Detecting ELM originated by Sawtooth at DIII-D

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Introduction

1. Suppressing edge localized mode (ELM) in a tokamak is essential to prevent disastrous damage to the wall.
2. Adaptive ELM controller using RMP has successfully suppressed ELM at KSTAR and DIII-D [1-4].
3. We are going to upgrade the adaptive ELM controller by detecting an ELM originated by Sawtooth in D-α signals which can not be suppressed by RMP.

Focus of the poster

1. Summarizing the ELM suppression results using the adaptive ELM controller
2. Detecting Sawtooth instabilities in D-α signals signal using ECE diagnostics

1. Basic descriptions of the ELM controller

- To harness nuclear fusion energy, donut-shaped research facilities (tokamak) were built and tested.
- High confinement mode (H-mode) of operation was discovered which can enhance the performance of a tokamak. [8]
- An instability called edge localized mode (ELM) is accompanied with H-mode.

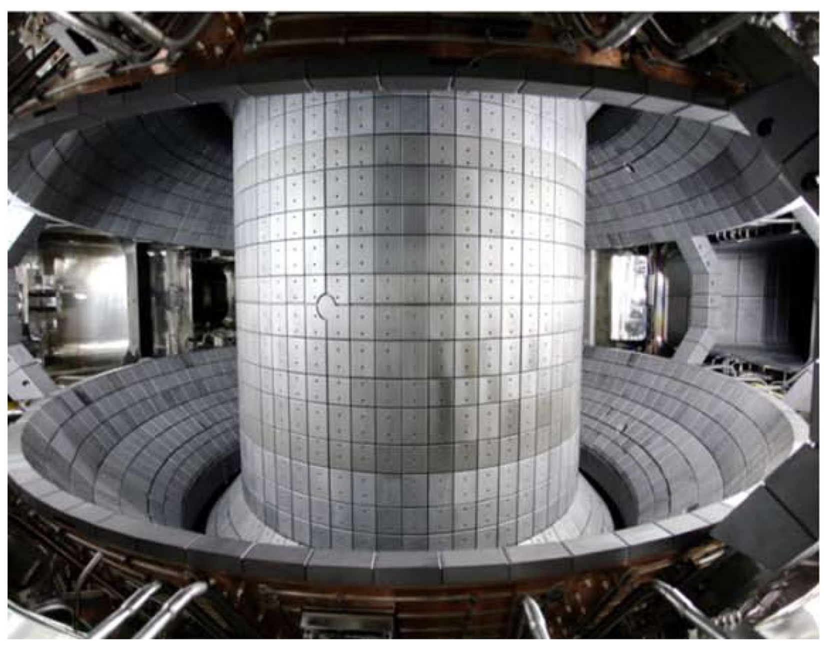


Fig.1. Inside of KSTAR tokamak [7]

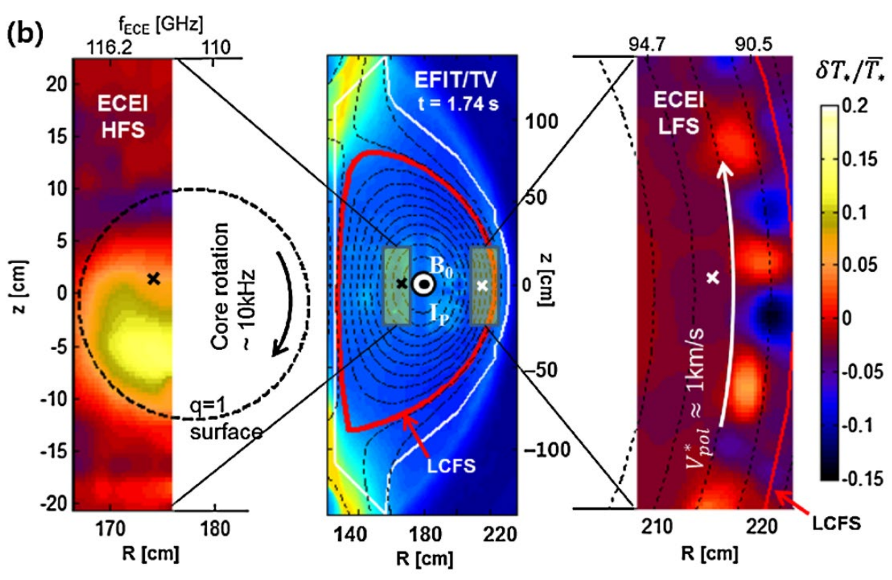


Fig.2. 2D visualization of Edge localized mode (ELM) at KSTAR [5]

- ELM in a tokamak can damage the first-facing wall.
- The damage will be severe in ITER or larger scale tokamaks.
- Applying Resonant magnetic perturbation (RMP) to a tokamak is considered as a promising candidate for ELM mitigation.

- In-vessel control coil (IVCC) can impose the RMP to a tokamak.
- To achieve high performance plasma, IVCC currents should be optimized.
- The novel feedback adaptive RMP ELM controller was developed by Plasma control group [2-4].

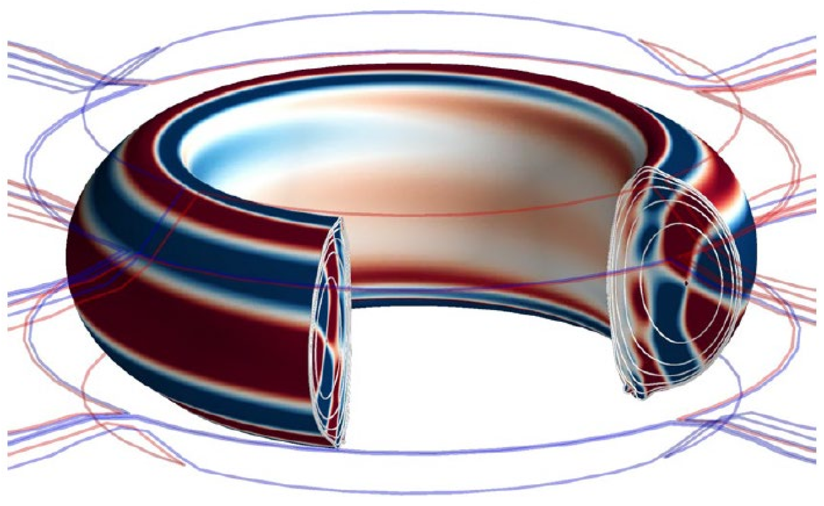


Fig.3. KSTAR 3D coils and fields [6]

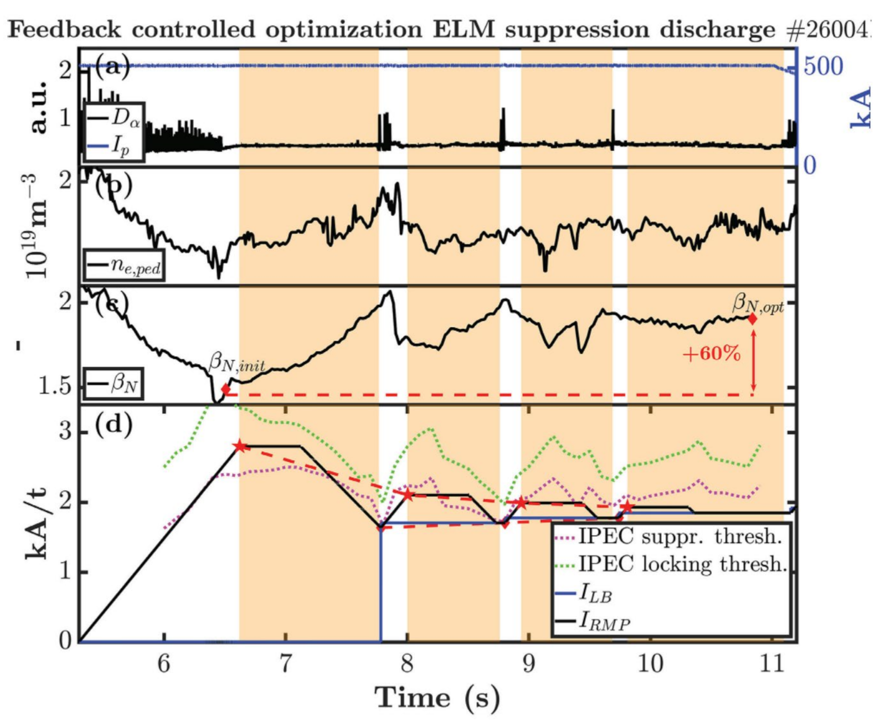


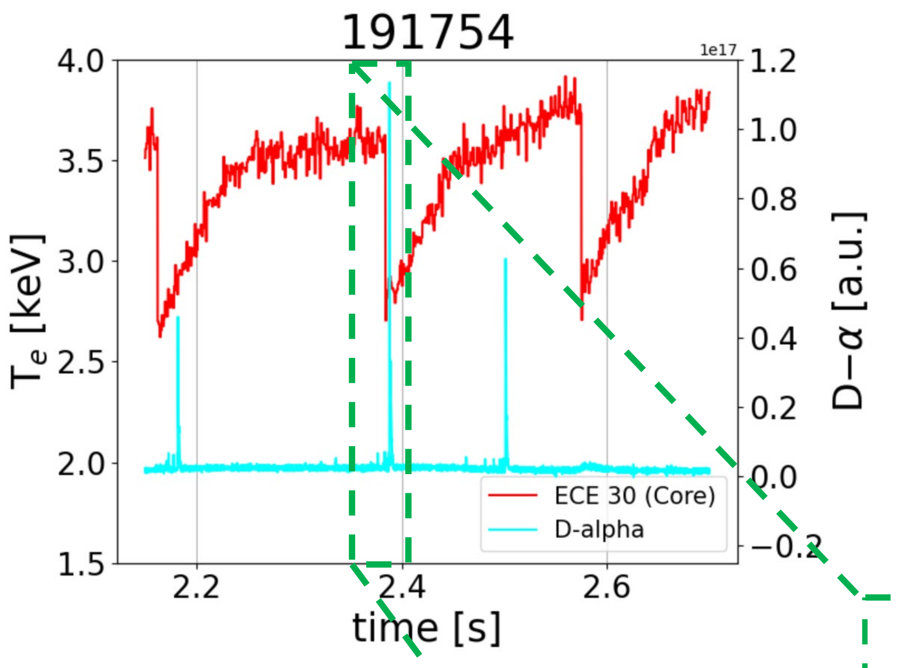
Fig.4. Results of the adaptive ELM controller at KSTAR [2]

- Hysteresis effect in ELM suppression gives a chance to lower IVCC currents.
- Ramp-down IVCC currents until ELM suppression is lost.
- If ELM suppression is lost, ramp-up IVCC currents again to gain ELM suppression.
- BY doing so, ELM can be suppressed with optimized plasma confinement.

Issues and goals

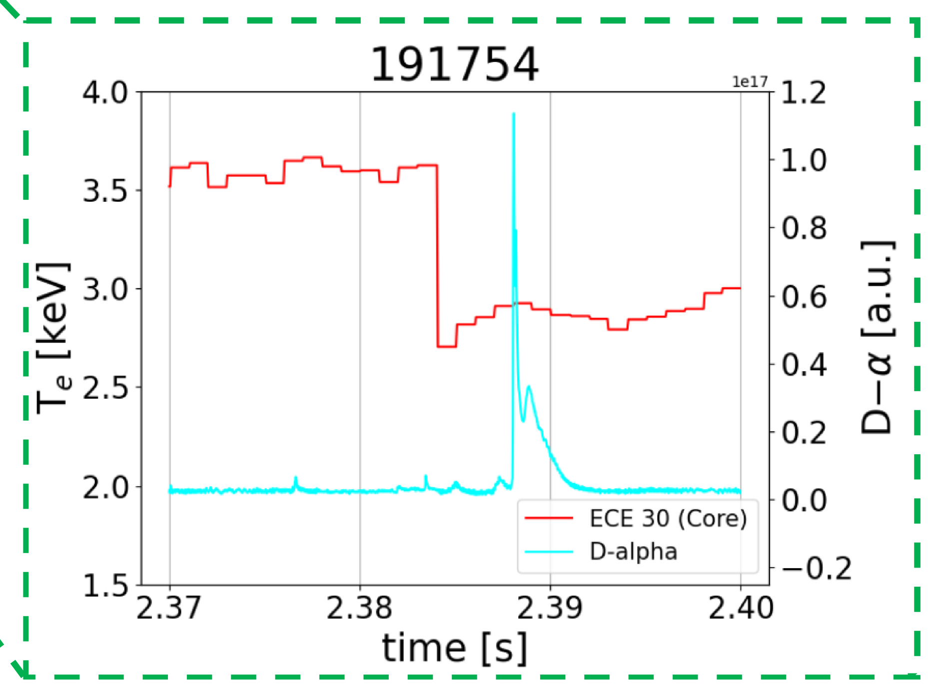
- ELM originated from Sawtooth oscillation can not be suppressed by RMP.
- To optimize the confinement, IVCC currents should not be increased for the ELM originated by Sawtooth.
- Detecting the ELM originated by Sawtooth is crucial to upgrade the adaptive ELM controller.

2. Sawtooth in ECE with a D-α peak

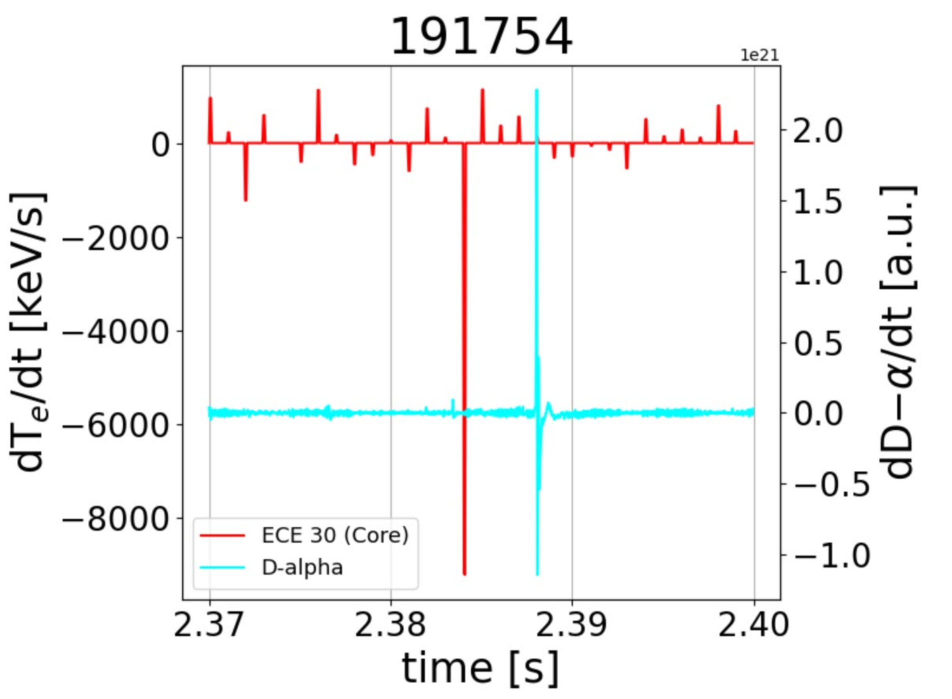


- Electron cyclotron emission (ECE) diagnostics at DIII-D tokamak can measure electron temperature at core plasma in real-time (≈ 20 kHz).
- Filter scope diagnostics at DIII-D tokamak can measure Deuteron Balmer alpha lines (D-α) in real-time (≈ 50 kHz).

- Sawtooth oscillation in core plasma can induce ELM. [9]
- D-α peak right after sudden drop of core T_e may present an ELM originated by Sawtooth.
- We do not need to adjust IVCC currents for the ELM originated by Sawtooth.



3. Detecting ELM originated by Sawtooth



1. Taking time derivative on T_e and D-α signals
2. Detecting peaks in signals by comparing derivative with a threshold
3. If a D-α peak is detected after a T_e peak no more than 5ms, interpreting the signal as an occurrence of an ELM originated by Sawtooth.
4. In this case, IVCC currents are not modified.

4. Conclusions and Future works

Conclusions

- Through this project, I could review the adaptive ELM controller developed by our group.
- I could learn Sawtooth oscillation at core of fusion-grade hot plasmas and ELM originated by Sawtooth.
- I could consider the way how to detect ELM originated by Sawtooth.

Future works

- Optimizing threshold for signal peak detection
- Considering physics-based time lag between T_e drop and a D-α peak
- Integrating the algorithm with the adaptive ELM controller and testing at DIII-D pcs

Acknowledgements

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