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Identification of the plasma current density 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 [1]. A C++ software, called NICE [3], has been developed and tested for the tokamaks WEST (the CEA-EURATOM Tokamak at Cadarache), JET (Joint European Torus), TCV, AUG and JT-60 SA in particular through the ITER-IMAS infrastructure. 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 [2]. An important problem is to achieve this within a few ms, so as to be able to control in real time the current profile.

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