§68. Operational Density Range and Radiation Fraction in NBI and ICH Long Pulse Discharges

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In order to establish steady state operation with a high performance plasma, it is of great importance to understand the characteristics of plasma produced by each heating method and to enlarge the operational regime. In long pulse experiments, there is a big difference in operational density range between NBI and ICRF heated discharges as shown in Fig. 1. For NBI discharges, the plasma density can be controlled with gas puffing and pellet injection up to ~ 10^{20} m^{-3}. Even in long pulse discharges with low power (< 2 MW), a high-density plasma with the density of 6 x 10^{19} m^{-3} can be maintained without radiation collapse. On the other hand, it is not so easy to increase the plasma density for ICH discharges. The operational density is less than 2 x 10^{19} m^{-3} and one-third of that for NBI discharges with the same injection power. In the high-density region, the plasma is terminated by radiation collapse. Therefore, we investigate the ratio of total radiation power to absorbed heating power. Figure 2 shows the density dependence of radiation fraction for NBI and ICH discharges, including the discharges without graphite divertors. In the case of stainless steel (SS) divertors, the metallic impurity (mainly Fe) was accumulated in the plasma core and the plasma density was limited by "breathing phenomenon", in which a periodic expansion and contraction of the temperature profile is observed. After installation of graphite divertors, the density limit was increased up to 6 x 10^{19} m^{-3} for NBI discharges. The radiation fraction is not so large (< 0.25) in the high-density region. While, for ICH discharges, the radiation fraction increases rapidly with the density and the achievable plasma density is limited to 2 x 10^{19} m^{-3}. From this result, it is found that the impurity content in the plasma is larger than that of NBI heated plasma. Furthermore, we can find the main impurity content in ICH plasma from radiation profiles. Figure 3 shows radiation profiles for NBI and ICH discharges with different densities. In NBI discharges, the radiation is localized at the peripheral region and the core radiation does not increase with the density. This means that the radiation is originated from low Z impurities (C, O). On the other hand, a remarkable increase in core radiation is observed in ICH discharges with increasing the density. The calculation of radiation profile from MIST code (impurity transport code) shows that the distinguished core radiation is due to high Z impurities (Fe etc.).

As described above, it is found that a large number of high Z impurity is contained in the ICH plasma in comparison with the NBI plasma. The low density limit in ICH discharges may be caused by the large content of high Z impurity. In order to enlarge the operational density range, the reduction of impurity penetration into the core would be required. A candidate of effective method is the impurity control by formation of magnetic island [1], which will be tried in the next experimental campaign.

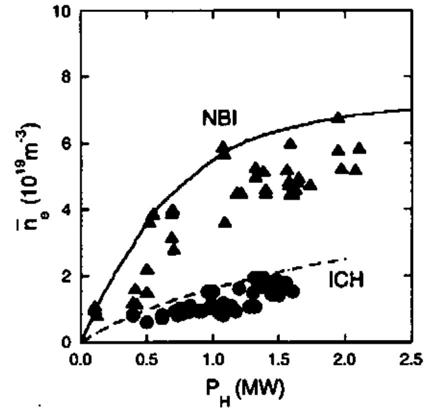

Fig. 1. Operational density range in long pulse discharges

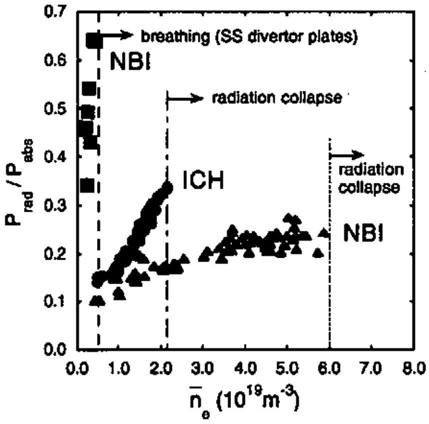

Fig. 2. Density dependence of radiation fraction in NBI and ICH discharges

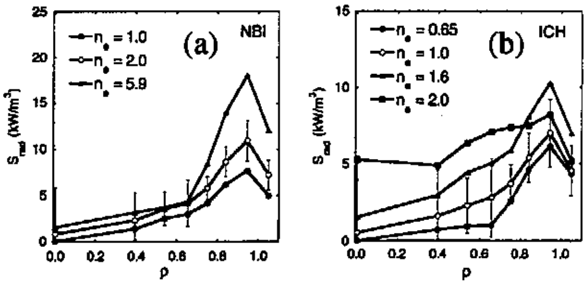

Fig. 3. Radiation profiles for (a) NBI and (b) ICH discharges with different densities.

Reference

[1] Nakamura, Y., et al., Nuclear Fusion **43** (2003) 219.