

H-mode and ELM Dynamics Studies at Near-Unity Aspect Ratio in the PEGASUS Toroidal Experiment and their Extension to PEGASUS-Upgrade

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Tokamak operation at near-unity A provides access to advanced tokamak physics at modest plasma and device parameters. Ohmic H-modes are routinely attained on the PEGASUS ST, in part due to the low L-H power threshold P_{LH} arising from low- B_T operation at $A \sim 1$. Their characteristics include: improved τ_e , with $H_{98} \sim 1$; edge current and pressure pedestal formation; and the occurrence of ELMs. Recent experiments have examined magnetic topology and n_e dependencies of P_{LH} . P_{LH} exceeds the ITER L-H scaling by 10–20 \times , with P_{LH}/P_{ITPA08} increasing sharply as $A \rightarrow 1$. No P_{LH} -minimizing n_e has been found. Unlike at high- A , P_{LH} is insensitive to limited or diverted magnetic topology to date. Modest pedestal values at $A \sim 1$ afford unique edge diagnostic accessibility to study ELMs and their nonlinear dynamics. $J_{edge}(R, t)$ measured through a Type I ELM shows a complex pedestal collapse and filament ejection. These studies are being extended to higher I_p and longer pulse length with LHI non-solenoidal startup to improve MHD stability.

An upgrade to the PEGASUS ST, PEGASUS-Upgrade, is planned to exploit low- A characteristics and diagnostic accessibility to support the validation of the physics basis needed for ITER and beyond. Unique studies will be pursued in three areas: local measurements of pedestal and ELM dynamics at Alfvénic timescales; direct measurement of the local plasma response to application of 3D magnetic perturbations with high spectral flexibility; and extension of LHI startup to NSTX-U relevant confinement and stability regimes. Significant but relatively low-cost upgrades to the facility are proposed to support them: a new centerstack with larger solenoid and doubled TF conductors; a new TF and reconfigured OH power supplies; and installation of an extensive 3D magnetic perturbation coil system. PEGASUS-Upgrade will provide 0.3 MA plasmas with pulse lengths of 50–100 ms I_p flattop, aspect ratio < 1.25 , and toroidal field up to 0.4 T.

This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Fusion Energy Sciences, under Award Number DE-FG02-96ER54375.