Personal Statement

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While completing a summer project with the JET data processing group at Culham, I developed a keen interest in fusion plasma physics and returned a year later to start a PhD at Culham with Imperial College London which I will be submitting in the coming months. My PhD work, under the supervision of Jakob Svensson and Darren McDonald, has concerned the application of Bayesian principles and techniques to tokamak data analysis and has involved the modeling of several diagnostic systems on JET. The aim of the wider project, being lead by Dr Svensson, is to develop as clear and consistent a picture as possible of the Tokamak plasma based as much as possible on the wide range of observations made and as little as possible on our prior assumptions of physics the concerned.

This work has given me a particular interest in the rigorous experimental verification of plasma physics theory which, combined with my work modeling the JET Polarimeter system, lead me to the publication of a paper giving the first experimental verification of relativistic effects in plasma polarimetry, confirming one of two competing theoretical treatments. This work involved the careful statistical examination of JET data which, despite being available for several years, had not yet been used to observe the effect, since it is significantly smaller than the diagnostic uncertainty. Only the rigorous treatment of the data was able to extract a reliable confirmation.

The bulk of my PhD work has involved the modeling of the JET LIDAR and edge-LIDAR systems. The dependence of this work on the plasma magnetic geometry (as with the vast majority of tokamak data analysis), has lead me to a particular interest in the experimental determination of the tokamak current and magnetic field profiles. We have been developing methods to determine these under the assumption of the plasma being near equilibrium but without the large number of extra assumptions commonly used about current profile shape, scrape-off layer currents and the relation of the equilibrium pressure to the measured electron kinetic pressure. The methods also provide a rigorous calculation of the uncertainty that results from the diagnostic data and, more importantly, from the large uncertainty that comes from the under determined nature of the problem.

This has involved the consistent treatment of the equilibrium constraint within the Bayesian framework and has shown that with this significant relaxation of the assumptions made about the pressure and current profiles, the JET magnetic sensors alone contain sufficient information to observe the H-mode pedestal in the equilibrium pressure profiles. This has only otherwise been possible with internal measurements such as MSE, or the direct inclusion of pressure measurements. This result, to be submitted for publication later this year (after the completion of my thesis), shows clear qualitative agreement with the electron kinetic pressure profile and its evolution within the Type-I ELM cycle.

Having already invested a large amount of time completing the framework and demonstrating the basic capability, I would now like the opportunity to apply the system to relevant physics problems. The area of particular interest to me is the evolution of the edge current, a typically under diagnosed quantity, especially on JET. The ability to assess the equilibrium at the length scales of the H-mode pedestal should allow the study of the evolution of the pedestal current during the ELM cycle, independent of assumptions often imposed relating the parallel current to neoclassical calculations of the bootstrap and Pfirsch-Schlüter currents. This should provide a means to rigorously and directly test these current models in the large gradients and short scale lengths of plasma pedestal region where the assumptions of the theories are less likely to be valid.

With the addition of the consistent determination of high-resolution edge electron kinetic profiles from multiple JET diagnostics (also already completed), the current density information can be used to assess the MHD stability of the edge plasma. Comparing the calculations of theoretical stability boundaries with plasmas observed to be stable shortly before an ELM helps identify the instabilities responsible for different types of ELM. While this is often done using standard equilibria and analysis of kinetic parameter diagnostics, it usually imposes the neoclassical current models and the statistical significance of the results is not usually assessed. Since the edge current and pressure gradient results from the Bayesian analysis include a detailed description of the uncertainties, many of the current theoretical models for ELM behavior could be tested directly against almost entirely experimentally inferred quantities.

Since the code developed so far as been within the Minerva framework, this and any further work will be automatically transferable to the MAST current tomography project already being developed by the joint MAST, Australian National University and Wendelstein 7-X team.