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Evolution of the Ion Temperature in Pedestal during the ELM Mitigation by SMBI

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To study the mechanism of the ELM mitigation by SMBI, a high spatial and temporal resolution charge exchange recombination spectroscopy (CXRS) has been developed. This paper presents the first observation of the evolutions of ion temperature and its gradient in the pedestal measured with CXRS. It is found that the gradient of the ion temperature and the pedestal size both decrease around one third during ELM mitigation. In addition, it is observed that at least 20% decrement of Ti has to be attained in order to achieve a noticeable ELM frequency change.

In shot 22536, around 2.5×10ˆ19 deuterium molecules are injected and the plasma density increases from 2.8 to 3.1 ×10ˆ19 mˆ-3. The ion temperature and plasma toroidal rotation velocity decrease from 276 eV and 30 km/s to 81 eV and 13 km/s, respectively; the ELM frequency measured from D_α signals increases from ˜140 to ˜1200 Hz. As for the ETB of ion temperature, its height decreases but its structure sustains during the ELM mitigation phase.

To assess the cooling effect of the SMBI in detail, edge ion temperatures of 24 shots and 33 SMBI pulses are analyzed. The averaged ion temperature at the pedestal top decreases from 216 eV to 108 eV; whereas it decreases from 89 eV to 58 eV at the pedestal bottom, indicating the ion temperature decreases more at the pedestal top than that at the pedestal bottom. This cooling effect results in the ion temperature gradient decreasing from 45 eV/cm to 26 eV/cm. Furthermore, the averaged pedestal width decreases from 2.9 cm to 2 cm.

The ELM frequency can be increased significantly by SMBI. However, no ELM frequency change can be observed when the injected inventory is small. By increasing the SMBI pulse duration from 1.5 ms to 3 ms (the pressure keeps constant as 2 MPa) in shot 22497, the injected inventory is doubled. The first two SMBI pulses result in the relative decrement of Ti around ˜20%, and the influence on the Dα and its frequency is ignorable. However, the ELM frequency increases significantly when the last two SMBI pulses are injected, as the relative decrements of Ti are 35% and 37%, respectively. It seems that the ELM frequency keeps no change when the decrement of Ti is equal or less than 20%. And the increment of ELM frequency increases exponentially with δTi/Ti. The trend indicates that the decrement of δTi/Ti of ˜20% is the critical value.

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