Rotating Magnetic Fields Probe Plasma Stability at High Pressure

New control coils recently installed in the DIII–D tokamak have been used to measure the properties of an important plasma instability while the plasma is still stable. The pressure of a magnetically confined plasma is ultimately limited by a fast growing kink-type deformation of the magnetic configuration. The presence of a metallic wall close to the plasma boundary converts this fast growing free-boundary mode into a slowly growing resistive wall mode (RWM). A compelling feature of the RWM arises from the interaction between its slow plasma deformation and a near-sonic bulk-plasma flow, which can stabilize the mode. While the underlying stabilizing mechanism is still under debate, experiments in the DIII–D tokamak (E.J. Strait, "Resistive Wall Mode Stabilization with Internal Feedback Coils in DIII–D," to be published in Bull. Am. Phys. Soc., 2003) have demonstrated the stabilization of the RWM by sufficient plasma rotational flow. This results in a doubling of the plasma pressure over the conventional "no wall" limit.

In order to probe the RWM stability in rotating DIII–D plasmas, the technique of MHD spectroscopy has been extended to lower frequencies than previously used (H. Reimerdes, "MHD Spectroscopic Study of the Stabilizing Effect of Plasma Flow on the Ideal Kink Mode," to be published in Bull. Am. Phys. Soc., 2003). Newly installed internal control coils can be programmed to generate a rotating magnetic field, that can interact with the RWM. While the externally applied field is too small to perturb the plasma properties, it is large enough to excite a finite amplitude marginally stable RWM. This happens when the plasma pressure exceeds the "no wall" limit. Measurements of the perturbed magnetic field at the wall have revealed a plasma response with the typical RWM structure. The amplitude of the plasma response peaks when the externally applied field rotates slowly, at a frequency of a few rotations per second, in the direction of the plasma rotation. The plasma response becomes larger as the plasma pressure increases towards the stability limit. The dependence of the plasma response on the applied frequency is in good agreement with predictions, as shown in the figure.

The recent MHD spectroscopy experiment confirms our understanding of the interaction between the RWM and externally applied fields and provides a measurement of the plasma stability in the attractive regime significantly above the "no wall" limit. Such measurements may be useful to provide an "early warning" of an impending instability, before the plasma actually becomes unstable.

Work supported by U.S. Department of Energy under Contract No. DE-AC03-99ER54463.

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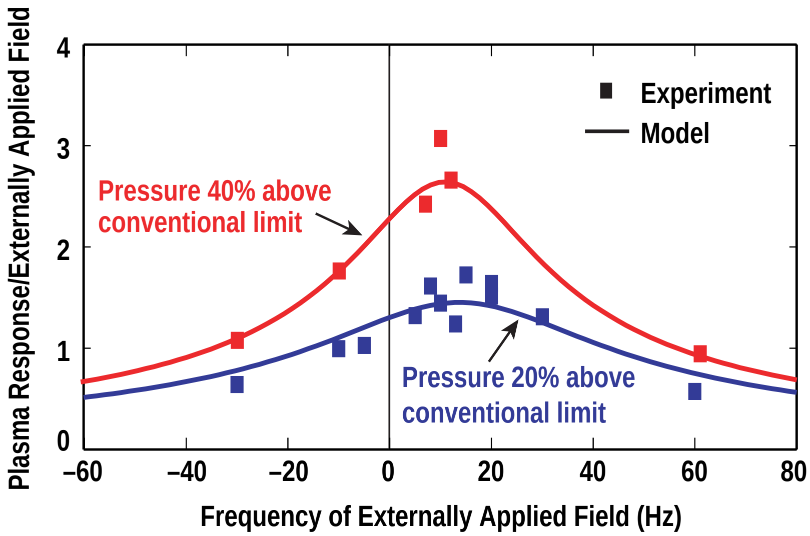

The amplitude of the plasma response peaks when the externally applied field rotates in the direction of the plasma rotation. The plasma rotation is ~6000 Hz, much faster than the mode.