Real-time control of internal transport barriers in JET : Experiments and simulations

D. Moreau[1, 2], F. Crisanti[3], L. Laborde[2], X. Litaudon[2], D. Mazon[2], A. Murari[4], T. Tala[5], P. De Vries[6], R. Felton[7], F. Imbeaux[2], E. Joffrin[2], M. Lennholm[2], V. Pericoli-Ridolfini[3], M. Riva[3], L. Zabeo[2], K.D. Zastrow[7] and contributors to the EFDA-JET workprogramme.

[1]EFDA-JET Close Support Unit, Culham Science Centre, Abingdon, OX14 3DB, U. K.
[2]Euratom-CEA Association, CEA-Cadarache, 13108, St Paul lez Durance, France
[3]Euratom-ENEA Association, C.R. Frascati, 00044 Frascati, Italy
[4]Euratom-ENEA Association, Consorzio RFX, 4-35127 Padova, Italy
[5]Euratom-Tekes Association, VTT Processes, FIN-02044 VTT, Finland
[6]Euratom-FOM Association, TEC Cluster, 3430 BE Nieuwegein, The Netherlands
[7]Euratom-UKAEA Association, Culham Science Centre, Abingdon, U. K.

Real-time control of the plasma profiles (current, pressure and flows) is a key issue to sustain steady state discharges with internal transport barriers (ITB) and a large bootstrap current fraction. In order to simultaneously control the current and pressure profiles in JET ITB discharges, a multi-variable model-based technique has been proposed. It is based on a truncated singular value decomposition (TSVD) of an integral model operator and retains the distributed nature of the plasma parameter profiles. The related algorithms have been implemented in the JET control system, and applied to the control of the current profile in reversed shear plasmas using three actuators (neutral beam injection, ion cyclotron heating and lower hybrid current drive). Successful control of the q-profile has been achieved in quasi steady state conditions with a significant fraction of bootstrap current. In these experiments the strength of the ITB's was marginal during the control phase, due to the chosen q-profile setpoints and to the moderate heating power which was requested by the controller. Hence, further experiments aiming at the simultaneous control of the current profile and of the normalized ITB temperature gradient are being pursued and first results will possibly be reported. Integrated modelling of the proposed control algorithms is also being attempted using transport codes (JETTO, CRONOS). Preliminary results will be shown concerning interpretative modelling of past experiments as well as predictive modelling for future experiments with the complete algorithms. In particular, the way the control matrix is determined from open loop experiments can be mocked up with simulations. The application of the TSVD in closed loop can then be tested in order to assess the capability of the model-based (linear) algorithms in achieving adequate control and the effect of transport non-linearities on the closed loop response. This can be very valuable in optimizing the proposed method and the characteristics of the controller in parallel with the experiments.

Invited talk at the Joint Meeting of US-Japan JIFT Workshop on Theory-Based Modeling and Integrated Simulation of Burning Plasmas, and 21COE Workshop on Plasma Theory.
Kyoto (Japan), 15-17 Dec. 2003