

## **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  $\tau_e$ , 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.

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