Topic number

3D modelling of Negative Ion extraction in ITER-like NBI *via* massive parallel calculations

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Neutral Beam Injection (NBI) is one of the key elements for additional heating and current drive in fusion devices. The NBI system for ITER is based on the extraction and acceleration of negative ions (NI) produced in a low pressure plasma with complex 3D magnetic fields. The modelling of the extraction region is of high interest as it mostly determines the NI beam characteristics such as current density, emittance, etc. Modelling these very high electron density (~ 10^{17} m^{-3}) plasmas using Particle-in-Cell (PIC) simulations demands refined mesh and together with the 3D treatment huge computation resources to respect the stability criteria. The comparative results obtained by several numerical schemes are discussed and the main features of the NI beam are presented as issued from massive parallel calculations.

1. Introduction

The NBI for ITER is based on NI extracted from low pressure plasma ion source. A total current of 40 A will be further accelerated up to 1 MeV by a multi-grid, multi-aperture extraction system.
The RF prototype source for ITER corresponds to 1/8 size of the ITER source [1 *and references in*]. Understanding of the NI beam formation is of high importance for the optimisation of the beam optics. The beam divergence affects its focusing and can lead to serious power load on beam line components, and even to the failures of the system.
Moreover, plasma electrons are co-extracted together with NI. In order to reduce electron extraction, a bias potential is applied to the first grid, the plasma grid (PG), and additionally complex 3D magnetic fields are used. Hence, modelling of the extraction region is necessarily 3D to take into account this complex field topology.

2. Numerical modelling schemes

The ONIX code uses the Particle-in-Cell Monte-Carlo collision approach for modelling a part of the extraction region: a small volume surrounding a single extraction aperture. This volume extends each side of the PG, 2 cm in the plasma source and 1 cm outside. Details are given in [2].
The influence of the mesh size, of electron thermalization in the particle injection region and of different particle re-injection schemes, investigated by massive parallel simulations, are presented and discussed [3].

3. Results and discussion

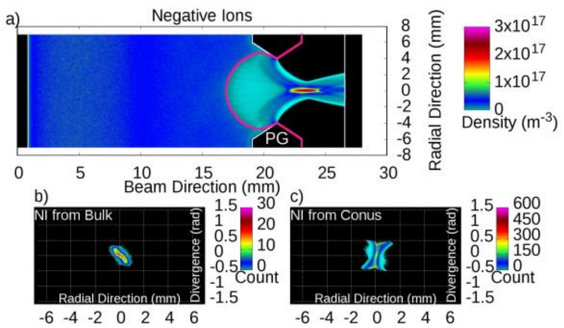

Fig.1. (a) Cross section of a NI beamlet obtained by ONIX with 4096 CPUs for the configuration of the prototype source; NI beam emittance for (b) NI coming from the plasma volume and (c) from the conical part of the PG.

Independent of the numerical schemes, the NI beam features (Fig. 1) are very alike. It comes out that the NI beamlet is composed of two NI ensembles: one is well focused and originates from the plasma volume. A second one originates from the chamfered wall of the aperture that provides an overfocused beamlet and dominates the current density.

4. References

[1] B. Heinemann *et al.* New Journal of Physics 19 (2017) 015001
[2] S. Mochalskyy *et al.* Nucl. Fusion 10 (2016) 106025
[3] A. Revel *et al*. Nucl. Fusion (2017) *to be submitted*