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# Electron diffusivity profiles in ECH plasmas of the TJ-II Heliac

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## Introduction

In the present work the studies of particle transport at TJ-II are presented. The estimate of particle diffusion involves difficulties such as evaluating the electron source coming from the wall and the direct losses. This work is focused on the estimate of particle diffusivity and confinement time for diferent values of the line-averaged density, for which we have used measurements of the plasma electron temperature, $T_e$, (Thomson Scattering TS) and density profiles, $n_e$, (TS and reflectometry) in stationary conditions and a calculation flux surface average of the electron source profile, $S_e$, from a Monte-Carlo code (3D Monte-Carlo code EIRENE).

## Experimental data

The discharges analyzed here belong to typical ECH TJ-II plasmas heated with two gyrotrons with 400 kW of net heating power each. The values of the line-averaged density are in the range $0.6 - 0.8\ 10^{19}\mathrm{m}^{-3}$. The discharges present stationary conditions in the vicinity of the TS time.

The gas puffing data at the TS time have been considered for each discharge. These discharges have been chosen under the condition that the recycling factor be equal to one. It is known that, for ECH TJ-II plasmas with boronised wall, the recycling factor can fulfill such condition after some 10 discharges have been normally performed counting from the glow discharge carried out at the beginning of the experimental day [1]. These are the discharges used in what follows.

Another variable to be included in the input parameters for the EIRENE code is the position of the mobile poloidal limiters. All the selected discharges have the limiters in the nominal LCFS position.

## Models

The ASTRA system is used to estimate the particle confinement time and effective particle difussivity knowing the electron source. The direct losses are obtained from an analytic function with two terms, one due to pump-out processes in the core (Gaussian profile), and the other due to direct losses (hyperbolic tangent centered near the edge). Nevertheless the radial drift velocities have been calculated using an orbit-following code [2] to check for the appropriateness of our formulation. The comparison of results is shown in Fig.1.a.

A transport model allows us also to simulate the time evolution of the electron density, with the update of the electron sources provided by EIRENE every 5 ms, assuming a fixed electron temperature profile. With the modification of the parameters of the model, the density evolution till stationary conditions in accordance with our experimental profiles can be achieved. In this way we obtain the particle confinement time, the electron source and a density gradient profile similar to its experimental counterpart; and finally putting everything together we estimate the electron diffusion. The formula for the electron diffusivity used is:

$$D_e(\rho) = D_e^{exp}(\rho) + \frac{n_e(\rho)v(\rho)V'(\rho)\,|\langle\nabla\rho\rangle|}{n_e'(\rho)G(\rho)} \tag{1}$$

where $D_e^{exp}(\rho) = -S_I(\rho)/n_e'(\rho)G(\rho)$; $S_I = \int_0^\rho S_e V' d\rho$ and $G(\rho) = V'\left\langle(\nabla\rho)^2\right\rangle$. Here we assume that $v$ is a flux surface averaged drift velocity, or pure convection; $V$ is volume and $\rho$ is a typical normalized flux surface coordinate. As usual, a prima indicates derivative with respect to $\rho$; and the gradients are flux surface averages $\langle\cdots\rangle$ evaluated for the vacuum configuration of the density scan.

For the particle confinement, $\tau_p = \frac{\int_0^1 n_e V' d\rho}{S_I}$ , we assume that the recycling factor, the puffing rate and the Monte-Carlo calculation can be trusted.

To match the experimental density profile we use the following formula for the particle balance, $D_e^{model} = C_1 + C_2 f_t^2 \chi_e$ with $\chi_e = C_3 + C_4 \nu_e \rho^2 f_t^3$, where the $C$ are constants, $\nu_e$ is the electron collision frequency and $f_t$ is the trapping fraction (a $\rho$-dependent formula). We write our transport coefficient $D_e^{model}$ in this way so the reader can identify the dependencies with the anomalous transport based on trapped electron instabilities proposed in Ref. [3].

**Results**

TJ-II ECH plasmas show values for particle confinement time between 3.2 ms and 18.0 ms in the density range studied (Fig.1.b).

The electron source calculated by the EIRENE code presents a maximum value around $\rho = 0.8$ that decreases with the inverse of the line-averaged density (Fig.1.c). The volume integral values of the particle source are found between 40 and 160 $10^{19}\mathrm{s}^{-1}$.

The radial drift profiles got with the orbit-following code and the analytical functions that make the density match the experimental data show similar trends values (Fig.1.a).

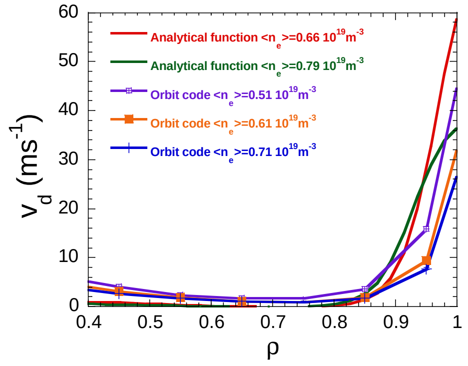
The electron diffusivity shows a decrease with the density in the interval between $0.5 < \rho < 0.9$, which corresponds to the density gradient region (Fig1.d). This region shows a weak dependence on the radial drift, which can be observed with the comparison between the results for $D_e^{exp}$ and $D_e$ given by the Ec.1. The aim of reducing our interest region to $0.5 < \rho < 0.9$ is due to the well characterized electron density gradient and also to the small values of the radial drift for that region according Fig.1.a. This allows us to obtain a good estimate of the electron diffusivity $D_e$. Finally, in the future, we hope to extend the density scan and the number of analyzed discharges to obtain a better characterization of particle diffusivity.

**References**

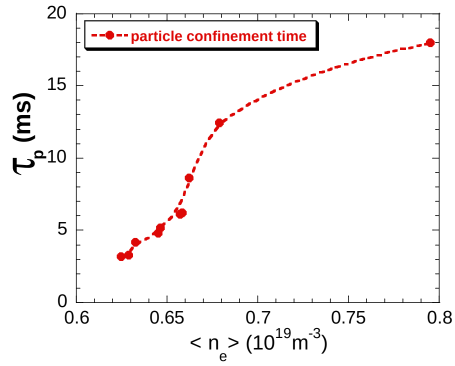
[1] J. A. Ferreira, F. L. Tabarés, D. Tafalla, *Particle balance in TJ-II plasmas under boronized wall conditions*, Proc. of the 32nd EPS Conf. on Contr. Fusion and Plasma Phys., Tarragona, 27 June – 1 July 2005, ECA Vol. 29 C P-4.009 (2005).

[2] F. Castejón *et al.*, *Ion kinetic transport in the presence of collisions and electric field in TJ-II ECRH plasmas*, Plasma Phys. Control. Fusion **49** 753-776 (2007).

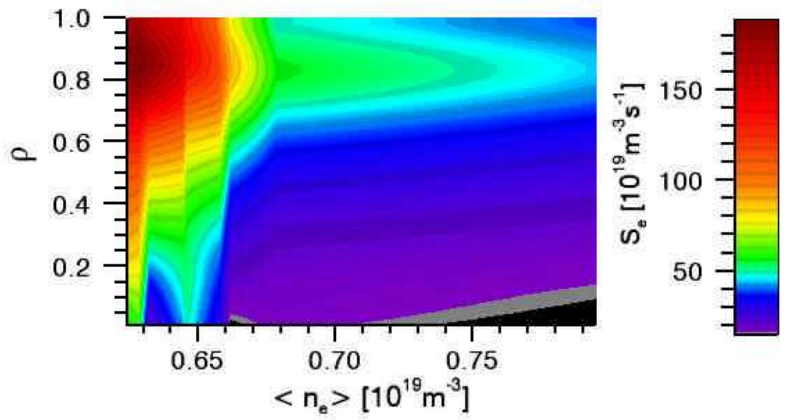
[3] B. B. Kadomtsev, O. P. Pogutse, *Trapped particles in toroidal magnetic systems*, Nucl. Fusion **11**, 67 (1971).



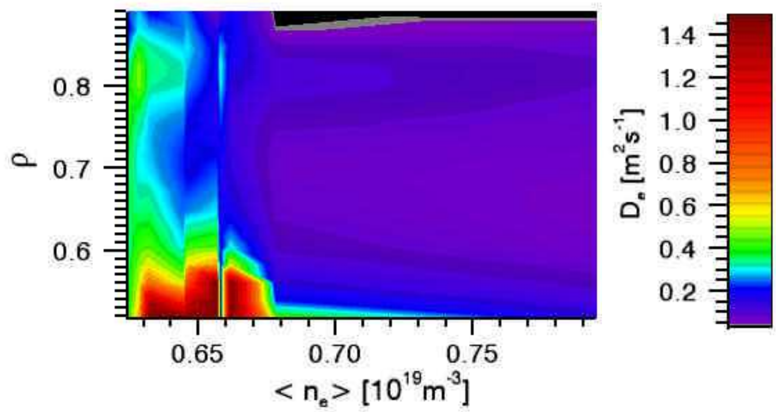

(a)




(b)




(c)




(d)

Figure 1: (a) Profiles of radial drift with the orbit-following code and analytical function; (b) particle confinement time; (c) electron source; and (d) efective diffusion coefficients. Black areas are out of scale.