Contribution ID: **293** Type: **Poster**

EX/P2-09: First-Principles Model-based Closed-loop Control of the Current Profile Dynamic Evolution on DIII-D

Tuesday 9 October 2012 14:00 (4h 45m)

Recent DIII-D experiments represent the first successful use of first-principles, model-based, full magnetic profile control in a tokamak. For ITER to be capable of operating in advanced tokamak operating regimes, characterized by a high fusion gain, good plasma confinement, magnetohydrodynamic stability, and a non-inductively driven plasma current, for extended periods of time, several challenging control problems still need to be solved. For instance, setting up a suitable toroidal current density profile is key for one possible advanced operating scenario characterized by noninductive sustainment of the plasma current and steady-state operation. The control approach at the DIII-D tokamak is to create the desired current profile during the ramp-up and early flat-top phases of the plasma discharge and then actively maintain this target profile for the remainder of the discharge. The evolution in time of the current profile in tokamaks is related to the evolution of the poloidal magnetic flux profile, which is modeled in normalized cylindrical coordinates using a nonlinear dynamic partial differential equation referred to as the magnetic diffusion equation. This first-principles control-oriented model of the current density profile evolution in response to auxiliary heating and current drive systems [Neutral Beam Injection (NBI)], line-averaged density, and electric field due to induction, was developed and used to synthesize a combined feedforward + feedback control scheme to drive the current profile to a desired target profile. The model combines the magnetic diffusion equation with empirical correlations obtained at DIII-D for the temperature and noninductive current. Static and dynamic plasma response models were integrated into the design of the feedback controllers by employing robust, optimal, and backstepping control theories. A general framework for real-time feedforward + feedback control of magnetic and kinetic plasma profiles was implemented in the DIII-D Plasma Control System. Experimental results are presented to demonstrate the ability of the first-principles model-based feedback controllers to control the toroidal current density profile.

This work was supported by the NSF CAREER award program (ECCS-0645086) and the US DOE under DE-FG02-09ER55064, DE-FG02-92ER54141 and DE-FC02-04ER54698.

Country or International Organization of Primary Author

USA

Author: Mr BARTON, Justin E. (USA)

Co-authors: Mr PENAFLOR, Benjamin G. (General Atomics); Dr HUMPHREYS, David A. (General Atomics); Dr SCHUSTER, Eugenio (Lehigh University); Dr FERRON, John R. (General Atomics); Mr BOYER, Mark D. (Lehigh University); Dr WALKER, Michael L. (General Atomics); Mr JOHNSON, Robert D. (General Atomics); Dr LUCE, Timothy C. (General Atomics); Mr SHI, Wenyu (Lehigh University); Mr WEHNER, Willliam P. (Lehigh University)

Presenter: Mr BARTON, Justin E. (USA)

Session Classification: Poster: P2

Track Classification: EXS - Magnetic Confinement Experiments: Stability