§20. Formation of Internal Transport Barrier in Dimensionally Similar Low Temperature Plasmas Produced at Very Low Toroidal Field

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In CHS, transport simulation of high temperature plasma in the range of kilo-electron volts using low temperature having only about 20 eV is attempted, where various dimensionless parameters except normalized gyro-radius are the same in both plasmas [1, 2]. In this low temperature plasma, correlation measurement of various fluctuations with Langmuire probe is exclusively performed.

The low temperature plasma is produced at very low toroidal field B_t less than 0.1T with 2.45GHz microwaves of about 20 kW. The achieved dimensionless parameters are plotted on the plane of collision frequency normalized by transit frequency ν_{ei}* and normalized gyro-radius ρ_s* that is the ratio of ion gyro-radius evaluated with electron temperature normalized by the minor radius (Fig.1). The averaged toroidal beta is close to the lowest boundary of that in high temperature one. Obviously, the obtained range of ν_{ei}* overlaps with those in CHS and LHD plasmas achieved at high B_t ($\geq \sim$1T) with high heating power of MW level. Of course, the value of ρ_s* is larger by a factor of two to three for that of high temperature one obtained in CHS at high B_t.

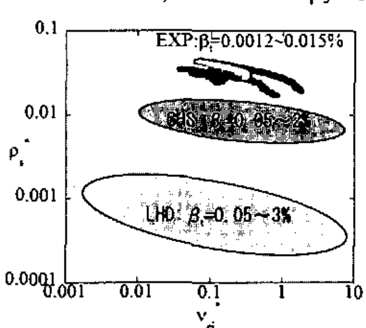

Fig.1 *Achieved range of important dimensionless parameters in low temperature plasmas produced at very low B_t(<0.1 T) with 2.45 GHz microwaves.*

In the range of lower ν_{ei}*, plasma exhibits a very typical character of so-called "electron root" that is realized in high temperature plasma. A typical shot where electron root has been realized is shown in Fig.2. At t~150 ms, electron temperature T_e, electron density n_e and plasma space potential V_s in the core region suddenly jump up, indicating the phase transition. Across the transition the electron density profile suddenly evolves from the parabolic profile to more peaked one having steep gradient region, that is, internal transport barrier (ITB-) region, as shown in Fig.3(a). The radial electric field Er is also suddenly changed from nearly zero to positive value of ~600 V/m (Fig.3(b)). This positive value of Er corresponds to ~ 10 kV/m due to very low B_t~0.06T. This ExB drift velocity is fairly large and comparable to that observed in high temperature electron root plasma. The formation of ITB may be caused by the entering to the electron root regime. Most significantly, particle transport barrier as well as electron heat transport barrier has been formed simultaneously.

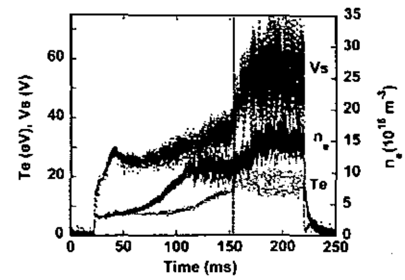

Fig.2 *Typical time evolutions of T_e, n_e and V_s at ρ~0.3 in a typical shot that the transition to ITB formation takes place, where ECR power is about 12 kW, B_t=0.0613T and the magnetic axis position Rax=0.974m.*

In conclusion, thus produced low temperature and low density plasmas exhibit a typical character of electron root that is commonly observed in dimensionally similar high temperature plasmas. Turbulent transport in these low temperature plasmas would be expected to have similarity to that in high temperature one produced at high B_t with high heating power of MW range.

[1] K. Toi et al., 29th EPS on Plasma Physics and Controlled Fusion, Montreux, 2002, Paper No. P4-061.
[2] K. Toi et al., 13th International Toki Conf. on Plasma Physics and Controlled Fusion, Toki, 2003, and to be published in J. Plasma Fusion Res. SERIES 6 (2004).

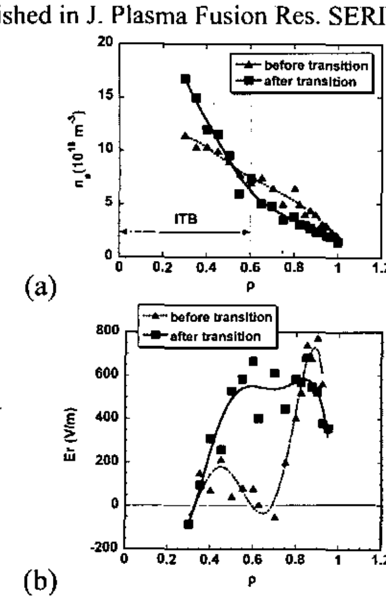

Fig.3(a) *Change of the density profile across the transition of ITB formation at t~150ms,*
(b) *change of Er profile across the transition.*