Radial profiles of the electron temperature on COMPASS and ASDEX Upgrade from ball-pen probe and Thomson scattering diagnostic

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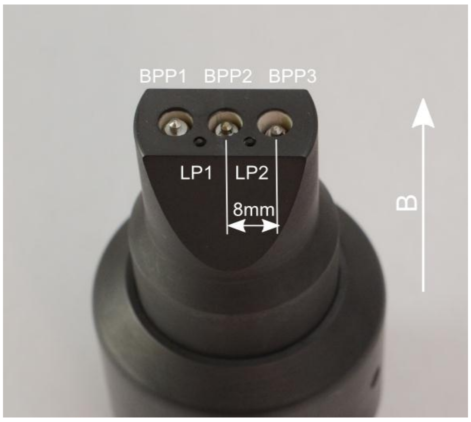
1 Introduction

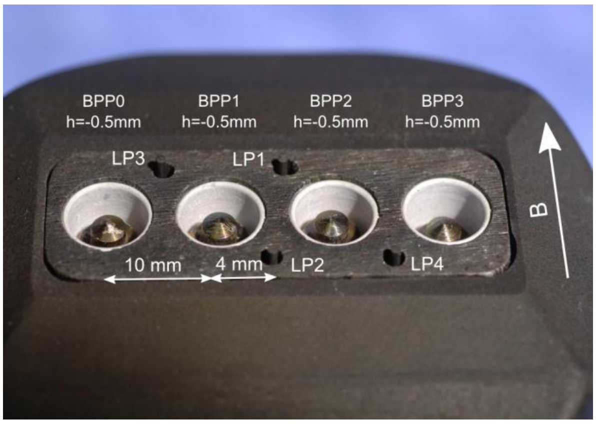
Investigations of plasma potential, electric field, electron temperature and its fluctuations remain important tasks in the context of anomalous edge plasma transport [1]. The ball-pen probe (BPP) [2–5] for direct measurements of the plasma potential Φ_{pl} was developed by Adamek et al. [6, 7] in the Institute of Plasma Physics in Prague. A combination of BPP and common Langmuir probe (LP) provides the value of the electron temperature T_e by the difference between the plasma and floating potential $T_e = (\Phi_{pl} - V_{fl})/2.2$ [4]. The BPP/LP head was mounted on the reciprocating midplane manipulator. Comparative measurements using probe diagnostics and edge/core Thomson scattering on COMPASS and ASDEX Upgrade are reported in the paper.

2. Probe construction and experimental set-up

The fast reciprocating probe shaft on the COMPASS and ASDEX Upgrade midplane manipulator was used to insert a probe head containing BPPs and LPs as seen on Fig. 1a and Fig. 1b, respectively. Measurements of the plasma and floating potential are performed by means of the central BPP2 with the retraction depth (h = –0.5 mm) and one of the Langmuir probes (LP1 or LP2) on the tokamak COMPASS. The diameter of the probe head is about 3 cm on the top (Fig. 1a). The ball-pen probes are made of stainless steel collectors with diameters of 2 mm and alumina shielding with an inner diameter of 5 mm. The Langmuir probes have the same dimensions as on ASDEX Upgrade. They are made of graphite pins with diameters of 0.9 mm and protruding 1.5 mm into the plasma. The poloidal distances between the LPs and BPPs are 4 mm. The data acquisition system is working with a sampling frequency f = 5 MHz.

Similar measurements on ASDEX Upgrade were performed by means of BPP1 and two neighbouring Langmuir probes LP2 and LP4 (Fig. 1b). The ball-pen probes consist of stainless steel collectors with diameters of 4 mm, fixed at h = –0.5 mm and of boron nitride





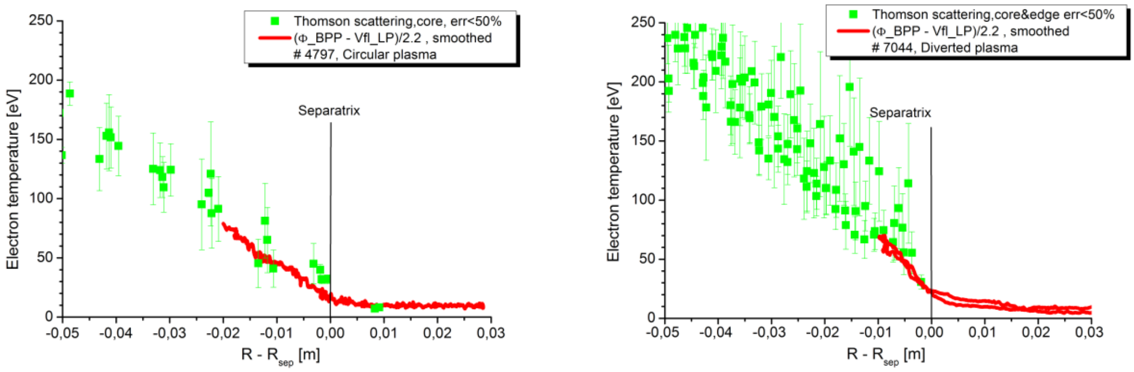
(a) **(b)**

Fig. 1: (a) - Picture of the ball-pen probe (BPP) head used in COMPASS midplane manipulator. It consists of three ball-pen probes made of stainless steel collector and alumina shielding tube and two graphite Langmuir probes. The front side of the probe head has a diameter of 3 cm. **(b)** – Picture of the ball-pen probe head used in AUG. The probe head has four BPPs made of stainless steel collector and boron nitride shielding tube. In addition, there are four graphite Langmuir probes. The front side of the probe head has a diameter of 5 cm.

shielding tubes with inner diameters of 6 mm. The whole probe head has a diameter of 5 cm. The temporal resolution of the potential measurements is limited by the sampling frequency f = 2 MHz of the data acquisition system. The Thomson scattering system on ASDEX Upgrade is described in [8, 9]. The measurements on COMPASS were performed in circular and diverted plasma with Ohmic heating and typical values of toroidal magnetic field B_T= 1.15 T, plasma current I_P = 100 kA, density $n_e = 3\cdot10^{19}$ m^{-3} in the circular plasma and with I_P = 160 kA, density $n_e = 3\cdot10^{19}$ m^{-3} in the diverted plasma. The high resolution multi-point Thomson scattering diagnostic provides the electron temperature and density profiles on the COMPASS covering a region from 16 mm below the mid-plane to 284 mm above the mid-plane in a vertical direction [10]. The diagnostic consists of two sub-systems, observing core core and edge plasma region, with a small overlap. The two sub-systems share the laser beams (two 1.5 J, 3 Hz Nd-YAG lasers, passing vertically through the plasma). Spatial resolution after mapping on midplane is up to 5 mm for the core and up to 3 mm for the edge regions [11]. The measurements on AUG were performed in L-mode discharges with NBI heating 1 MW (#28277) or ECR heating of 0.7 MW (#28292), a toroidal magnetic field B_T= 2.5 T, a plasma current I_P = 1 MA and a line averaged density n_e =4-5$\cdot10^{19}$m^{-3}.

3 Radial profiles of the electron temperature

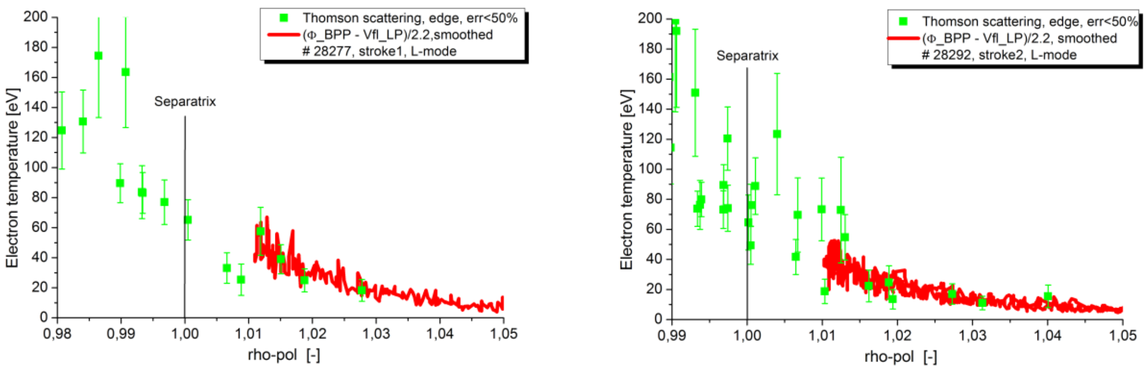
Radial profiles of the electron temperature measured by the BPP/LP technique and by Thomson scattering on COMPASS are plotted in Fig. 2. The electron temperature provided by Thomson scattering diagnostic is plotted only with error bars less than 50%. The comparative measurements have been performed for circular and diverted plasma during discharges #4797 and #7044. The position is plotted with respect to the separatrix provided by



(a) **(b)**

Fig. 2: Radial profiles of the electron temperature measured by BPP/LP (red line) and Thomson scattering (green squares) during circular (a) and diverted (b) plasma on tokamak COMPASS.

EFIT reconstruction. The agreement of both techniques is well seen for both types of discharges. However, the radial profiles measured by Thomson scattering mapped on midplane and probe technique are systematically shifted during the diverted configuration. The difference between the positions of the separatrix from EFIT and maximum of the plasma potential of BPP, which represents the radial electric field equal zero $E_r = 0$ V/m, was used as a correction of the R coordinate of the Thomson scattering data in Fig.2b.



(a) **(b)**

Fig. 3: Radial profiles of the electron temperature measured by BPP/LP (red line) and Thomson scattering (green squares) during L-mode discharge with NBI (a) or ECR (b) heating on ASDEX Upgrade.

A comparison of the radial profiles of the electron temperature measured by BPP/LP and Thomson scattering techniques on ASDEX Upgrade is plotted in Fig. 3. The measurements were performed during L-mode discharges #28277 and #28292 with NBI and ECR heating, respectively. The electron temperature provided by edge Thomson scattering diagnostic is plotted only with error bars less than 50%. It is seen in the figure that both techniques are providing profiles in good agreement for both heating mechanisms.

4 Conclusions

The radial profiles of the electron temperature provided by ball-pen/Langmuir probe and Thomson scattering techniques are in a good agreement for circular and diverted plasma and different heating mechanisms (ohmic, NBI, ECRH). The comparative measurements also confirm that the formula $T_e=(\Phi_{pl} - V_{fl})/2.2$ is valid for both tokamaks and for different positions of the probe head, outside and inside the separatrix. This gives us a strong tool to provide the electron temperature using only two floating probes, which doesn't require any external power supplies or sweeping technique. Therefore, the electron temperature is measured with high time and space resolution. The probe technique is limited by the transition of Langmuir probe to the self-emitting regime during the deep reciprocation [7].

Acknowledgements

This work was carried out within the EURATOM and was supported by projects GA CR P205/12/2327 and P203/14/35260S of the Grant Agency of Czech Republic and MSMT Project #LM2011021 and project P19901-N20 of the Austrian Science Fund (FWF).

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