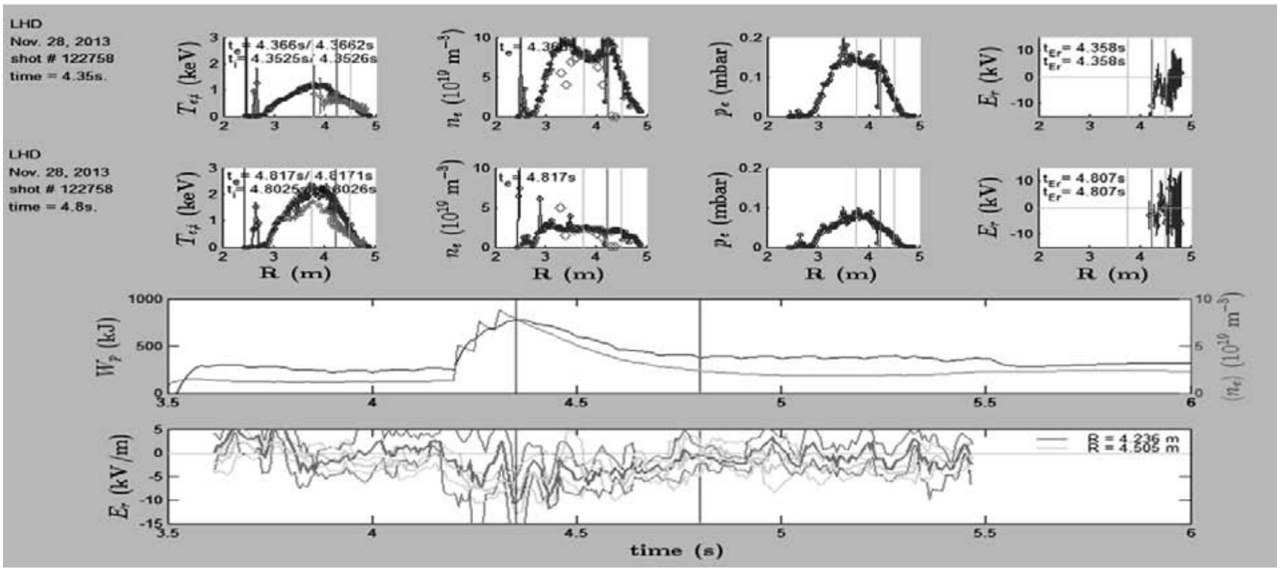

Fig.1 (Top two rows): Electron and ion temperature, density (with line density profile, red diamonds), electron pressure profiles and edge profiles of the radial electric field right after pellet injection and after (t=4.35s) almost full decay (t=4.8s) of the density (all profiles in real space). The bottom two rows show temporal evolution of the plasma stored energy and the line averaged density. The time evolution of the radial electric field is shown for two positions; the color code indicates the position in the profiles (first row, rightmost plot).