Real-time control of the CIII emission front using MANTIS

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One of the major challenges in realizing a commercially viable fusion reactor is the handling of the power and particle exhaust into the divertor of most used magnetic configurations today. A proposed approach is operation in the so-called detached regime. An actuator, often local neutral gas puffing, increases the power loss mechanisms, leading to a significant particle and heat flux reduction at the divertor target. However, such a detached regime has its internal dynamics and is sensitive to external perturbations that can be controlled through active monitoring and control of the gas puff actuator in real-time. Unfortunately, in detached conditions, many of the existing plasma diagnostics have a low signal-to-noise ratio or are not real-time capable. We sensed the radiation front location in real-time in TCV with imaging spectrometer MANTIS. In detached TCV L-mode plasmas, the radiation front is well approximated by the C-III emission front. The poloidal location of this front can be estimated in real-time by newly developed image processing software acting upon direct camera images. The present set-up features a temporal resolution of 5 ms and a -hardware limited- latency of 1 ms. A gas introduction valve with Deuterium gas was used as actuator. The input-output dynamics of the detached plasmas identified using a multi-sine system identification approach in two L-mode discharges. This yields the transfer function from the gas valve actuation to the measured front location, which was used to synthesise a conservative controller off-line. Subsequent closed loop experiments were carried out in which good tracking of the radiation position reference was achieved without additional tuning of the feedback controller.

We will present MANTIS and the real-time emission front identification algorithm. We then will introduce the concept of system identification and the specific multi-sine identification procedure applied to the gas injection actuator. We show how the controller was derived and the resulting performance in TCV plasma detachment experiments.

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