§1. Transition from L Mode to High Ion Temperature Mode in CHS Heliotron/Torsatron Plasmas

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The high ion temperature (T_i) mode plasma [1] is one of the improved modes in Heliotron/torsatron and in stellarator. Recently, similar high T_i mode discharges have been observed for neutral beam heated plasmas by turning off the gas puff at the onset of neutral beam in CHS.

The target plasma is produced by electron cyclotron resonance heating (ECH) pulse and neutral beam is injected for 40-140ms. The helical magnetic field is 1.76T. When the electron density increases in time with gas puffing, the ion temperature stays almost constant in time in the L-mode discharges. However, when the gas puff is turned off after the neutral beam injection, both central electron density, $n_e(0)$, and central ion temperature, $T_i(0)$, increase in time and the central ion temperature reaches 0.7-0.8 keV. The transition between the high T_i mode and L mode is sensitive to the fraction of beam fueling to the gas puff fueling and a small amount gas puff or high wall recycling will prevent the discharge from getting into the high T_i mode.

Fig.1(a) shows central ion temperature as a function of heating neutral beam power in CHS. The central electron temperature increases gradually in proportion to $P^{0.35}$ as the NBI power is increased. However, the central ion temperature increased sharply at the critical NBI power of 0.7MW. The sharp increase of ion temperature indicates the transition from L mode to high T_i mode. Since the co-injected NBI power in CHS is 0.7-0.8MW, which is slightly higher than the critical values, a slight increase of electron density by gas puffing prevents the discharge from making transition from L mode to high T_i mode. Therefore, there is an upper limit of electron density for the high T_i mode transition with the fixed NBI power as seen in Fig.2(b). At the low density regime (t = 70 and 90 ms), there are sharp drops of $T_i(0)$ at $n_e(0) = 1.4 \times 10^{19} m^{-3}$ (t = 70ms) and $n_e(0) = 2.2 \times 10^{19} m^{-3}$ (t = 90ms), which indicates the upper limit for the high T_i mode. The upper limit of the electron density for the high T_i mode increases as the peaking factor of electron density is increased (1.5 @ t = 70ms -> 1.8 @ t = 90ms). There is no sharp drop observed at t = 110ms because the electron density exceeds the upper limit for the high T_i mode and plasma is in the L mode. When the recycling is high due to the poor wall condition, the central electron density increases without gas puff and the density peaking factor is low (< 1) then the plasma is always in the L mode. To achieve high T_i mode discharge, the peaking factor should increase as the central electron density increases. Therefore the central fueling by neutral beam is key for the high T_i mode.

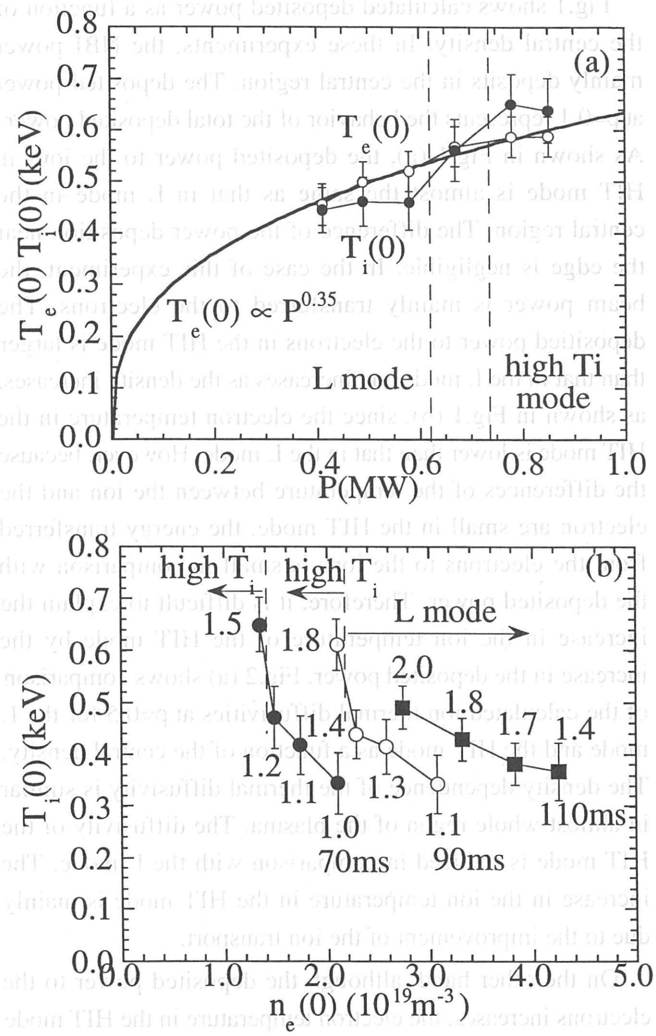

Fig.1 (a) Central ion and electron temperatures as a function of NBI heating power and (b) central ion temperature as a function of central electron density.

Reference.

[1] K.Ida, et al., Phys. Rev. Lett. **76**, 1268 (1996).