Modelling of Alfvén cascades in NBI heated stellarator plasmas

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In magnetic fusion, machines with a Reversed magnetic shear (RS) with an off-axis local minimum in the rotational transform are associated with internal transport barriers [1, 2]. In a RS configuration, Alfvén eigenmodes (AEs) called reverse shear Alfvén eigenmodes (RSAE) or Alfvén cascades (ACs) [2] can be excited by energetic ions enhancing fast-ion re-distribution and losses, which are of major concern for plasma scenarios with low or reversed magnetic shear [3]. In this paper, we study ACs observed [4] in the NBI heated discharge 27804 in the TJ-II stellarator ($B_0 = 0.95$ T, $R = 1.5$ m, $a = 0.22$ m, $N_{fp} = 4$, $P_{NBI} \leq 1.0$ MW, $E_{NBI} \leq 32$ keV, $P_{ECRH} \leq 0.6$ MW) using numerical calculations. In this plasma with an increasing rotational transform ι in time, an AC with fast frequency sweeping was observed, with the range of the frequency sweeping in excess of 100 kHz and a minimum frequency in the range of ~25 kHz as shown in Figure [4].

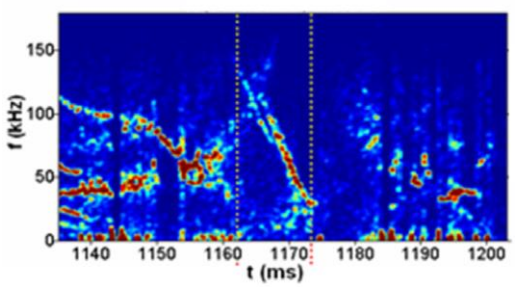

Figure: *Frequency sweeping Alfvén Eigenmodes (AE) in discharge 27804 in TJ-II stellarator. We focus on the AC observed at t = 1170 ms with fast frequency sweeping and a large frequency range.*

We have modelled discharge 27804 based on a reduced MHD model [5, 6] using the experimental density profile and the reversed ι profile reconstructed with VMEC [7]. Our modelling shows a wide spectrum of modes covering a frequency range from~50 to~200 kHz and located at a normalised minor radius of 0.3-0.7, roughly consistent with the position of the iota extremum point and the experimental findings. If we use a monotonic ι profile instead, our simulations show a smaller number of modes located at larger minor radii with frequencies covering a narrower range than that observed in the experiment.

References

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