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Benchmarking of PRETOR-Stellarator code using PROCTR simulations on TJ-II Shots

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INTRODUCTION

The "Departament de Física i Enginyeria Nuclear"(DFEN) of "Universitat Politècnica de Catalunya" (UPC) is being collaborating with the"Laboratorio Nacional de Fusión" of Ciemat using remote participation tools. This collaboration includes the development of a new version of PRETOR code to perform transport analysis in stellarators [1]. This new version of the code has been used to perform some studies with TJ-II data, obtaining good results of the simulations [2].

Some shots have been simulated in order to benchmark two transport codes: PROCTR and PRETOR-Stellarator. This simulated shots belong to a density scan devoted to study the enhanced heat confinement (EHC) in TJ-II plasmas as well as a configuration scan to study the influence of the *q* resonances on core transport [3].

EXPERIMENTAL DATA

The chosen shots to perform the analisys are from the experimental campaing of october-december 1999 in the case of the density scan and from the april-july 2000 campaing for the configuration scan.

The density scan has been performed with 300 kW of ECRH with on-axis deposition. The maximum density varies from $0.71\cdot 10^{19}$ m^{-3} to $1.1\cdot 10^{19}$ m^{-3} from one shot to another. In all the cases a hollow profile was obtained as a consequence of ECRH pump out (fig. 1). The line density of these shots is under $0.6\cdot 10^{19}$ m^{-3} while the usual line density of TJ-II plasmas is above $0.8\cdot 10^{19}$ m^{-3}. The central electron temperatures ranges from a maximum of 1.44 keV to a minimum of 0.73 keV, with peaked profiles.

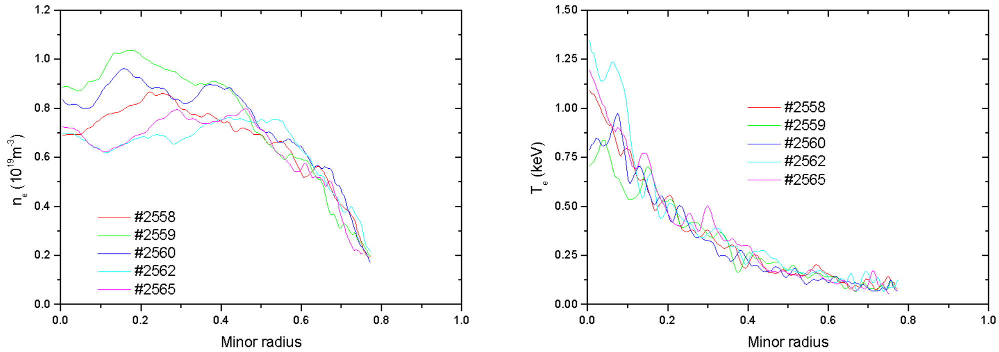

Figure 1. Density and temperatureversus minor radius in shots beloging to the density scan. Data smoothed from Thomson scattering.

The configuration scan has been done also with the same ECR heating as in the density scan. In this case the conditions of central density and temperature in all these configuration shots are almost the same, in fact the maximum electron temperature in the shots varies from 1.3 keV to 1.11 keV and the central density is always about 0.5 10^{19} m^{-3} with a flat profile (fig 2).

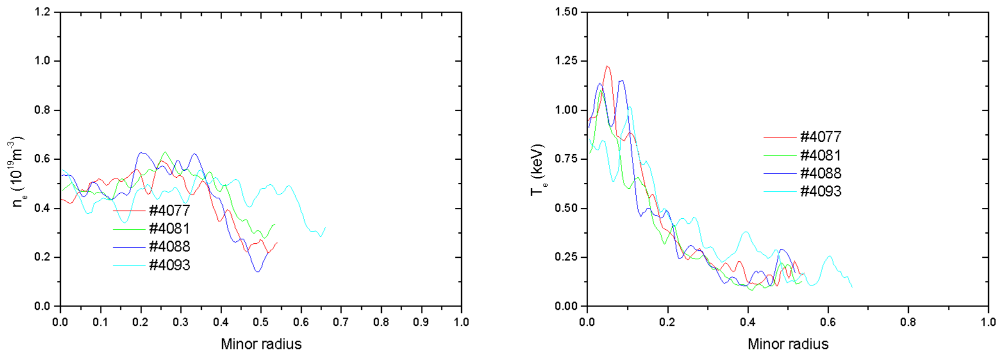

Figure 2. Density and temperature versus minor radius in shots belonging to the configuration scan. Data smoothed from Thomson scattering.

SIMULATION

In order to perform the analysis with PROCTR and PRETOR-Stellarator it has been necessary to implement a new heat diffusivity profile to take into account the Enhanced Heat Confinement regime. The new function to implement is the following [4]:

$$\chi_e(r) = \chi_s(r) \times \left(1 - h \times e^{-\left(\frac{r-r_b}{w}\right)^{\alpha}} \right) (1)$$

where h gives the reduction of transport, r_b is the radial position of the centre of the enhanced confinement region, w is the width of this region, α is an exponent that allows one to vary the shape of the decreasing area of the conductivity, and χ_s is the electron thermal diffusivity obtained from transport analysis of discharges without EHC. The parameters of the conductivity are adjusted in such a way that the simulated temperature and density profiles fit the experimental ones.

All the shots simulated have the same position and width of the reduction transport area, always in the inner region of the plasma, the only variation is in the reduction of transport. The results of some of these shots are showed in figure 3.

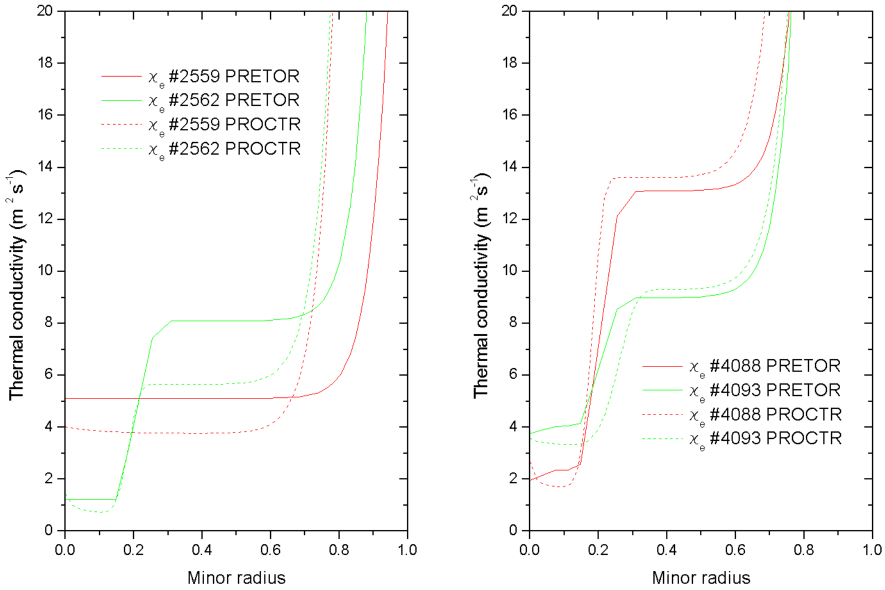

Figure 3 Conductivity for density scan (left) and configuration scan (right). Only the most relevant results are showed in these graphics.

In the figures it can be seen that the results with PROCTR and PRETOR-Stellarator codes are very similar. Also it is observed the necessity to implement the eqution (1) in order to have a good agreement beetwen the experimental data and the results from the code.

In figure 3a there is a comparation beetwen a shot with high EHC (# 2562) and another without this feature (#2559). It is easily seen that the one with EHC has a very low conductivity value in the center of the plasma (<2 m^2s^{-1}) whereas in the medium region of the plasma this conductivity is higher that in a "normal" plasma shot. This difference on conductivity explains the peaked profile of the temperature of the shot. As can be seen from figure 1b, all the shots have more or less the same temperature for ρ>0.2, while there is a big difference in central electron temperature.

In the figure 3b there is a comparation between results in PROCTR and PRETOR-Stellarator. It is clear that both codes give the same result for the electron conductivity. The influence of the rational q in the core transport of the plasma is seen in this graphic. The density is bellow the limit density to have EHC but the profile of the electron conductivity is similar to those shots with EHC. The central conductivity is very low whereas the conductivity in middle radius is higher than in plasmas without EHC.

CONCLUSIONS

Two series of TJ-II shots have been simulated, one density scan and one configuration scan, with a total of nine shots. All of them are heated by 300 kW of ECH, but with some differences beetwen them. In the configuration scan the influence of the q-resonance has been studied while in the density scan, this parameter has been variated to check the EHC mode in TJ-II. The simulations, both in PROCTR and PRETOR-Stellarator, shows a good agreement with the experimental data.

To perform the simulations with enough accuracy a new transport model has been implemnted in both codes: PROCTR and PRETOR-Stellarator. This transport model modifies results from the empirical LHD transport model by a factor that takes into account the reduction of the transport in the plasma core. The introduction of this new model allows to do a good temperature and density simulation of experimental data, and the conductivity results from both codes agree, so the EHC model is valid to simulate this phenomenon.

ACKNOWLEDGMENTS

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