§8. Laser Thomson Scattering Diagnostics for Low Temperature Recombining Plasmas in MAP-II Divertor Simulator at the Univ. Tokyo

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Recombining plasma in the divertor/edge region in magnetically confined fusion-relevant plasma can be a sink of particle and energy due to the neutralization of the plasma before reaching the divertor plate (this phenomenon being referred to as "detachment"), so that the production and the control of the recombining plasma are key issues in future fusion devices. Since the processes depend strongly on the electron temperature, T_e, in particular the electron-ion recombination (EIR) consisting of radiative and three-body recombinations exhibits $T_e < 0.1$ eV, the measurement system applicable for such a low temperature is required.

A problem involved in applying a single probe to recombining plasmas is that the electron current exhibits values anomalously lower than those expected from the ion saturation current (known as an anomalous current-voltage characteristic). As a result, the electron temperature is overestimated if one *believes* the probe characteristics to be valid, and in turn the electron density become immeasurable. The atomic Boltzmann plot method applied to the Rydberg spectra from the highly excited states, being in partial local thermal equilibrium (p-LTE), can be simply applied to determine the electron temperature. However, the spectroscopic measurement always reflects the brightest point, which makes it difficult to analyze the spatial distribution and dynamic behavior of the detachment.

In this respect, Laser Thomson scattering (LTS) can be an efficient diagnostics covering from ionizing to recombining regimes, although its application to the low temperature plasma is challenging.

To this end, LTS system is installed in the steady-state linear divertor / edge plasma simulator, MAP (Material and Plasma)-II.[1)]. A frequency doubled Nd:YAG laser beam (10 Hz, 500 mJ, 532 nm) is used as a probe beam and the scattering light was measured using a double monochromator equipped with so-called Rayleigh-block for the stray light suppression, and an image-intensified charge-coupled device (ICCD) [2)]. The recent upgrades of our LTS system (reduction of stray light and reduction of the bandwidth of the notch filter) allowed us to measure temperatures as low as 0.1 eV and to investigate Electron Ion Recombination (EIR) processes in He plasma [3)].

Spatial profiles of electron temperature and density along the plasma column have been taken moving the plasma "recombination front" across the measurement point by controlling the gas pressure from 80 to about 145 mTorr. A comparison between LTS results and spectroscopic analysis based on a He I collisional-radiative (CR) model including radiation trapping have confirmed, with considerable reliability, the validity of the electron temperature below 0.1 eV obtained from the Rydberg spectra [4)]. A further major upgrade to access to the brightest region in the EIR plasmas is planned in the near future.

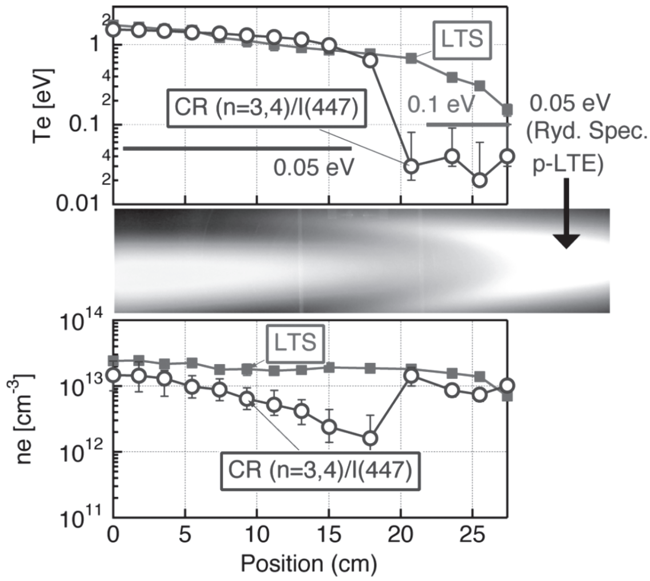

Fig. 1 Electron temperature and density measured using LTS and He I CR model. The picture in the middle indicates the measured position. The brightest point of He EIR exhibits 0.05 eV from spectroscopy, while 0.1 eV is the lower measurable limit of the current LTS system.

References

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