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Bayesian Inference of the Impurity Concentrations and Ion Confinement Times in the TCV Divertor

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Future high-power tokamaks such as ITER and DEMO will require impurity radiation to dissipate > 90 % of the power crossing the separatrix to maintain steady-state heat loads below material limits (~ 10 MWm^{-2}) [1, 2]. A detailed understanding of impurity transport is required to maximise radiative losses in the SOL and divertor while mitigating reduction in fusion performance.

Bayesian Spectral Analysis Routine (BaySAR) is a novel technique for inferring the spatially resolved probability distribution functions of the electron temperature (T_e), density (n_e) and divertor impurity concentrations including a rigorous treatment of experimental uncertainties [D.S. Gahle et al, to be submitted]. The impurity transport is approximated using the ion confinement time (τ, a proxy for transport) resolved Collisional-Radiative model from ADAS [3, 4].

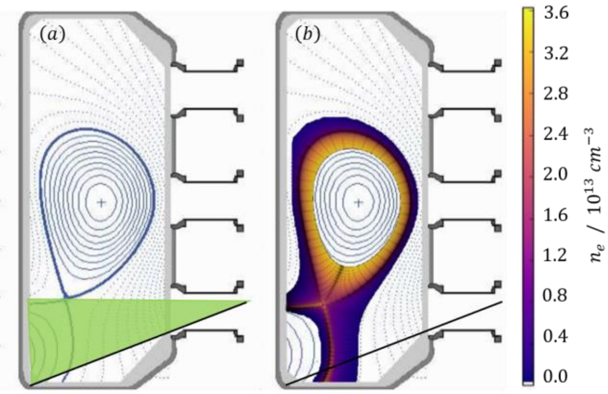

Figure 1. Shows the magnetic equilibrium of a TCV pulse (#62893). The view of the spectrometer is shown in green in (a) (bottom chord highlighted in black in (a) and (b)). The n_e poloidal cross-section from a SOLPS simulation (MDS #160842) of the pulse is shown in (b).

The impurity concentrations and ion confinement times of nitrogen are inferred from line integrated spectroscopy (diagnostic described in [5]) for a collection of nitrogen seeded, lower single-null, L-mode plasmas on the TCV tokamak with complimentary SOLPS simulations [A. Smolders et al, submitted], geometries are shown in figure 1 (a) and (b) respectively.

An example of fitting synthetic data with BaySAR is shown in figure 2 (a). The synthetic data is produced using the plasma profiles from the black chord in the SOLPS simulation shown in figure 1 (b). The reproduction of the n_e and T_e profiles along the line of sight are shown in figure 2 (b) and (c) respectively.

Using BaySAR and bolometry the radiative losses can be decomposed into components from deuterium, carbon and nitrogen. This facilitates a detailed comparison of the transport model in SOLPS to experiment and how the transport changes through detachment.

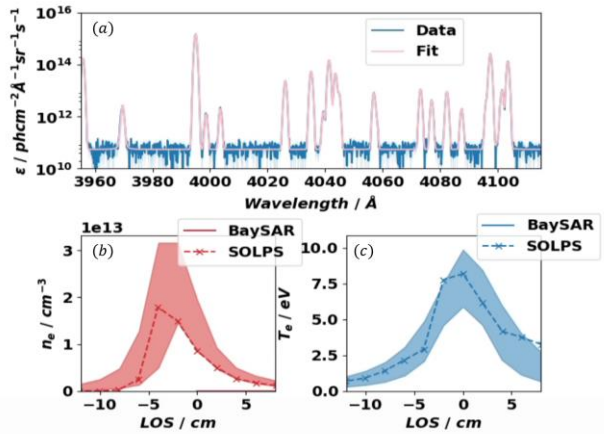

Figure 2. Shows the synthetic analysis of the black sightline produced from the simulation in figure 1 (b). The 95 % confidence interval for the spectral fit is shown in (a) (spectra in blue and the fit in pink). The reconstruction of the n_e and T_e profiles are shown by the band in (b) and (c) respectively, where the dashed-crosses lines are the SOLPS profiles (bands show the 95 % confidence intervals).

References

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