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Stabilization of the Resistive Wall Mode and Error Field Reduction by a Rotating Conducting Wall[1]

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The hypothesis that the Resistive Wall Mode (RWM) can be stabilized by high-speed differentially-rotating conducting walls is tested in a linear device. This geometry allows the use of cylindrical solid metal walls, whereas a torus would require a flowing liquid metal. Experiments over the past year have for the first time explored RWM stability with a rotating copper wall capable of achieving speeds ($r\Omega_w$) of up to 280 km/h, equivalent to a magnetic Reynolds number (R_m) of 5. The main results are: 1) Wall rotation increases the stability window of the RWM, allowing $\approx$ 25% more plasma current (I_p) at R_m = 5 while maintaining MHD stability. 2) Error field reduction below a critical value allows the observation of initial mode rotation, followed by braking, wall-locking, and subsequent faster growth. 3) Locking is found to depend on the direction of wall rotation ($\hat{\Omega}_w$) with respect to the intrinsic plasma rotation, with locking to both the static wall (vacuum vessel) and rotating wall observed. Additionally, indirect effects on RWM stability are observed via the effect of wall rotation on device error fields. Wall rotation shields locking error fields, which reduces the braking torque and inhibits mode-locking. The linear superposition of error fields from guide field (B_z) solenoid misalignments and current-carrying leads is also shown to break symmetry in $\hat{\Omega}_w$, with one direction causing stronger error fields and earlier locking irrespective of plasma flow. Vacuum field measurements further show that rotation decreases the error field penetration time and advects the field to a different orientation, as predicted by theory. Experiments are conducted on the Rotating Wall Machine, a 1.2 m long and 16 cm diameter screw-pinch with $B_z \approx 500$ G, where hollow-cathode injectors are biased to source up to 7 kA of I_p, exciting current-driven RWMs. MHD activity is measured through 120 edge B_r, B_θ, B_z probes as well as internal Bdot, Langmuir and Mach probes. RWM eigenfunctions are found to be skewed towards the anode end, likely due to anode-directed axial flows measured to be $\approx$ 6 km/s. Eigenfunctions also illustrate increased helicity at higher I_p and helicity is reversed with B_z, while wall counter-rotation is found to reduce mode helicity.

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