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VERIFICATION OF THE BTR CODE FOR NEUTRAL INJECTION SYSTEMS DESIGN *)

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The BTR (Beam Transmission with Re-ionisation) code [1-2] has been actively used for many years in the design and engineering-physics analysis of neutral injection systems, including the ITER project [3]. In 2008, ITER commissioned the verification of the initial version of BTR [4], which demonstrated the high quality of the code and the consistency of its results with calculations from the ION code for the JET tokamak injection system. Over the years, the BTR code has actively evolved based on user feedback, leading to new versions, including BTR-5 (in 2020). With each new version, the functionality of BTR expanded, and the entire project's source code underwent significant changes. Given the updates and the ongoing need for BTR code, verification is essential. This verification not only ensures the reliability of individual computational procedures but also serves as a guide for the correct application of the code to various optimization tasks and the analysis of processes in neutral beam injection ducts.

This work presents a set of tests divided into two groups: checking the proper functioning of BTR and investigating the sensitivity of models to input data. These tests apply not only to BTR-5 and earlier versions but are also intended for future BTR versions, which are expected to undergo full verification using manually or automatically applied tests. The first group of tests includes the verification of physical models and conditions: particle motion equations in electromagnetic fields; phase distribution of the beam from the ion source-accelerator; neutralization in the gas target, re-ionization losses, ionization in the tokamak plasma; particle conservation and power balance in the system. The second group of tests involves parametric scaling demonstrating the impact of individual input parameters on modeling results: exploring the influence of magnetic fields on injected power; gas target parameters on neutralization efficiency; beamlet focusing errors on overall beam transport efficiency; beamlet shape parameters on final power load profiles; detailing of the injector geometry on the accuracy of calculating heat loads and injector performance.

A comparison of BTR results with analytical solutions is provided, demonstrating that when used correctly, the BTR code serves as a reliable tool for detailed analysis and optimization of injection systems. Additionally, the BTR code can be applied to study the efficiency of various injection and power capture in the tokamak plasma schemes.

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