Control system-ELM synchronization in the ASDEX Upgrade tokamak

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We perform time domain time series analysis on signals that track global changes in the plasma and control system associated with the occurrence of Edge Localized Modes (ELMs) in the ASDEX Upgrade (AUG) tokamak. The ELM occurrence times are determined from the (thermo-) electric current into an outer divertor tile. We compare these with toroidally integrating signals that provide simultaneous high time resolution measurements of the current in the vertical control system flux loops, the plasma total MHD energy and the position of the outbound plasma edge. We find that under certain conditions of plasma electron cyclotron resonance heating and nitrogen seeding, the vertical control system current continually oscillates. Larger intrinsic ELMs that result in well-defined drops in plasma total energy and change in edge position occur around a specific phase of these oscillations in the vertical control system current signal. This is consistent with the occurrence of natural ELMs being paced by a synchronization between the plasma dynamics and the control system. When pellets are injected to precipitate ELMs, this temporarily changes the plasma conditions and this can be used to test whether this synchronized state is attractive, limit cycle dynamics; if so, the phase relationship can be temporarily lost, but will then recover once the plasma line-of-sight density returns to its unperturbed value. Such a control system-plasma interaction naturally paces ELMs without the need for externally applied ‘kicks’ in the vertical coil current and could thus in principle play a role in ELM mitigation. Previously [1] on JET we found that the phase of full flux loop current signals that track global changes in the plasma and control system can contain information on when ELMs will occur. These results confirm that this can also be the case in AUG plasmas.


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