Axisymmetric Control in Alcator C–Mod

by

GERASIMOS TINIOS

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ABSTRACT

This thesis investigates the degree to which linear axisymmetric modeling of the
response of a tokamak plasma can reproduce observed experimental behavior. The
emphasis is on the vertical instability. The motivation for this work lies in the
fact that, once dependable models have been developed, modern control theory
methods can be used to design feedback laws for more effective and efficient tokamak
control. The models are tested against experimental data from the Alcator C–Mod
tokamak. A linear model for each subsystem of the closed–loop system constituting
an Alcator C–Mod discharge under feedback control has been constructed. A non–
rigid, approximately flux–conserving, perturbed equilibrium plasma response model
is used in the comparison to experiment. A detailed toroidally symmetric model
of the vacuum vessel and the supporting superstructure is used. Modeling of the
power supplies feeding the active coils has been included. Experiments have been
conducted with vertically unstable plasmas where the feedback was turned off and
the plasma response was observed in an open–loop configuration. The closed–loop
behavior has been examined by injecting step perturbations into the desired vertical
position of the plasma.

The agreement between theory and experiment in the open–loop configuration
was very satisfactory, proving that the perturbed equilibrium plasma response model
and a toroidally symmetric electromagnetic model of the vacuum vessel and the
structure can be trusted for the purpose of calculations for control law design. When
the power supplies and the feedback computer hardware are added to the system,
however, as they are in the closed–loop configuration, they introduce nonlinearities
that make it difficult to explain observed behavior with linear theory. Nonlinear
simulation of the time evolution of the closed–loop experiments was able to account
for the discrepancies between linear theory and experiment.