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Joint experiments tailoring the plasma evolution to maximise pedestal performance

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The pedestal height has been significantly increased by optimising the plasma conditions at H-mode access in joint experiments in JET, ASDEX Upgrade, MAST and TCV. A predictive pedestal model has been developed negating the need to specify the global β and core density peaking. This model predicted that doubling the core pressure during the L-mode phase in JET would increase the pedestal height by 20%. Experiments on JET therefore tailored the plasma evolution to increase the core pressure before the pedestal is formed to stabilise ballooning modes. Small changes to the magnetic geometry coupled with early impurity seeding increased the H-mode threshold power by a factor of two. The resultant 70% increase in core pressure before pedestal formation resulted in an 18% increase in pedestal height, in excellent agreement with ab initio Europed predictions.

We have demonstrated causality that an increased core pressure stabilises ballooning modes allowing hotter pedestals using the flexibility in magnetic configuration in the medium-sized devices MAST and TCV. By shifting a double-null configuration upwards by 2cm in MAST, it is possible to increase the L-H transition threshold power significantly. On returning to a balanced configuration, an immediate L-H transition is triggered, allowing a systematic variation of the core plasma pressure upon pedestal formation. It is observed that the pedestal top electron pressure before the first ELM is increased by 100% when the global beta at the moment of the L-H transition is increased by 25%. Pedestal performance with variation in core pressure has also been tested on TCV by switching configuration rapidly from unfavourable GradB drift and long divertor connection length to favourable GradB configuration with shorter divertor legs. Stability analysis confirms that the enhanced Shafranov shift stabilises the ballooning modes, allowing the pedestal to reach higher pressures before the ELM crash. Furthermore, a self-consistent averaged ballooning equation has been derived at low shear to explicate succinctly the benefit of increasing global beta in s-alpha stability space from the enhanced Shafranov shift and plasma shaping. Finally, we test an ITER-relevant method to increase the core pressure prior to pedestal formation by suppressing the L-H transition using non-axisymmetric perturbations in ASDEX Upgrade.

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