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

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The **main purpose** of this participation was to continue the work undertaken during campaign C10 (2003): **"Current and Pressure Profiles Reconstruction on JET by using magnetic data and data resulting from the Motional Stark Effect (MSE) measurements as constraints"**, by using the Equilibrium and Stability Code (ESC), based on a moments 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 gyro-kinetic codes. It communication system is organized in a rigorous manner by a special software, the Code Builder.

Accomplished milestones, during campaign C14 (01.02.2004-04.03.2004) and secondment (5.12.2005-18.12.2005)***:***

- An improved version of the ESC code has been implemented on the JACK cluster computer system (under LINUX);
- The introduction of the geometrical data regarding coils, magnetic diagnostics coils and loops, vacuum vessel, iron core, etc in the input of the ESC code by matching the ESC input format to the output data file given by the diagnostic system of JET (of JET Pulse Files (JPF) and Processed Pulse Files (PPF) type) has been finalized.
- The ESC code can be used to reconstruct JET current hole discharges as well as discharges with standard monotonic q-profiles. In a previous stay at JET (Campaign C10 – 2003), ESC has been successfully used to reconstruct the equilibria of JET current hole discharges and a current hole model, in which a fixed core region of zero current density is applied. For this special case,

the solution of the Grad-Shafranov equation is constrained additionally by the Motional Stark Effect (MSE) measurement of the pitch angle profile (the direction of the magnetic field lines inside the plasma). During campaign C14 (01.02.2004-04.03.2004) and secondment (5.12.2005-18.12.2005) at JET, discharges with standard monotonic q-profiles have been considered only.

- The code C2E, developed in PPPL for reconstruction of the response functions from the JET data base of magnetic signals, has been installed on the JACK cluster computer system and the necessary modifications have been performed.
- First runs to obtain reconstructed profiles 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 [2, 3] to consider the iron influence, by using surface currents, has been developed in order to obtain a better fit of the magnetic data.
- 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 data furnished by our calculations and the first measurements and calibrations have been already performed at JET.

This work has been made in close cooperation with Dr.L.E.Zakharov from PPPL and Dr.S.Gerasimov from JET during the campaign C14 (01.02.2004-06.04.2004) and during the secondment (5.12.2005-18.12.2005).

In a **next step** the following milestones will be considered:

- to finalize the implementation of the ESC (Equilibrium and Stability Code) on the JACK cluster computer system (under LINUX);
- to finalize 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];
- to improve the on-line help of the ESC code for users.

Publications:

[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).