

# Exploration of Alfvén Eigenmode physics via active antenna

## excitation in JET deuterium and hydrogen plasmas

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to be published in *Nuclear Fusion* special issue: Overview and Summary Papers from the  
28<sup>th</sup> Fusion Energy Conference (Nice, France, 10-15 May 2021)



### Alfvén Eigenmode Active Diagnostic (AEAD)

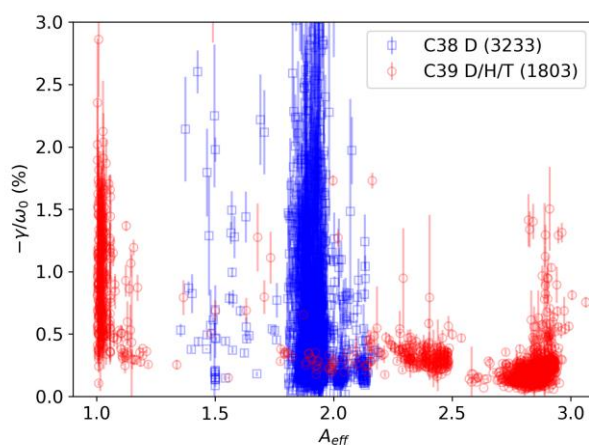
- 8 toroidally spaced antennas in JET [1,2]
- Independent power/phase:  $\sim 6$  A,  $|n| < 20$  [3]
- Scan frequency range  $f \sim 25$ -250 kHz
- Actively resonate with *stable* Alfvén Eigenmodes
- Fast magnetic coils measure plasma response:
  - Net damping rate  $\gamma < 0$
  - Resonant frequency  $f_0 = \omega_0/2\pi$
  - Toroidal mode number  $n$
- Compare  $f_0, \gamma, n$  with theory and simulation
- Predict AE stability of future tokamaks, like ITER

### Strategy for operation in JET DTE2 campaign

- Limitations in AEAD operational space:
  - Fewer AEs detected at high  $I_p, P_{NBI}, P_{ICRH}$  [4]
  - Decreased efficiency in X-point vs limiter [5]
  - Reduced accessibility in H-mode [6]
- Yet *novel* measurements have been made:
  - Stable EAE at high  $P_{NBI} + P_{ICRH} \approx 25$  MW [6]
  - Unstable-to-stable AE transition measured [7]
  - Simultaneous un/stable AEs observed [7]
- Alphas might destabilize AEs *outside the core* [8]
  - AEAD well-suited to assess alpha drive

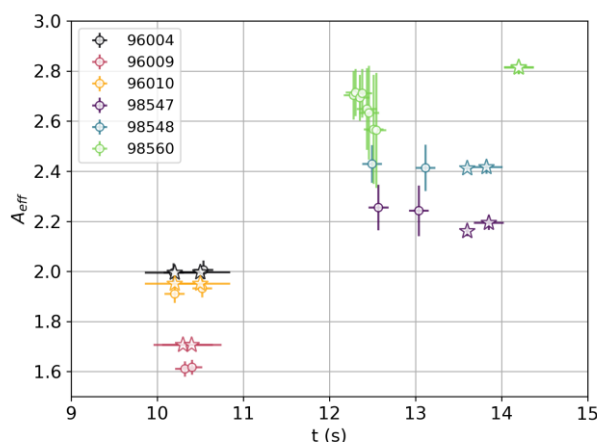
### Databases of AE stability in H, D, & T plasmas

- Thousands of stable AEs measured in JET campaigns
  - $\sim 7500$  in 2019-2020 D (C38) campaign [4-6]
  - $\sim 3000$  in 2020-2021 D/H/T (C39) campaign (*new*)
- C38 and C39 data exhibit increased damping with
  - Edge safety factor  $\rightarrow$  continuum damping [4,6]
  - Edge magnetic shear  $\rightarrow$  radiative damping [5,6]
- Transition from D to H to T plasmas in C39 campaign
  - Damping decreases with  $A_{\text{eff}} = \sum_i A_i n_i / n_e$
  - Observed before for  $|n| \leq 2$ , but not  $|n| \geq 3$  [9,10]
  - Mode conversion to kinetic Alfvén waves? [9]



### Isotope ratio measurements from stable AEs

- Effective mass evaluated via  $f_0 \propto (A_{\text{eff}})^{-1/2}$
- Measured before with the AEAD pre-upgrade [11,12]
- 6 plasmas with similar plasma parameters
  - $B_T \approx 2$  T,  $I_p \approx 2$  MA,  $q_0 \approx 1$ ,  $q_{95} \approx 3.5$
  - $n_e \approx 2-6 \times 10^{19} \text{ m}^{-3}$ ,  $T_e \approx 2-4$  keV
  - 3 H-D ( $A_{\text{eff}} \leq 2$ ) and 3 H-T ( $A_{\text{eff}} > 2$ )
- Good agreement seen for  $A_{\text{eff}}$  evaluated from...
  - Stable AE resonant frequencies (*circles*) [13]
  - Spectroscopic measurements (*stars*)
- Complementary  $n_D/n_T$  measurement in JET DTE2



- [1] Fasoli 1995 PRL  
[2] Panis 2010 NF  
[3] Puglia 2016 NF  
[4] Tinguely 2020 PPCF  
[5] Tinguely 2021 NF  
[6] Tinguely 2021 Submitted to NF  
[7] Tinguely 2021 APS DPP  
[8] Fitzgerald 2021 In progress  
[9] Fasoli 2000 PLA  
[10] Testa 2012 NF  
[11] Fasoli 2002 PPCF  
[12] Testa 2015 NF  
[13] Puglia 2021 In progress



This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

This work was supported by US DOE Award DE-SC0014264.