For submission to *Physics of Plasmas*

Modeling of feedback and rotation stabilization of the resistive wall mode in tokamaks

(December 18, 2003)

M. S. Chu,[a] A. Bondeson,[b] M. S. Chance,[c] Y. Q. Liu,[b]

A. M. Garofalo,[d] A. H. Glasser,[e] G. L. Jackson,[a] R J. La Haye,[a]

L. L. Lao,[a] G. A. Navratil,[d] M. Okabayashi,[c]

H. Remierdes,[d] J. T. Scoville,[a] E. J. Strait[a]

[a]General Atomics, San Diego, California 92186-5608 USA

[b]Chalmers University of Technology, Goteborg, Sweden

[c]PPPL, P.O. Box 451,Princeton, New Jersey 08543 USA

[d]Columbia University, New York, NY 10027 USA

[e]Los Alamos National Laboratory,Los Alamos, New Mexico 87545 USA

Abstract

Steady-state operation of the advanced tokamak reactor relies on maintaining plasma stability with respect to the resistive wall mode (RWM). Active magnetic feedback and plasma rotation are the two methods proposed and demonstrated for this purpose. A comprehensive modeling effort including both magnetic feedback and plasma rotation is needed for understanding the physical mechanisms of the stabilization and to project to future devices. For plasma with low rotation, a complete solution for the feedback issue is obtained by assuming the plasma obey ideal magnetohydrodynamics (MHDs)

and utilizing a normal mode approach (NMA) [M.S. Chu, *et al.,* Nucl. Fusion **43**, 441 (2003)]. It is found that poloidal sensors are more effective than radial sensors and coils inside of the vacuum vessel more effective than outside. For plasmas with non-negligible rotation, a comprehensive linear non-ideal MHD code, the MARS-F has been found to be suitable. MARS-F [Y.Q. Liu, *et al.,* Phys. Plasmas **7**, 3681 (2000)] has been benchmarked in the ideal MHD limit against the NMA. Effect of rotation stabilization of the plasma depends on the plasma dissipation model. Broad qualitative features of the experiment are reproduced. Rotation reduces the feedback gain required for RWM stabilization. Reduction is significant when rotation is near the critical rotation speed needed for stabilization. International Thermonuclear Experimental Reactor (ITER) [R. Aymar, *et al.,* Plasma Phys. Control. Fusion **44**, 519 (2002)] (scenario IV for advanced tokamak operation) may be feedback stabilized with β above the no wall limit and up to an increment of $\sim$50% towards the ideal limit. Rotation further improves the stability.