INTEGRATED BAYESIAN ESTIMATION OF Z_{eff} IN THE TEXTOR TOKAMAK FROM BREMSSTRAHLUNG AND CX IMPURITY DENSITY MEASUREMENTS

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Abstract

The validation of diagnostic data from a nuclear fusion experiment is an important issue. The concept of an Integrated Data Analysis (IDA) allows the consistent estimation of plasma parameters from heterogeneous data sets [1]. Here, the determination of the ion effective charge (Z_{eff}), a critical local measure of impurity concentration, is considered. Several diagnostic methods exist for the determination of Z_{eff}, but the results are in general not in agreement. Moreover, so far none of the available methods has provided a Z_{eff} estimate that is reliable over the entire plasma cross-section, which is at present a real challenge.

In this work, the problem of Z_{eff} estimation is approached from the perspective of IDA, in the framework of Bayesian probability theory. The ultimate goal is the estimation of a full Z_{eff} profile that is consistent both with measured bremsstrahlung emissivities, as well as individual impurity spectral line intensities obtained from Charge Exchange Spectroscopy (CXS). We present an overview of the various uncertainties that enter the calculation of a Z_{eff} profile from bremsstrahlung data on the one hand, and line intensity data on the other hand. These appear at several levels, including the measurement process itself (together with independent electron density and temperature measurements), the inversion procedure (including knowledge of the magnetic equilibrium), the atomic data, the diagnostic calibrations, etc. We discuss a simple Bayesian model permitting the estimation of a central value for Z_{eff} and the electron density n_{e} on TEXTOR from bremsstrahlung emissivity measurements in the visible, and carbon densities derived from CXS. Both the central Z_{eff} and n_{e} are sampled using an MCMC algorithm. Extensions of the model to a full Bayesian analysis, incorporating all critical measurement and model uncertainties, are examined. Relevance to ITER through the pilot active beam experiment on TEXTOR is discussed.

References:

[1] R. Fischer and A. Dinklage, Rev. Sci. Instrum. **75**, 4237 (2004).