1.7 Measurement of Edge Parameters with ICRF in HL-1M Tokamak

CN0002827

YAN Longwen YANG Shikun QIAN Jun WANG Enyao

Key words Langmuir probe Edge plasma ICRF Pellet injection

One of significant tasks in Tokamak plasmas is to understand the physics with high temperature and density. Therefore, the auxiliary heated experiments with ion cyclotron radio-frequency (ICRF) and neutral beam injection (NBI) have been developed in HL-1M Tokamak after lower hybrid heating (LHH) and electron cyclotron heating (ECRH) were applied. The fuelling with pellet injection and molecular beam injection (MBI) were used to increase plasma density. Especially, MBI can obviously increase the confinement time of particle and energy[1].

The measurement and control of edge plasma are very important to investigate the feature of central plasma. So the main diagnostics for edge parameters are electrostatic Langmuir probes[2] and Much probe to measure fluid velocity in HL-1M Tokamak, which provide us main data to study edge physics. Main parameters in HL-1M are R=102 cm, a=26 cm, $B_t \approx 2$ T, $I_p \approx 200$ kA, and so on. A movable probe array with 4 tips is used to measure edge parameters. It can be shifted from r=22 cm to outer vacuum region and is 67.5 toroidal degree far from ICRF antenna, radial radius of antenna is located in 27 cm. In addition, 20 triple probes along poloidal closeness are 154 toroidal degree far from ICRF antenna and are fixed r=26.5 cm. They are also applied to measure edge temperature and density at another toroidal position.

The edge parameters have been ob-

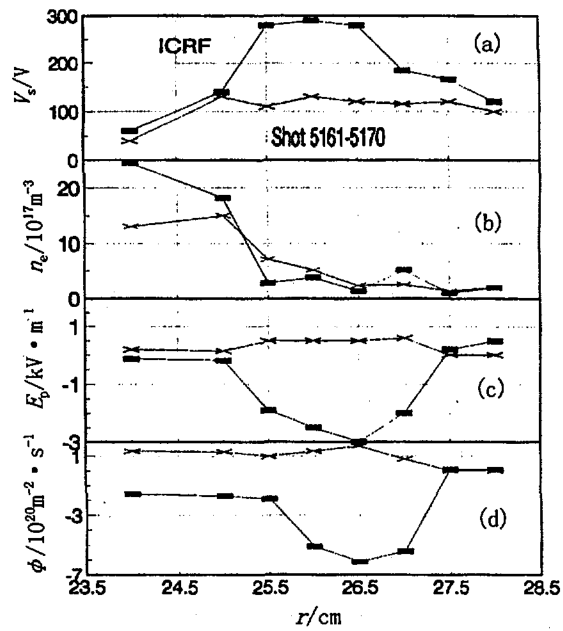

Fig. 1 Edge parameters via radius with ICRF

The solid square is with ICRF and the other is without it.

(a) Space potential via minor radius with ICRF or without it; (b) Edge density versus radius; (c) Poloidal electric field via radius; (d) Edge particle flux versus radius.

tained by shifting radial positions of movable probe during the first ICRF experimental campaign in HL-1M Tokamak. A sudden change for edge density, space potential and poloidal electric field within $t=250\sim280$ ms has been observed with $P_{ICRF}=120\sim230$ kW. A twice rising in space potential near ICRF antenna is shown in Fig. 1 (a) and a similar one appears in temperature. This rising is not toroidal symmetry because it is not observed on triple probes. Fig. 1(b) shows that density gradient on the inside of potential barrier is clearly rising and one is weakly dropping on the outside of the barrier, which manifests that a potential gradient is more significant than itself to form transport barrier. In Fig. 1(c), ICRF injection makes not only poloidal electric field within potential barrier increase a few times but also reverse its direction. Fig. 1 (d) shows that particle flux within potential barrier increases $3\sim4$ times and its direction is also reversed, which is consistent with poloidal electric field. This result supports that ICRF injection easily makes impurity accumulate into plasma center. It has been observed that ICRF injection causes large change of main plasma parameters in another typical discharge with higher ICRF power. The impurity radiation after ICRF injection suddenly increases and then causes discharge disruption. Therefore, to decrease the impurity concentration during ICRF experiments is very important to obtain good heating effect.

It has been observed that edge temperature suddenly decreases and density abruptly increases during the discharges with 8 pellet injections. The kind of rapid changes can keep during $2\sim10$ ms, which is the same order as the timescale of the pellet ablation. Moreover, the fly time from emit gun to the edge plasma needs more than 10 ms. Typically, the velocity of 4 larger pellets is about 800 $m\cdot s^{-1}$ and that of 4 smaller ones is about 500 $m\cdot s^{-1}$, whose ratio of particle number is $2.5\sim2.8$. Therefore, larger pellet has much stronger effect on plasma than smaller one. The incremental amplitude of edge density will gradually decrease when pellets are injected frequently. A possible reason is that fuelling efficiency is lower and lower.

In addition, many obvious phenomena appear during the discharges with MBI fuelling, for example, the edge density rises, temperature drops, afloat and space potential decrease, particle confinement may increase from 25 ms to 120 ms before and after MBI[3]. Some sudden changes appear after MBI is completely ended, for example, the edge temperature abruptly rise, the plasma center moves inward which causes inward density increases and outward one decreases obviously.

Finally, NBI heated experiment has made the ion temperature increase from 400 eV to 800 eV, whose influence on edge plasma is not observed. A possible reason is that the power of NBI is still small. The change of the edge parameters during ECRH experiments has not observed yet because its injected power is a little and its time is short ($\approx$30 ms). The same result appears on the LHCD over 1 s for injected power being small as well.

In conclusion, the clear changes of the edge parameters have been observed during the first ICRF campaign in HL-1M. For example, the space potential is twice rising and forms barrier in 2 cm, the density gradient on the inside of the barrier is obviously increasing, poloidal electric field and particle flux within the barrier increase a few times and their direction is reversed. The edge temperature dropping and density rising appear during the discharges with pellet injection and MBI. The edge parameters have not larger change during the discharges with E-CRH and NBI because the auxiliary heated power is still small.

We would like to thank good cooperation from all the scientists on HL-1M team. Especially, useful helps and beneficent discussions were obtained from Prof. LU Zhihong and Associate Prof. ZENG Jianer on I-CRF experiments and data analyses, Prof. XIAO Zhenggui on pellet injection, Prof. YAO Lianghua on MBI fuelling, Associate Prof. CHEN Liaoyuan and LIN Haoshu on data acquisition and analyses.

REFERENCES

1 YAO Lianghua, TANG Nianyi, CUI Zhengying, et al. Plasma Behaviour with Molecular Beam Injection in the HL-1M Tokamak, Nucl. Fusion, 1998, 38(4): 631

2 Diebold D, WANG Enyao, Pew J, et al. Triple Langmuir Probe Measurements in the Phaedrus-T Tokamak. Rev. Sci. Instru., 1990, 61 (10): 2870

3 Staib P. Probe Measurement in the Plasma Boundary Layer. Journal of Nucl. Materials, 1982, 111 & 112: 109