PARTICIPATION IN THE EXPLOITATION OF THE JET FACILITIES

CURRENT AND PRESSURE PROFILES RECONSTRUCTION ON JET BY USING MAGNETIC DATA AND DATA RESULTING FROM THE MOTIONAL STARK EFFECT (MSE) MEASUREMENTS AS CONSTRAINTS

C.V. Atanasiu, I.G. Miron, A. Moraru

National Institute for Laser, Plasma and Radiation Physics, Magurele

The **main purpose** of this participation was to continue the work undertaken during campaign C14 (01.02.2004-04.03.2004) in collaboration with Task Force D, JET, Culham, UK, and the Theory Department of the Princeton Plasma Physics Laboratory, USA.

1. Introduction

Although quite "old" , the reconstruction problem is still actual and needs to be improved, at least form two points of view: the possibility of on-line reconstruction and the improving of experimental magnetic measurements due to existing eddy currents and iron field environment in which such measurements take place at JET.

This reconstruction is based on the Equilibrium and Stability Code (ESC), based on a moment formulation. The ESC code [1] is a fast equilibrium solver based on linearization of the Grad-Shafranov equation. In its fixed boundary equilibrium momentum formulation, ESC has multiple choices of the radial coordinates and input plasma profiles; while the free boundary solver of ESC has several modes of operations. Beside the conventional interface with other relevant codes, ESC generates a compact a universal Equilibrium Spline Interface (ESI) suitable for stability, transport, particle orbit and guiro-kinetic codes. It communication system is organized in a rigorous manner by a special software, the CodeBuilder.

2. Results

The following **milestones** have been accomplished:

- An improved version of the ESC code has been implemented on the JACK cluster computer system (under LINUX);

- The code C2E, developed in PPPL for reconstruction of the response functions from the JET database of magnetic signals, has been installed on the JACK cluster computer system and the necessary modifications have been performed.
- First runs to obtain reconstructed profile for different JET equilibria have been performed and we have found some differences with the reconstructed profiles given by the EFIT (Equilibrium Fitting) code. We are looking now for qualitative explanations in the key part of both codes: the mathematical strategy for reconstruction. This will be a difficult, time consuming, but necessary task.
- A first model to consider the iron influence, by using surface currents, has been developed in order to obtain a better fit of the magnetic data [2, 3].
- The improving of the on-line help of the ESC code for different users has been started and will be continued in the next step in function of different users' remarks.
- The possibility to extend the existing experience with the real time equilibrium reconstruction by linking it with transport simulations has been investigated, and is now under development.
- As a supplementary work, made on the request of our JET colleagues, was to complete the methodology for the "Design of a Helmholtz pair coils" (to be used at JET to calibrate magnetic probes), with magnetic flux calculations at different magnetic probes. Note that the experimental device of the Helmholtz pair coils has been constructed in agreement with the design date furnished by our calculations and the first measurements and calibrations have been already performed at JET;
- In place of the milestone "to perform runs of the ESC code with data obtained from JET and comparison of the reconstructed profiles with those given by the EFIT code", on the special request of our colleagues from JET, we have considered o more important task – not solved at this moment at JET -: the calibration of JET sensors for equilibrium reconstruction with the target of elimination of uncertainties in magnetic signals due to the presence of the iron core and due to eddy currents in passive conductors. With this in view, a correlation matrix between sensors located outside and inside the vacuum vessel has been introduced in order to determine the parasitic $n \neq 0$ perturbation in magnetic fields generated by the iron core. An other time dependent matrix of response functions has been introduced in order to eliminate the $n \neq 0$ perturbation generated by the eddy currents. Both elements can be determined using calibration shots (without plasma) only, they allow to pre-process magnetic signals of plasma discharges for further use in the equilibrium reconstruction codes. In this view, on our request, "dry runs" have been performed at JET, during three days of the present stay.

3. <u>Next steps</u>

We intend to continue the reconstruction of current and pressure profiles at JET, by considering the following milestones:

- to finalize the implementation of the ESC (Equilibrium and Stability Code) on the JACK cluster computer system (under LINUX);

- to finalize of the adaptation of the ESC input format to the output data file given by the diagnostic system of JET (of JPF and PPF type);
- to perform runs of the ESC code with data obtained from JET and comparison of the reconstructed profiles with those given by the EFIT code, with special attention given to the hollow profiles and to the influence of the separatrix, with our special treatment of the X point [4, 5];
- to improve the on-line help of the ESC code for users;
- to continue the calibration of the magnetic measurements by taking into account the influence of the eddy currents induced in the vacuum vessel and the iron core influence (activity partially already performed in 2006, campaign C15-C17 (11.03.06-8.04.06)).

References

[1] **Zakharov L.E.**, **Pletzer A.**, "*Theory of perturbed equilibria for solving the Grad-Shafranov equation*", Physics of Plasmas **6** , 4693 (1999).

[2**] Atanasiu C.V., Zakharov L.E., Moraru A.**, *"Integral equations method in equilibrium and stability computations for iron core transformer tokamaks"*, Computer Physics Communications, **70**, 483 (1992).

[3] **Atanasiu C.V., Zakharov L.E**., *"Description of the MHD Equilibrium in Iron Core Transformer Tokamaks"*, Nuclear Fusion, 30, 1027 (1990).

[4] **Atanasiu C.V., Günter S., Lackner K., Moraru A., ZakharovL.E., Subbotin A.A.**, *"Linear tearing modes calculation in diverted tokamak configurations"*, Physics of Plasmas **11,** 5580 (2004).

[5] **Günter S., Angioni C., Atanasiu C.V., et al**., *"Overview of ASDEX Upgrade results- development of integrated operating scenarios for ITER"*, Nuclear Fusion, **10** (2005) 98.