Contribution ID: **99** Type: **Contributed Poster**

DECAF update and study of the relationship between electron temperature collapses and disruption triggering through DECAF analysis

Tuesday, 3 September 2024 17:35 (25 minutes)

Rapid plasma dynamics preceding some disruptions in tokamak devices can be inferred through the electron temperature profile evolution due to the fast thermal transport along the field lines. In particular, local collapses in the electron temperature profile are the signature of nonlinear events such as flux surface tearing, observed due to the sudden thermal transport that follows changes in the confining field line topology. In some cases, such flux surface evolution can lead to the formation of Neoclassical Tearing Modes (NTMs), which can then lock and disrupt the plasma. In other cases, the reorganization of the magnetic field lines during an electron temperature collapse that precedes an accompanying current spike indicates that a fast reconnection event has occurred, which is often followed by a plasma disruption.

This work presents a general framework to identify and categorize electron temperature crashes, along with specific analysis applications. Identification of the crash time and radial location is performed by convolving a subset of electron temperature profile channels with a specialized kernel [1]. Once a collapse event has been identified, all of the available channels are used to reconstruct a 'crash profile'containing the features that allow the categorization of each event as a sawtooth crash, ELM, or a more general full electron temperature collapse. While all three events can seed NTMs, the required plasma state leading to NTM formation after a crash differs for each event type. It is shown that the plasma state before the thermal collapse, along with the characteristics of the electron temperature crash can give a significantly early prediction of plasma disruptions. The formalism presented in this work has been implemented in the DECAF* code [2], allowing the analysis of a wide range of shots across multiple tokamak devices.

Supported by US DOE Grants DE-SC0020415 and DE-SC0021311.
*U.S. and international patents pending.

References

[1] A Gude et al 2017 Plasma Phys. Control. Fusion 59 095009.
[2] S.A. Sabbagh, et al., Phys. Plasmas 30, 032506 (2023); https://doi.org/10.1063/5.0133825

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Session Classification: Prediction & Avoidance

Track Classification: Prediction and Avoidance