Lithium influence on edge plasma parameters at T-11M tokamak

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1. Introduction

The problem of choosing materials for plasma-facing components (PFCs) is a key issue to achieve high plasma parameters. Liquid lithium is a promising candidate for PFC material because of it has several advantages. The use of Li leads to decreasing of H recycling and the amount of impurities in the plasma [1]. Li sputtered from the surface of PFCs mainly remains in the edge plasma and efficiently participates in redistribution of radiation [2].

Lithium program of T-11M tokamak is focused on solving the technological problems of creating a closed lithium circulation loop in fusion devices. Prototypes of lithium emitters and collectors based on capillary-porous system (CPS) has been tested at the installation. For that program, the edge plasma parameters were measured using a Mach probe for various operation modes of the collector system.

2. Experimental setup

2.1 T-11M tokamak

The experiments were conducted at T-11M tokamak: R=0.7 m, a=0.27 m, B_t=1 T, Ip=70 kA, pulse duration ~250 ms. It has a limiter configuration and a vacuum chamber of circular cross-section. In 2018, a second longitudinal CPS-based Li limiter was installed in the tokamak chamber symmetrically to the first (basic) Li limiter. All the limiters can be heated up to 400°C using preheating system. The second Li limiter was used as a lithium collector in 3.1, where the vertical Li limiter was the main Li source and as Li emitter in 3.2.

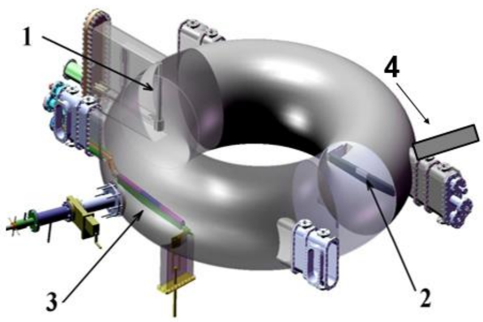

Figure 1. A scheme of T-11M tokamak: 1 – Vertical Li limiter; 2 – First (basic) longitudinal Li limiter; 3 – Second longitudinal Li limiter; 4 – Mach probe.

2.2 Mach probe

A main instrument for edge plasma diagnostics at T-11M tokamak is a Mach probe (figure 2). It consists of two 2 mm tungsten electrodes separated by a stainless steel plate. During the experiments, a positive or negative potential was applied to the electrodes relative to the plate in the stationary phase of the discharge. A specially designed liquid-metal coupling was used to move the probe to a given distance to a tokamak chamber. In detail probe construction and experimental data processing were describe in [3].

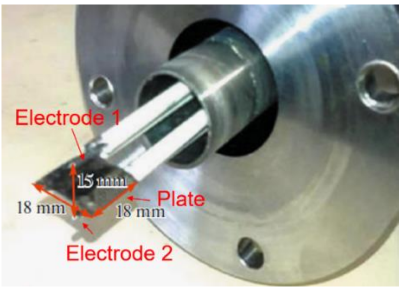

Figure 2. A Mach probe installed at T-11M tokamak

3. Results and discussion

3.1 Experiments with two longitudinal Li limiters

After installing the second longitudinal Li limiter in the tokamak chamber, radial distributions of the ion saturation current and the electron temperature were obtained (Figures 3a and 3b). One can see that these dependencies have no maxima, in contrast with the experiments with one longitudinal Li limiter [3]. It can be concluded that the symmetrization of the collector system leads to the symmetrization of current perturbations and the absence of a magnetic island near the vertical Li limiter and the source of the magnetic island formation is the vertical Li limiter. It also should be noted that the asymmetry of the ion saturation current (the asymmetry of Li fluxes) from the ion and electron sides of the probe remains.

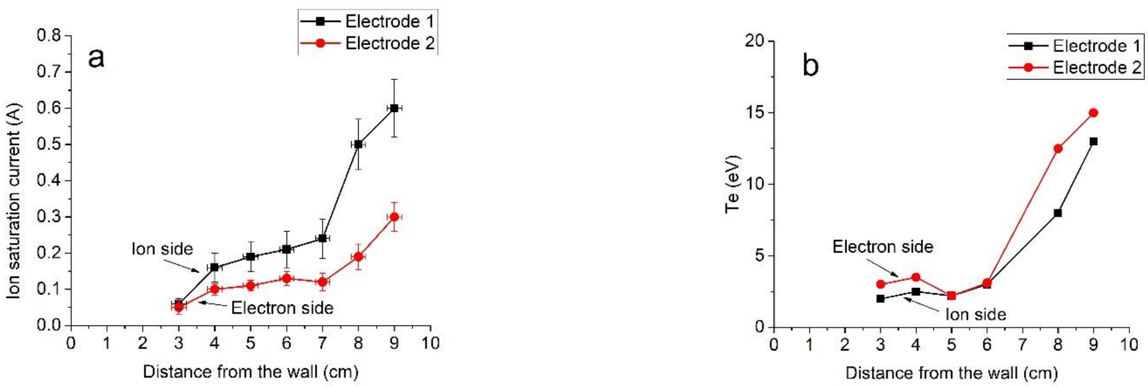

Figure 3. Radial distribution of ion saturation current (a) and electron temperature (b). Two longitudinal Li limiters are inserted

3.2 Experiments with hot and cold the second Li limiter

In order to study the effect of the lithium emission in the edge plasma on its parameters, radial distributions of the electron temperature were obtained at two different temperatures of the second longitudinal Li limiter (room temperature and 250°C). According to the dependence of neutral Li light emission on temperature, the hot limiter corresponds to a higher Li emission in the edge plasma [4]. As can be seen from figure 4 using of hot second Li limiter causes flat electron temperature profile, which can be explained by decreasing of H recycling with increasing of Li emission in the edge plasma according to [5]. Increasing of Li emission from the second longitudinal Li limiter leads to higher electron temperature in the edge plasma (figure 5). Previously a similar result was observed at LTX installation [6].

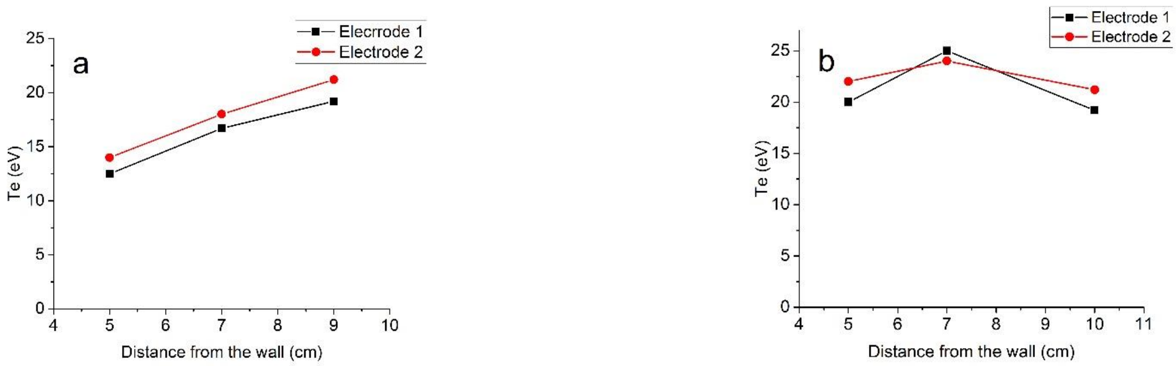

Figure 4. Radial distribution of electron temperature for cold (a) and hot (b) second longitudinal Li limiter. Two longitudinal Li limiters are inserted

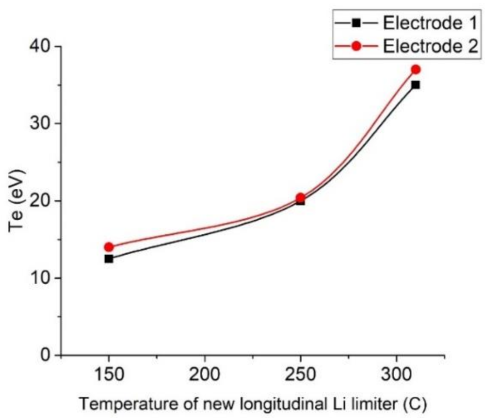

Figure 5. Electron temperature depending on the second longitudinal Li limiter temperature

4. Conclusions

The radial distributions of the ion saturation current and the electron temperature in a symmetric collector system were obtained. It was found that symmetrization of the collector system leads to the absence of a magnetic island near the vertical limiter. Increasing of Li emission in the edge plasma due to increasing of the second longitudinal Li limiter temperature leads to flat profile of the electron temperature and increasing of electron pressure.

Acknowledgements

We are thankful to T-11M tokamak team for help with experiments and data analysis. We also wish to thank the JSC "RedStar" for Mach probe design and making.

References

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