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EX/P6-07: Electron Fishbones in LHCD Plasmas on FTU and Tore Supra

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Usually, Electron driven fishbone modes are observed in Electron Cyclotron Resonant Heating (ECRH) plasmas[1,2]. The fast electrons produced by Lower Hybrid Current Drive (LHCD) systems often help destabilizing these modes when using a combination of ECRH and LHCD[2], but in most machines LHCD alone is unable to destabilize e fishbones[1,2]. However, in FTU and Tore Supra e-fishbones were recently observed in shots with LHCD only[3,4].
The evolutions of the mode radial position and frequency were determined from the ECE measurements using the procedure presented in[5]. In a second step, the energy of the resonant electrons was estimated based on the expression of the precession drift frequency[3].
In FTU, two regimes of e-fishbones (with and without bursts) can be obtained depending on the LH power[3], while in Tore Supra, only near stationary evolutions are observed. On the other hand, frequency jumps between modes with different mode wave numbers can be observed only in Tore Supra[4].
The relative trend of the mode frequency and position in FTU depends on the fishbone regime: the evolution in the regime without bursts is much slower than in the burst regime[6]. Moreover, the frequency evolution during the bursts is consistent with a nonadiabatic downward frequency chirping produced by mode particle pumping[6].
In Tore Supra, the mode position evolves continuously even during the frequency jumps. Moreover, the mode position evolution agrees with the q profile evolution and corresponds to an inverse cascade in mode wave numbers starting by an 4/4 mode and finishing in a 1/1.
In both tokamaks, the energy of the resonant electrons was found to be close to the thermal energy if the pitch angle correction is neglected. Moreover, recent theoretical works[7] have shown that the passing electrons may also contribute to the drive of e fishbones. The dispersion relation in this case allows solutions with the mode frequency much lower than the precessional drift frequency[7], in agreement with these observations.

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