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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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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 modelized 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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