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Oral_25: Plasma equilibrium reconstruction in a Tokamak

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\title{
Plasma equilibrium reconstruction in a Tokamak
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\author{J. Blum, C. Boulbe, B. Faugeras\
{\small Laboratoire J.-A. Dieudonn\'e (UMR 7351),} \
{\small Universit\'e C\^ote d'Azur, Parc Valrose, 06108 Nice Cedex 02, France} \
{\small email: jblum@unice.fr}
}

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%\tableofcontents
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The problem of the equilibrium of a plasma in a Tokamak is a free boundary problem, the plasma boundary being defined either by its contact with a limiter or as being a magnetic separatrix (hyperbolic line with an X-point). The equilibrium equation inside the plasma, in an axisymmetric configuration, is a semi-linear elliptic partial differential equation, called Grad-Shafranov equation. The right-hand side of this equation is a non-linear source, which represents the toroidal component of the plasma current density. The aim of this work is to perform the identification of this non-linearity from experimental data, such as magnetic measurements, polarimetric measurements (integrals of the magnetic field over several chords), kinetic pressure measurements or MSE (Motional Stark Effect) measurements. Discrete magnetic measurements are interpolated thanks to toroidal harmonics in order to provide Cauchy boundary conditions on a closed fixed contour surrounding the plasma \cite{ACL.B.Faugeras.14.2}. Polarimetry measurements can be modeled using the classical linear approximation or using the Stokes model \cite{ACL.B.Faugeras.17.2, ACL.B.Faugeras.18.2}. A C++ software, called NICE/EQUINOX \cite{ACL.B.Faugeras.12.1, ACL.B.Faugeras.18.2, ACL.B.Faugeras.20.2} has been developed in collaboration with the IRFM (Institute of Research on Magnetic Fusion) at CEA-Cadarache, and has been tested for WEST (the CEA-EURATOM Tokamak at Cadarache), JET (Joint European Torus), TCV, AUG and JT-60 SA in particular through the ITER-IMAS infrastructure. It is possible to simulate ITER configurations. Only a few number of degrees of freedom can be identified from the magnetic measurements (Dirichlet and Neumann boundary conditions) on the vacuum vessel. A better identification of the current profile is performed by using other measurements such as polarimetric measurements.

This considerably improves the identification of the non-linearities and hence of the toroidal plasma current density.

An important problem is to achieve this within a few ms, so as to be able to control in real time the current profile.

With all these techniques, it is possible to follow the quasi-static evolution of the plasma equilibrium in existing tokamaks.

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Primary author: Prof. BLUM, Jacques (Laboratoire LJAD, Université Côte d’Azur)

Co-authors: Dr FAUGERAS, Blaise (Université Côte d’Azur); Dr BOULBE, Cedric (Université Côte d’Azur)

Presenter: Prof. BLUM, Jacques (Laboratoire LJAD, Université Côte d’Azur)