Analysis of the Resistive Wall Mode Experiments in HBT-EP

Dmitry Maslovsky, Allen Boozer, Michael Shilov
Department of Applied Physics and Applied Mathematics
Columbia University, New York, NY 10027

A single mode approximation to the exact linear theory is used to study the plasma response as an external magnetic perturbation is applied in the HBT-EP tokamak in the presence of a resistive wall and plasma rotation. The free energy of the least stable plasma mode, given by the dimensionless parameter s, and the torque on the plasma, given by the dimensionless parameter α, completely describe the dynamics of the system near marginal stability. We identify the range of values of s and α corresponding to various dynamical regimes observed in the experiment.

When a resonant static magnetic perturbation is applied in HBT-EP using a set of 30 in-vessel driver coils, the resistive wall mode is excited, and its amplitude and phase are measured with poloidal sensors[1]. The permeability matrix $P = 1/(-s + i\alpha)$ models the plasma response[2]. Here, $s < 0$ corresponds to a stable mode, and $s > 0$ corresponds to an unstable mode without plasma rotation ($\alpha = 0$). The plasma surface inductance, L_p, the resistive wall self-inductance, L_w, and mutual-inductances between the plasma, the resistive wall, and the driving coil, required in the model, are estimated both 1) by using cylindrical geometry approximation, and 2) by matching the ideal wall limit parameter, s_{crit}, to that produced by a VALEN calculation of the growth rate of the RWM for HBT-EP geometry[3]. The plasma stability paramter, s, and the plasma rotation parameter, α, are the only free parameters in the approximation. The cases of the sagging amplitude of the plasma perturbation response are reproduced for $s/s_{crit} \sim 0$ and $\alpha^2/s_{crit}^2 \sim 0.2$, whereas the oscillatory behavior is observed for $s/s_{crit} \sim 0.5$ and $\alpha^2/s_{crit}^2 \sim 0.2$. Non-zero plasma rotation is required in both instances. Further study of the plasma response to an applied external perturbation will include time-dependent $s(t)$ and $\alpha(t)$ parameters.

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[2] A. Boozer, *Phys. Plasmas*, **10**, 5 (2003).
[3] J. Bialek, A. Boozer, M. Mauel, and G. Navratil, *Phys. Plasmas*, **8**, 5 (2001).