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Cross-Checked Analysis of ONIX Simulation Results and Experimental Data for Negative Ion Extraction from the BATMAN testbed

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The development of a large area RF driven negative hydrogen ion source is one of the key issues in the construction of the Neutral Beam Injection system (NBI) of the international experimental fusion reactor ITER. The source should supply 66 A (j=33.0 mAcm-2) extracted current in hydrogen and 57 A (j=28.5 mAcm-2) in deuterium operation under a pressure of 0.3 Pa. Obtaining these parameters is a scientifically and technically very challenging goal.

To improve the understanding of the negative ion (NI) extraction process and to determine conditions at which the extracted NI current reaches its maximum with simultaneously co-extracting a relatively low electron current (Ie /INI <1 for ITER) the 3D PIC MCC electrostatic code ONIX is exploited. Simulations were performed for plasma parameters (particle densities, temperatures, …) experimentally obtained on the source testbed BATMAN. The results of these simulations enable performing a cross-checked analysis with experimental results. Additionally, they can play a crucial role for the model validation.

After the code has been benchmarked and validated by various tests, predictive modeling of the extraction of NI has been performed. The results show that the extracted hydrogen NI current density could reach about ~30 mAcm-2, as measured in the experiments under the same plasma and source conditions. The dependency of the negative ion density in the bulk plasma region on the extracted NI current from both the modeling and the experiment was investigated by the code: the extracted current from NI produced at the Cs covered plasma grid (PG) surface, initially moving towards the bulk plasma and then being bend towards the extraction surfaces is lower compared to the extracted NI current from directly extracted surface produced ions. The separate distributions of the negative ion extracted current from the bulk plasma region and the PG surface will be shown here for different NI plasma volume densities and NI emission rates from the plasma grid wall respectively.