

Title: Forward and Backward Modelling of Spectroscopic Diagnostics in Fusion Plasmas

Author: Matěj Tomeš

Department: Department of Surface and Plasma Science

Supervisor: Mgr. Jakub Seidl, Ph.D., Institute of Plasma Physics of the Czech Academy of Sciences

Abstract: The thesis primarily focuses on developing forward and backward models for fusion diagnostics. It encompasses the development and application of these models for Thomson scattering, the inference of neon concentrations in JET's divertor and for synchrotron radiation.

In the first chapter, the forward model of Thomson scattering designed for Cherab is detailed. This includes the development of a laser module intended for a wide range of applications, primarily to facilitate Thomson scattering simulations. An application example is provided by a comprehensive model of the Thomson scattering diagnostic used at the COMPASS tokamak. The model of the diagnostic is combined with experimentally obtained electron profiles to assess its performance. The second half of the chapter focuses on the development of a backward model for Bayesian inference of temperature profiles from measured Thomson scattering data. The effectiveness of this model is compared to the conventional approach based on least square error optimization, revealing clear advantages of the Bayesian model.

Chapter two elaborates on the development of a zero transport backward model, based on Bayesian inference of neon spectral line intensity, for deducing neon concentration in JET's divertor during neon seeded discharges. Prior to applying this model to actual data, its performance is rigorously evaluated using data generated by a forward model. A method for comparing statistical inference with forward modeling is introduced. The quality of the inverted experimental concentration profiles is then scrutinized in light of several factors: reflections, concentration measurements at the midplane, and theoretical predictions derived from SOLPS simulations.

Chapter three introduces a novel synchrotron model for Cherab. The model's versatility includes the ability to simulate reflections from the first wall and the effects of toroidally asymmetric runaway electron distributions and 3D magnetic fields. The capabilities of the model are demonstrated on forward modelling of JET's infrared cameras KLDT-E5WC and KL7-E8WB. In the case of KLDT-E5WC, the model successfully replicates image patterns resulting from magnetic islands. For both cameras similarity in measured and forward modelled reflection patterns is observed.

Keywords: forward model backward model Raysect Cherab Thomson scattering synchrotron radiation neon seeding