§7. Experimental Demonstration of the Stabilizing Effect of a Superthermal Electron Avalanche during ECRH

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Concept: The stabilizing effect of the superthermal electrons [1], which are produced during ECRH through the avalanche effect [2], could be demonstrated only by the suppression of an MHD mode with ECRH, in an experimental arrangement which favors the development of a superthermal electron avalanche and excludes any other stabilizing effect, such as current modulation or electron heating.

Requirements: To avoid such effects the following requirements should be met at the experiment: **(i)** ECRH should be perpendicular to the magnetic field, to avoid any ECCD; **(ii)** The target plasma should not have any loop voltage, which in the presence of the improved conductivity would enhance the inductive current (this requirement essentially excludes tokamaks); and **(iii)** The target MHD mode should be ideal and not resistive, since the reduction of the resistivity would be stabilizing.

Arrangements: In CHS the dominant MHD mode, in low-density, NBI-heated plasmas, is the *m/n=2/1* fishbone mode. This is an ideal mode, driven by the energetic ions from the neutral beam and, hence, it is further destabilized by the electron heating (which increases the fast-ion density). The fishbone mode and CHS, consequently, meet all of the requirements for the proposed experiment.

Results: Given the suitability of our experimental arrangement, we conducted a radial scan of the EC resonance, inside the $q=2$ surface (at *11cm*), as follows:
(a) In the horizontal direction, from $r = 8cm$ to the plasma center, through a toroidal field scan (i.e. from $B = 0.80T$ to $B = 0.88T$) and readjustment of the almost vertical direction of the beam, and,
(b) In the vertical direction (along the beam), from the plasma center to $r = 8cm$, through a toroidal field scan (i.e. from $B = 0.88T$ to $B = 0.94T$).
The magnetic fluctuations during the ECRH pulse are shown in Fig.1. No effect on the fishbone mode could be seen at half-radius (in the vicinity of the $q=2$ surface), where the growth of the avalanche, according to the proposed theory, should be too slow for the time scale of the experiment.

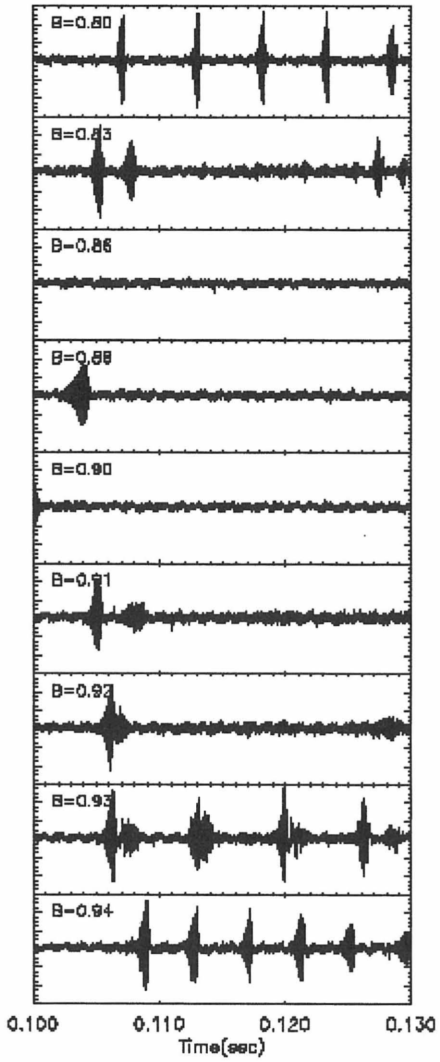

Fig. 1. *Magnetic fluctuations during ECRH, with the EC resonance scanning the plasma radius through a toroidal field scan (the field is shown in Tesla).*

On the contrary the fishbone mode is suppressed when the EC resonance is near the axis, where the avalanche grows almost instantly. The delay time of *5-10ms*, which is also seen (in Fig.1) in the latter case, apparently represents the growth time of the avalanche. Despite the separation of the superthermal production (in central heating) from the $q=2$ surface, if the superthermal slowing-down time (in low-density plasmas) exceeds the diffusion time, the superthermal density profile would be sufficiently broad, with a finite gradient at the $q=2$ surface, as required for the suppression of the fishbone mode.

References

[1] A.Lazaros, Phys. Plasmas **6**, 148 (1999)
[2] A.Lazaros, Phys. Plasmas **8**, 1263 (2001)