Identification and control of the plasma current density profile in a Tokamak

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Abstract

The reconstruction of the equilibrium of a plasma in a Tokamak is a free boundary problem described by the Grad-Shafranov equation in axisymmetric configuration. The right-hand side of this equation is a nonlinear source, which represents the toroidal component of the plasma current density. This talk deals with the identification of this non-linear source from experimental measurements in real time. The proposed method is based on a fixed point algorithm, a finite element resolution, a reduced basis method and a least-square optimization formulation.

This is implemented in a software called Equinox with which several numerical experiments are conducted to explore the identification problem.

It is shown that the identification of the profile of the averaged current density and of the safety factor as a function of the poloidal flux is very robust.

It is then necessary to control the current density profile, so as to have a correct safety factor profile that is essential for the magnetohydrodynamic instabilities.The best way to control it is to optimize the RF current-drive, which is generated by the additional RF-heating (lower hybrid, electron cyclotronic and ion cyclotronic). The infinite-dimensional model based on the resistive diffusion equation will be discussed, taking into account the non-inductive cuurent profile sources and some ideas about open-loop or feedback control will be given.

References:

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- E. Witrant et al: A control-oriented model of the current profile in Tokamak plasma: Plasma Phys. Control. Fusion 49, 2007, 1075-1105