Quantitative analysis of high n Balmer lines using multispectral imaging in detached divertor plasmas at TCV

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Plasma detachment is required to reduce the particle and heat loads in the divertor of fusion experiments. Atomic and molecular processes play a crucial role in this. To study the interplay between these processes, a novel, real-time capable, visible multispectral imaging system (MANTIS [1]) was installed on the TCV tokamak.

The images are analysed using a novel, high n Balmer line ratio method [2] to apportion the hydrogenic line emission between excitation and recombination processes. Particular emphasis is placed upon estimating the measurement uncertainties and the accuracy of the following tomographic inversions to obtain 2D maps of line emission. The emission ratios together with the experimental uncertainties are used to infer profiles of hydrogenic radiation, ionisation and recombination rates, charge exchange to ionisation ratios, and a characteristic Balmer temperature for excitation and recombination. The advantages and limitations of the quantitative multispectral imaging are evaluated and compared with the line integrated spectroscopic measurements acquired by the TCV's Divertor Spectroscopy System [2].

The possibility of using a real-time analysis to obtain approximated profiles for the ionisation front tracking is presented. Execution time and projected accuracy are evaluated in context of MANTIS's camera systems. With sufficiently fast and accurate algorithm, the ionization front position could be used together with the existing CIII (465nm) emission front estimation currently employed in detachment control efforts[3].

[1] W.A.J. Vijvers et al. JINST 12, C12058, 2017

[2] K. Verhaegh et al. to be published. DOI: 10.13140/RG.2.2.24292.48005/1.

[3] T. Ravensbergen et al. Real-time detection of the radiation front during divertor detachment using multi-spectral imaging, to be submitted.