Contribution ID: **59** Type: **Oral**

Paving the road towards ITER relevant long deuterium pulses at ELISE by investigating improved operational scenarios

Tuesday 4 October 2022 08:30 (30 minutes)

The ELISE test facility with its half ITER-size ion source is an essential part of the European Roadmap towards the ITER NBI system. One aim of ELISE is to demonstrate the ITER target values for the extracted current density, the ratio of co-extracted electrons to extracted ions and the uniformity of the extracted beam during long pulses, i.e. 1000 s in hydrogen and 3600 s in deuterium and at a filling pressure of 0.3 Pa.

Previously demonstrated in pulsed extraction mode, i.e. short beam extraction phases of ≈10 s each ≈150 s were 1000 s hydrogen plasma pulses with an extracted current density of over 90 % of the ITER target value, while also fulfilling the requirements for the electron-ion ratio and the beam homogeneity. In deuterium roughly 67 % of the ITER target for the extracted current density has been achieved for pulses longer than 45 minutes, limited by a pronounced vertical asymmetry and increase with time of the co-extracted electron current.

The temporal behaviour during such pulses, in particular of the co-extracted electrons, demonstrates a significant impact of the beam extraction on the caesium dynamics. Thus, CW extraction is mandatory for developing fully ITER relevant operational scenarios. After an extensive upgrade, ELISE is now capable of performing CW pulses, i.e. long-pulse beam extraction. The upgrade consists of a CW high voltage power supply and a CW beam calorimeter. The presentation introduces first results of long pulses in hydrogen.

In order to stabilize the co-extracted electron current during long pulses, particularly in deuterium, improved operational scenarios have to be developed. Investigated at ELISE was the effect of modifying electrostatic potentials close to the extraction system by means of setting the bias plate to a positive voltage with respect to the source vessel. In this operational scenario short pulses in deuterium can be achieved with an extracted negative ion current density of up to 90 % of the ITER target value.

In order to improve the physics insight, the experiments were supported by plasma diagnostics,with focus on Langmuir probes for determining electrostatic potentials as well as particle densities. Additionally, a 2D fluid code gives the general insight that the modified potentials of surface close to the extraction system strongly affect the fluxes of charged particles towards different surfaces and consequently can result in a reduction of the co-extracted electron current.

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Session Classification: Oral session 4

Track Classification: 11. Status of facilities