§52. The Role and Source of Core Radiation in 'Breathing' Plasma

Peterson, B.J., Rice, J.E. (PSFC, MIT, USA),
Funaba, H., Masuzaki, S., Nakamura, Y., Yamazaki, K.

In LHD during experiments using stainless steel divertor plates a slow (~ 1 second) cyclic oscillation in the plasma parameters known as 'breathing' plasma was observed during NBI-heated long pulse discharges [1]. Using an average-ion, corona-equilibrium model [2] for the iron impurity cooling rate, L_{imp}, the iron impurity density profile is calculated from

$$S_{imp} = n_{imp} n_e L_{imp}(T_e) \qquad (1)$$

for a normalized minor radius, $0.0 < \rho < 0.8$ from the measured electron temperature, T_e, density, n_e, and radiation emissivity, S_{imp}, profile data for these discharges in LHD [3,5]. This calculated iron density oscillates out of phase with the electron density (Fig. 1a) and peaks near $\rho = 0.4$ at a fraction of the electron density that varies by a factor of 4. This is in qualitative agreement with spectroscopic measurements of iron that show a similar oscillation [3,4,5]. The correlation of the iron impurity concentration with the change in electron temperature and with the local power balance between radiation and beam deposition indicates that when radiation from the iron impurity dominates the local power balance the core plasma is cooled (Fig. 1b) [5]. The increase in the calculated iron density during the phase of the oscillation when the divertor electron temperature exceeds the sputtering threshold (Fig. 1c) suggests that sputtering of the stainless steel divertor plate may be the source of the iron impurity [5]. Evidence of changing transport seen in the rapid transition from the falling to the rising phase in the iron density evolution (Fig. 1a) and the core radiation emissivity evolution (Fig. 1b) points to the need for a closer examination of the role of impurity transport in this oscillation.

References

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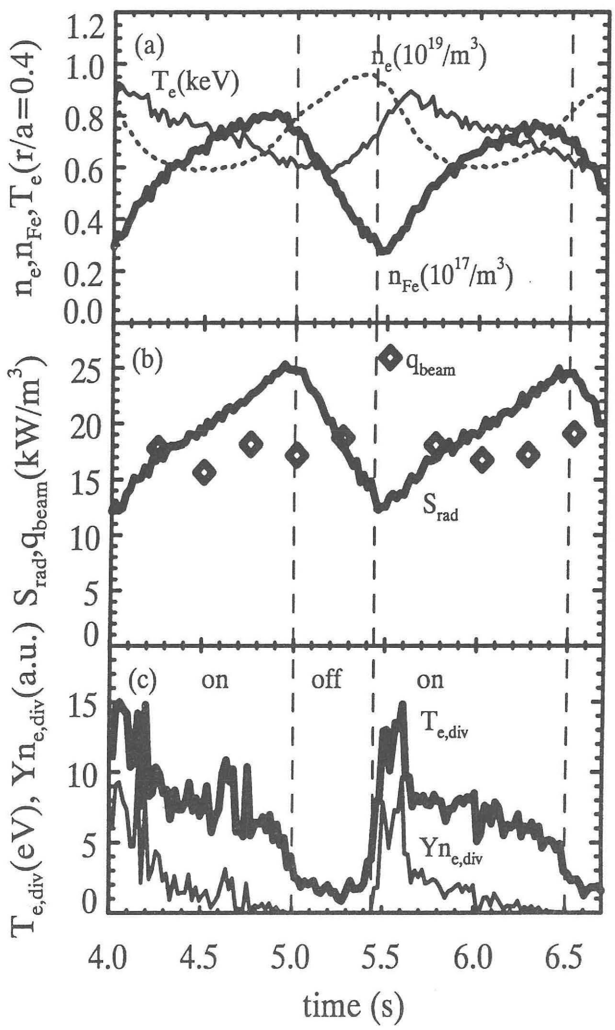

Figure 1 Evolution of (a) measured electron density and temperature, calculated iron density, and (b) measured radiation emissivity, beam deposition power density at $\rho = 0.4$ and (c) the measured electron temperature at the divertor and the calculated sputtering yield, during shot #6690.