Inference of 2D maps of ionization and recombination with quantitative imaging in detached conditions of TCV divertor

A. Perek\textsuperscript{a}, K. Verhaegh\textsuperscript{b}, B.L. Linehan\textsuperscript{c}, M. Wensing\textsuperscript{d}, M. van Berkel\textsuperscript{e}, I.G.J. Classen\textsuperscript{f}, B.P. Duval\textsuperscript{d}, O. Février\textsuperscript{d}, T. Ravensbergen\textsuperscript{a}, M.R. de Baar\textsuperscript{a}, the EUROfusion MST1 team\textsuperscript{1} and the TCV team\textsuperscript{2}

\textsuperscript{a} DIFFER-Dutch Institute for Fundamental Energy Research, De Zaal 20, 5612 AJ Eindhoven, Netherlands
\textsuperscript{b} CCFE, Culham Science Centre, Abingdon, Oxon, OX14 3DB, United Kingdom
\textsuperscript{c} Plasma Science and Fusion Center, Massachusetts Institute of Technology, 77 Massachusetts Avenue, NW17 Cambridge, MA 02139, U.S.A
\textsuperscript{d} Ecole Polytechnique Fédérale de Lausanne (EPFL), Swiss Plasma Center (SPC), CH-1015 Lausanne, Switzerland

A.Pere@DIFFER.nl

In fusion experiments, in order to reduce particle and heat fluxes to the divertor target, we operate in the so-called “detached mode” defined as a pressure loss along the field lines. In order to diagnose and control plasma detachment, several co-existing atomic and molecular processes have to be taken into account. Those processes can be diagnosed using line integrated spectroscopy [1]. However, those measurements can suffer from line integrated effects as the lines of sight pass through different regions in the divertor. To tackle this challenge, we developed MANTIS, a 10-channel multi-spectral imaging system to tangentially measure line emission in the TCV divertor [2].

This work presents quantitative data analysis using a Balmer line ratio method [3]. Hydrogen line emission is split between excitation and recombination fractions. Those fractions are then used to infer 2D maps of hydrogenic ionisation and recombination rates together with their characteristic Balmer temperatures. The analysis was applied to an L-mode density ramp discharge with 320 kA plasma current and drift direction unfavourable for H-mode access. Those maps reveal presence of a recombining region below 2 eV and densities $1-2 \times 10^{20}$ m$^{-3}$ developing on the inner divertor leg close to the separatrix. Radially outward, the plasma density decreases below $10^{20}$ m$^{-3}$ and the temperature increases above 10 eV. Density accumulation and the temperature gradient were reproduced by full drift simulations with SOLPS-ITER [4].

Large emphasis is put on evaluation of the measurement uncertainties and the accuracy of the tomographic inversions. The maps of ionization and recombination are then compared against Langmuir probe saturation current profiles. Finally, the maps are used to quantify electron pressure losses along the divertor leg during detachment.


\textsuperscript{1} See author list of B. Labit et al 2019 Nucl. Fusion 59 086020
\textsuperscript{2} See author list of S. Coda et al 2019 Nucl. Fusion 59 112023