SEEDING OF TEARING MODES BY INTERNAL CRASH EVENTS IN ASDEX UPGRADE AND DIII-D TOKAMAKS

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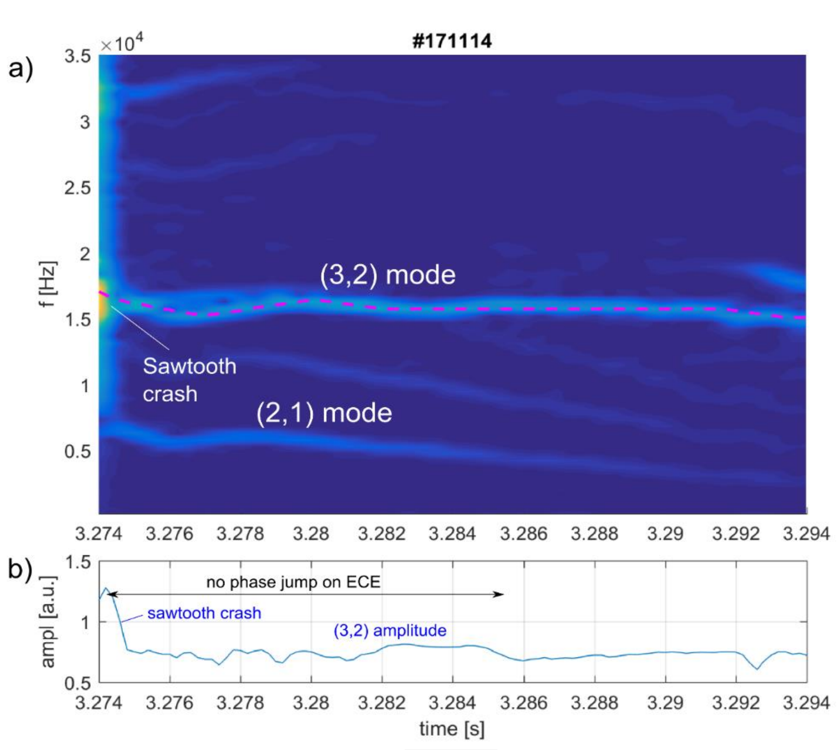
Introduction and main results

Seeding of neoclassical tearing modes (NTM) by perturbations from other MHD instabilities (sawteeth, fishbones, ELMs, etc) is one of the main MHD problems that has to be avoided or controlled in ITER. NTMs can lead to strong degradation of plasma confinement or even to a disruption. The present paper compares the seeding of (3,2) neoclassical tearing modes in the ASDEX Upgrade and DIII-D tokamaks. **It was found in both devices that the mode can start as ideal kink mode which converts into a tearing mode on a time-scale much longer than the duration of the trigger event.** These findings are in good agreement with those for (2,1) mode seeding in ASDEX Upgrade [1,2] as well as with non-linear MHD simulations [3,4]. This result revises the simplified picture of fast island formation during a trigger event.

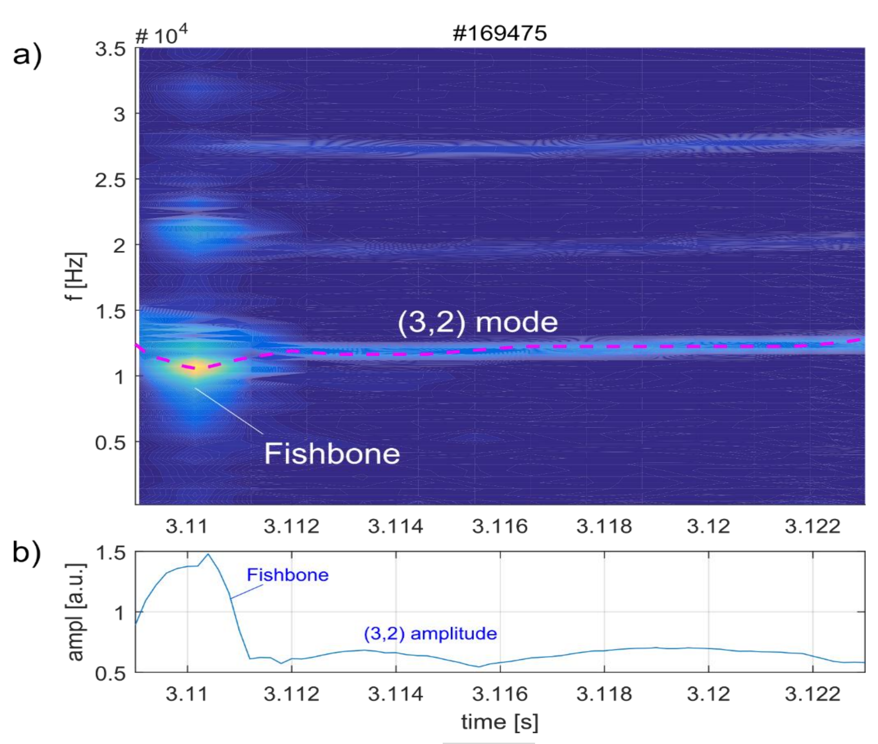
Comparison of (3,2) NTM Seeding in the ASDEX Upgrade and DIII-D tokamaks

(I) Spectrogram of the magnetic signal during the seeding event (a) and the amplitude of the tracked mode (b)

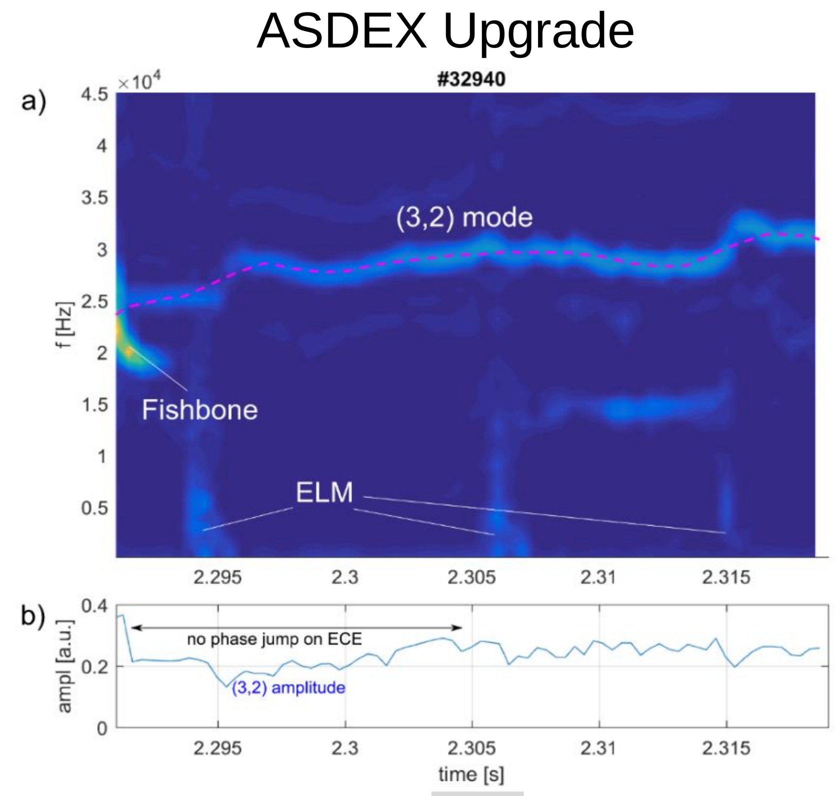
DIII-D



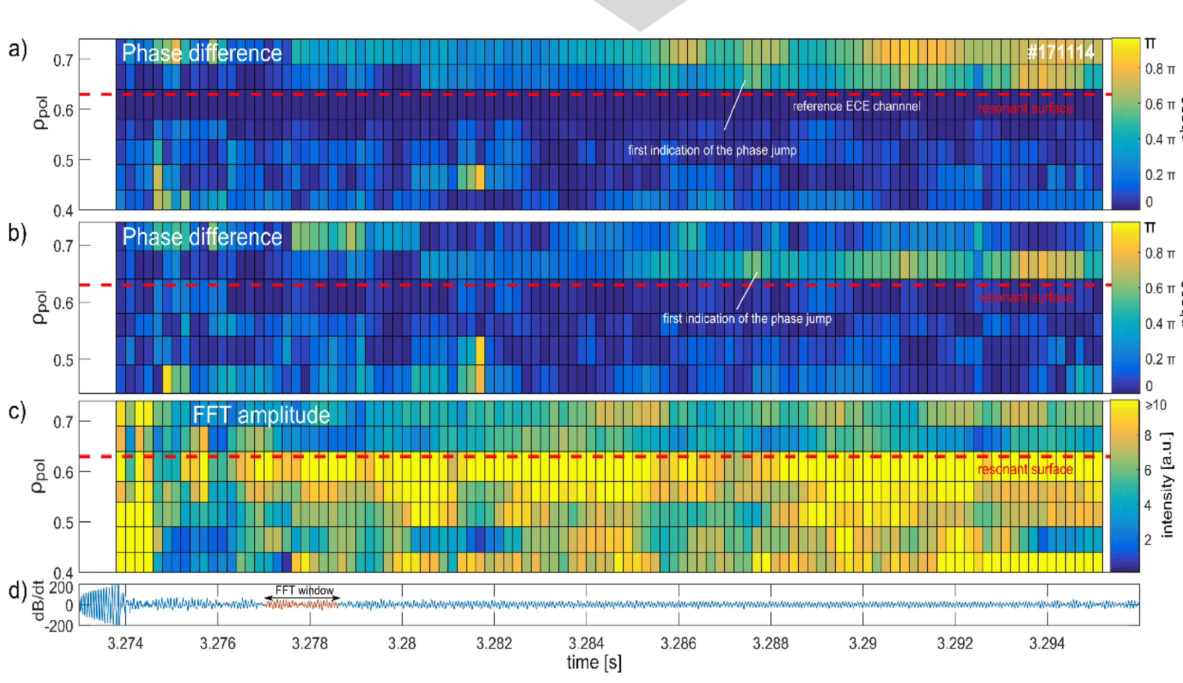
DIII-D

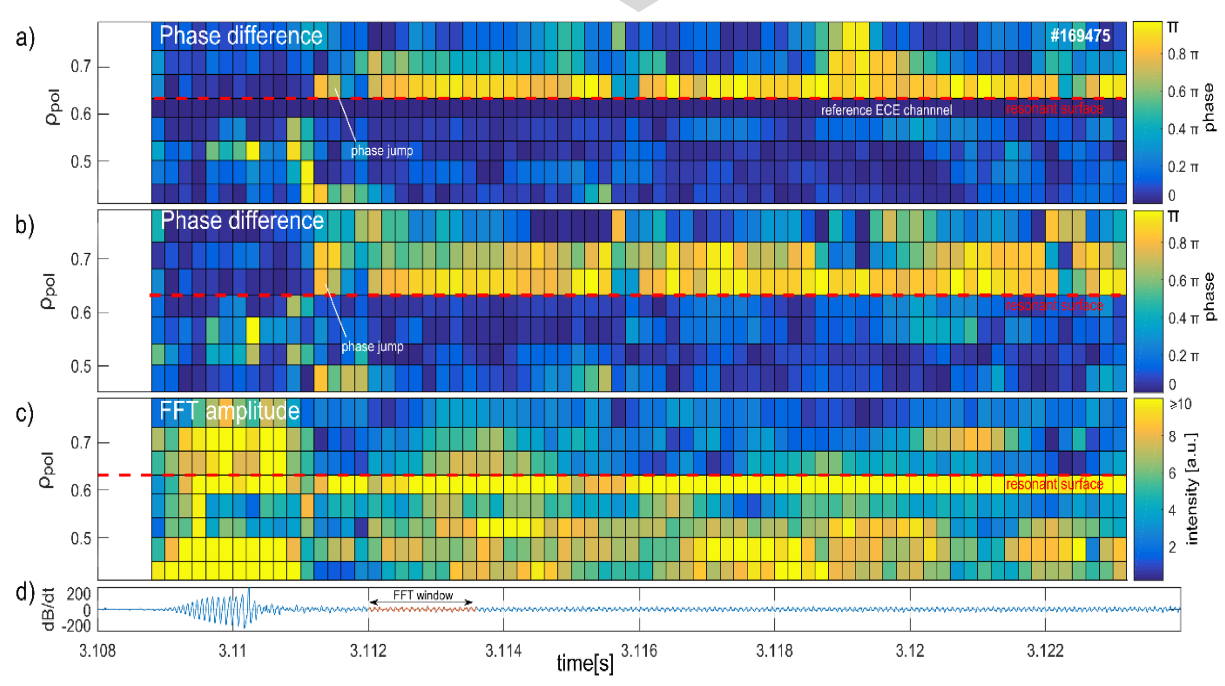


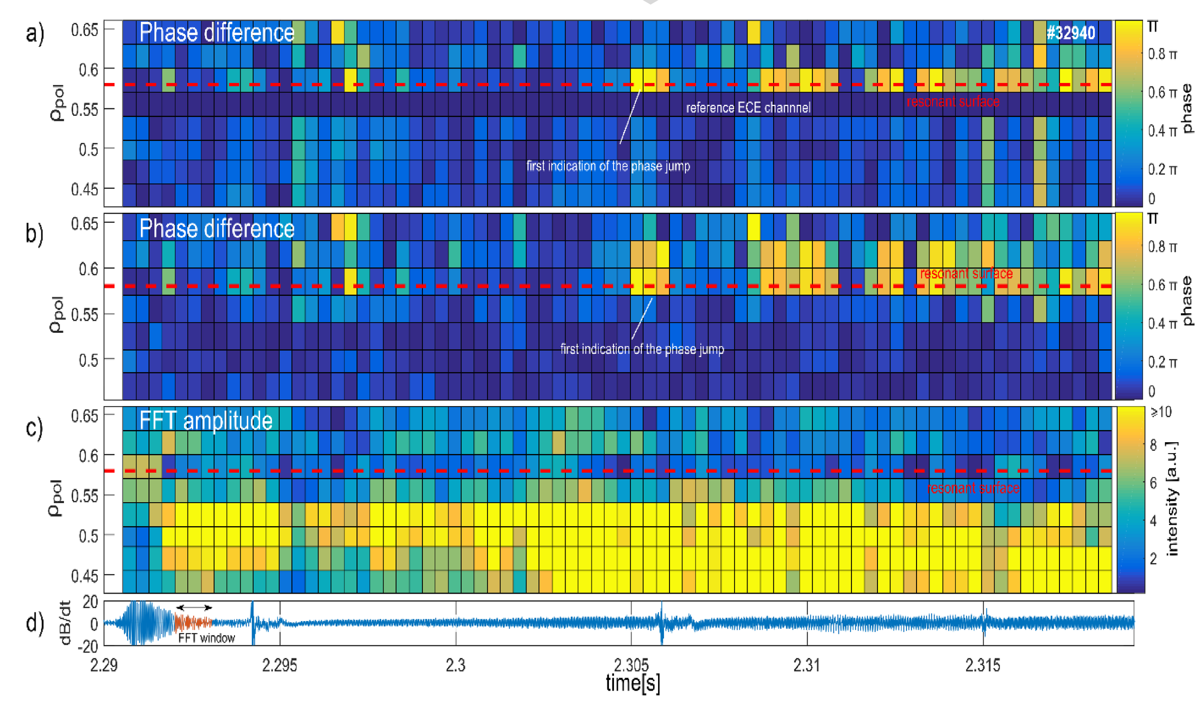
ASDEX Upgrade



(II) Identification of the ECE phase jump at the resonant surface by sliding FFT algorithm







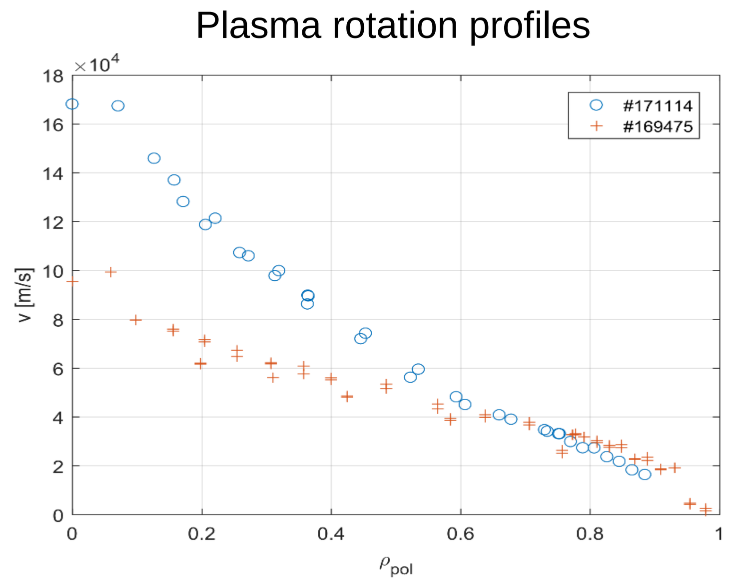
(a) The phase difference between the reference channel and the other channels at the mode frequency; (b) The phase difference between neighboring channels at the mode frequency; (c) The FFT Amplitude at the mode frequency; (d) magnetic signal with indicated time window size used for FFT transformation.

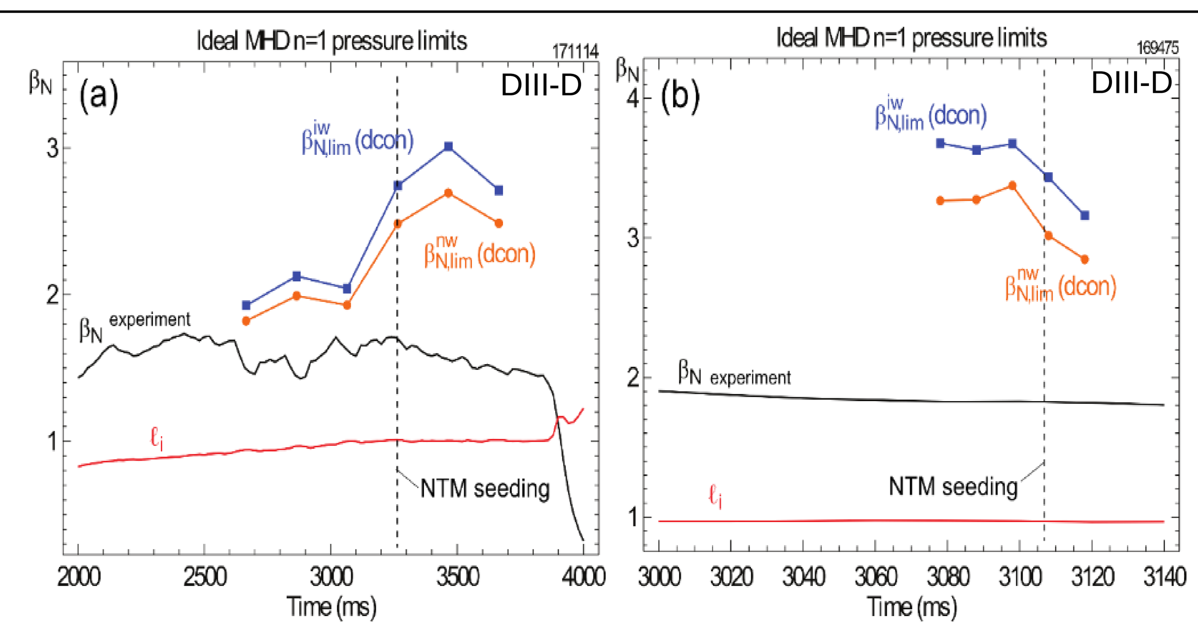
Lines between horizontal cell rows correspond to the position of ECE channels. The (3,2) resonant surface is marked by the dashed red line. Color bars show values of the phase.

(III) Additional information about the discharges

Tokamak	discharge	I_p[MA]	B_t[T]	β_N	κ	δ_{up}	δ_{low}
DIII-D	171114	1.6	1.9	1.8	1.825	0.07	0.65
DIII-D	169475	1.6	1.9	1.9	1.823	0.332	0.644
AUG	32940	0.8	2.5	2.17	1.757	0.118	0.493

DIII-D
Plasma rotation profiles





Comparisons of experimental β_N with calculated n=1 limits ("ideal wall" (blue lines) and "no wall" (red lines))

Conclusions and references

Conclusions:

❑ Experimental observations of (3,2) NTM seeding in the ASDEX Upgrade and DIII-D tokamaks show that the tearing mode formation can be a long process on the order of milliseconds.

❑ The mode amplitude observed in magnetic pickup coils immediately after the trigger event belongs in this case to a dominantly ideal kink mode structure, which converts into a tearing mode with the same helicity and nearly the same externally measured amplitude.

References

Identification of the island seeding (only if you have very good ECE measurements):

[1] V. Igochine et al.," Conversion of the dominantly ideal perturbations into a tearing mode after a sawtooth crash" Phys. Plasmas, 21, 110702 (2014)

[2] V. Igochine et al., "Tearing mode formation induced by internal crash events at different β_N", Nucl. Fusion, 57, 036015 (2017)

Non-linear MHD simulations:

[3] Q.Yu et.al., "NTM Excitation by Sawtooth Crashes and the Suppression of their Onset by Resonant Magnetic Perturbation", IAEA Conference 2018, TH-P5/19

[4] D. Meshcheriakov et al., "Tearing mode seeding by external magnetic perturbations", 45nd EPS conf., (2018)

Standard methods for identification of the mode structures are described here:

[5] V. Igochine (ed). "Active control of MHD instabilities in hot plasmas", Springer 2015, Chapter 3 by A.Gude.

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