§53. Behavior of Impurity Radiation and Edge Plasma during Radiative Collapse at the LHD Density Limit

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The onset of the radiative thermal instability leading to radiative collapse at the density limit has been empirically defined as the point when the radiated power is increasing with the third power of the density [1]. Since the dominant intrinsic light impurities are oxygen and carbon they should be responsible for the strong increase in the radiation from the edge. First we consider the radiation brightness from the divertor, core and edge plasmas in Fig. 1 as the discharge collapses. One notes that the onset of the thermal instability, as defined by the thick dashed line when x = 3 for the total radiation, is followed by the development of the previously observed [2] asymmetry in the radiation as the radiation from the inboard channel starts to diverge from the channel located near the outboard edge of the plasma. At the same time the radiation from the divertor leg region is increasing, but not as dramatically as the radiation from the inboard side. The ion-saturation current from the divertor probe begins to drop with the onset of the thermal instability and the radiation asymmetry as it approaches a detached state. Finally, considering the density exponents of the light impurities signals, CIII and OV, and the radiated power, one notes that the thermal instability begins in the OV, but that the CIII signal most closely matches the total radiated power indicating that the carbon is the dominant impurity. This temporal progression makes sense in that the oxygen should radiate at a higher temperature, and therefore the thermal instability should begin earlier in the oxygen as the edge temperature drops. Also, the above suggestion, that carbon is the dominant impurity, is consistent with observations before and after boronization, that while the reduction of OV radiation is stronger than that seen in the reduction of CIII, the reduction in CIII more closely matches the reduction in the total radiated power [3].

In Fig. 2 the evolution of the radiated power density profile from the bolometer array at the horizontally elongated cross-section [4] is shown. In the steady state portion of the discharge the profile is hollow. After the onset of the thermal instability the strongly radiating zone broadens and moves inward minor radially. Also one notes some indication of growth in the core radiation. At the edge of the plasma one notes the radiation reaches a maximum then decreases, then increases again. This is also seen in the inboard channel of the bolometer in Fig. 1 and may be related to the two peaks observed in the cooling rate of the impurities as a function of electron temperature. One should take care in the quantitative evaluation of the radiation profile during the collapsing phase as the asymmetry in the radiation signal may lead to errors in the tomographic inversion. These errors should be mitigated in this case by the orientation of the array which fans out vertically while the asymmetry has an inboard-outboard nature.

References
1) Peterson, B. J., et al., NIFS Annual Report 2003-2004 (2004) 6.
2) Peterson, B.J., et al., Phys. Plasmas **8** (2001) 3861.
3) Nishimura, K., et al., J. Plasma Fusion Res. **79** (2003) 1216.
4) Peterson, B.J., et al., Plasma Phys. Control. Fusion **45** (2003) 1167.

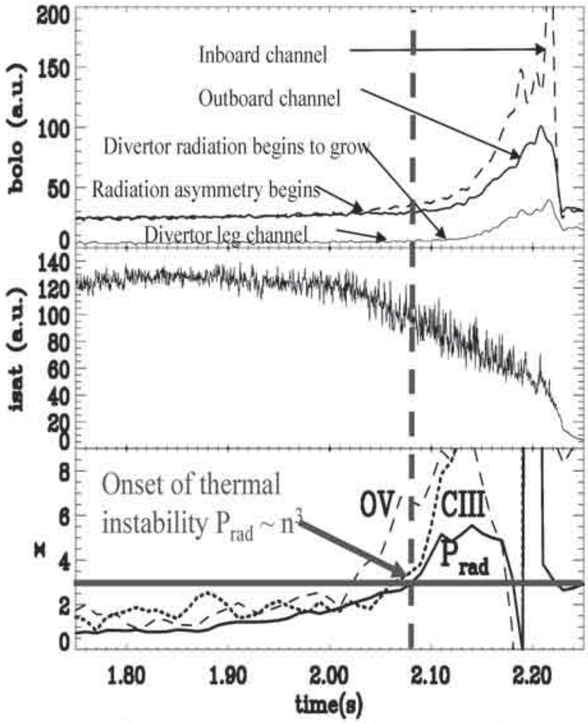

Fig. 1 Time evolution of bolometer brightness, divertor ion saturation current, and the densty exponent for the total radiated power, CIII and OV during radiative collapse of shot 43383.

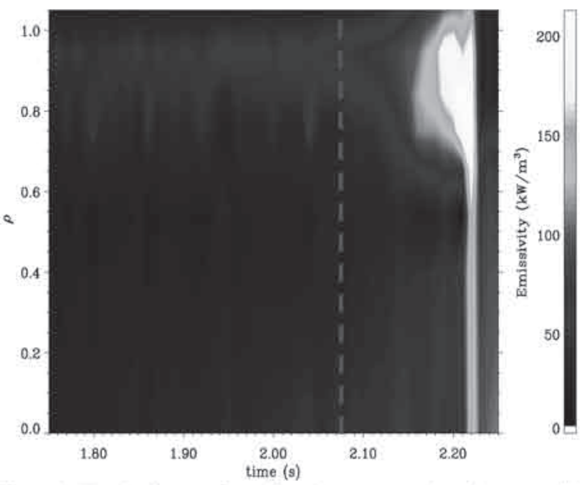

Fig. 2 Evolution of radiated power density profile during radiative collapse of shot 43383.