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Real-time applications of electron cyclotron emission interferometry for disruption avoidance in JET

In preparation for the upcoming deuterium-tritium (D-T) campaign on JET, efforts are being dedicated to developing control systems able to identify and safely terminate plasmas that are evolving towards a compromised state. This could mean reaching a condition at risk of disruption or otherwise missing the goal of high-performance conditions, resulting in a waste of strictly budgeted nuclear fuel. The possibility of using empiric metrics to identify these processes, as a proxy for the complicated underlying physical phenomena is appealing for its simplicity. In particular, electron cyclotron emission (ECE) interferometry measurements were recently used to define metrics related to electron temperature hollowing and edge cooling.

The ECE interferometers [1] are among the main sources of electron temperature measurements at JET. The interferometers provide absolutely calibrated electron temperature profiles covering both the low and high field sides, for the full range of magnetic fields used at JET. Data produced by the extraordinary-mode interferometer can now be accessed by the JET real-time data network (RTDN) and employed as inputs for control systems. Every Te profile is obtained from 16 ms of interferogram data (60 Hz). Real-time processing takes less than 1 ms, after which data are available to the RTDN, and does not require magnetic reconstruction to convert spectra into profiles.

The first application for these real-time data in plasma control was the monitoring of electron temperature profile hollowness, parametrized using a simple and robust definition. A control system based on a hollowness threshold was applied during the ramp-up phase of hybrid discharges [2] since 2019. When this threshold was exceeded, the control system intervened with a slow plasma termination command. Each pulse was terminated safely, before the start of the auxiliary heating phase, avoiding a disruption.

The hollowness metric, together with an estimation of the temperature logarithmic gradient at the plasma outer-core, is also being considered for applications in disruption avoidance in baseline plasmas, where it would act together with MHD and radiation detectors.

[1] S. Schmuck et al., Review of Scientific Instruments (2016)
[2] C. D. Challis et al., Nuclear Fusion (2015)

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Track Classification: Prediction and Avoidance