Quantitative Balmer line analysis of multispectral imaging data to infer 2D maps of edge plasma parameters in TCV

A. Perek[1,2], M. Wensing[2], K. Verhaegh[3], B.L. Linehan[4], H. Reimerdes[2], C. Bowman[5], M. van Berkel[1], I.G.J. Classen[1], B.P. Duval[2], O. Février[2], J.T.W. Koenders[1,6], T. Ravensbergen[7], C. Theiler[2], M.R. de Baar[1,6], MST1 team[8] and the TCV team[9]

[1] *Dutch Institute for Fundamental Energy Research, Eindhoven, The Netherlands*

[2] *Ecole Polytechnique Fédérale de Lausanne (EPFL), Swiss Plasma Center (SPC), Lausanne, Switzerland*

[3] *CCFE, Culham Science Centre, Abingdon, Oxon, OX14 3DB, United Kingdom*

[4] *Massachusetts Institute of Technology, 77 Massachusetts Avenue, NW17 Cambridge, U.S.A*

[5] *York Plasma Institute, Department of Physics, University of York , United Kingdom*

[6] *Eindhoven University of Technology, Eindhoven, The Netherlands*

[7] *ITER Organisation, Route de Vinon-sur-Verdon, CS 90 046, 13067 St. Paul Lez Durance Cedex, France*

[8] *See author list of B. Labit et al. 2019 Nucl. Fusion 59 086020*

[9] *See author list of S. Coda et al. 2019 Nucl. Fusion 59 112023*

This work presents the use of a collisional-radiative model to infer plasma parameters from 2D emissivities of several deuterium Balmer lines. The emissivities were obtained by MANTIS, an absolutely calibrated, 10-camera imaging polychromator with < 5 mm spatial resolution, up to 800 Hz frame rate, viewing the lower divertor tangentially.

Our analysis of those image frames generates 2D maps of plasma parameters such as electron density, temperature, neutral atomic density and the reaction rates for ionisation, recombination and charge exchange as a function of time. The analysis is compared and validated against a SOLPS-ITER simulation accounting for drifts. The results are compared against the simulation in 2D, radial and poloidal profiles to probe the numerous effects of particle transport in the Scrape-Off Layer, in particular in the approach to detached divertor leg conditions.

The inferred inner divertor leg radial profiles of the electron density and temperature were consistent with the SOLPS-ITER predictions. A significant transport of particles to the private flux region is found experimentally, that is not captured in the simulation. The simulation diverges from the experiment at the outer divertor target, where the plasma emission appears to be consistent with the emission driven by plasma-molecule interactions. Our analysis also shows prospects for aiding the power exhaust control efforts by potentially providing an optical tracking of the particle balance in the divertor.