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Key steps toward low-recycling, liquid lithium fusion devices in LTX-β

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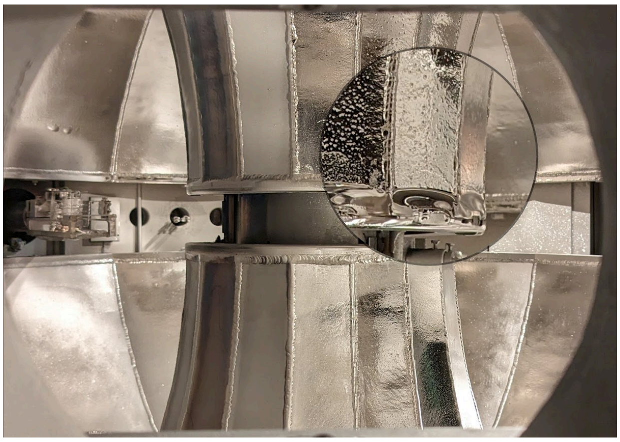

Figure 1: Liquid lithium coating the internal LTX-β shell

The Lithium Tokamak Experiment-β (LTX-β) has recently demonstrated several key prerequisites for the low-recycling liquid lithium approach to fusion [1], which is a potential solution to the major challenges of confinement [2] and power handling. Advances in operational techniques with liquid Li coatings fully surrounding the plasma achieved good plasma performance [3], the hot-edge low-recycling regime, and neutral beam heating and fueling [1]. Experiments with clean liquid Li walls reproduced plasma performance similar to that with solid Li [4], including the key result of a hot, low-recycling edge (R~0.5). Low-recycling reduces edge neutral cooling, and a hot edge can improve confinement by suppressing temperature gradient driven turbulence. In the low-recycling regime, replacing edge gas puffing with core fueling is essential in order to overcome wall pumping of the plasma density without cooling the edge [4,5,6]. With liquid Li, LTX-β showed neutral beam fueling and heating with a ~20% increase in plasma density and high normalized confinement [1].

LTX-β has now resumed operations after upgrades to further explore this regime and address open questions regarding low-recycling and liquid metals. The primary upgrade realigned the neutral beam to enable full beam energy and current [1,2]. Along with new beam and fast ion diagnostics, the upgrade increases beam fueling and enables study of dominant auxiliary heating with reduced ∇T. Plasma performance and new studies will be further enhanced by a real-time plasma control system (PCS), electron cyclotron heating (ECH) start-up, between-shots Li evaporation, and improved gas fueling systems.

An expanded diagnostic suite will enable detailed study of the hot, low density, low collisionality edge that is unique to the low recycling regime, in which ions can remain mirror trapped in the scrape-off layer (SOL) for long durations, potentially reducing strike point heat flux through several mechanisms. Diagnostics include edge/SOL and high-field-side Thomson scattering with improved sensitivity and spatial coverage, novel poloidal electric field measurements, diagnostic limiters and IR thermography for SOL heat flux width estimates, surface exposure probes, and improved toroidal and poloidal Lyman-alpha arrays for recycling analysis.

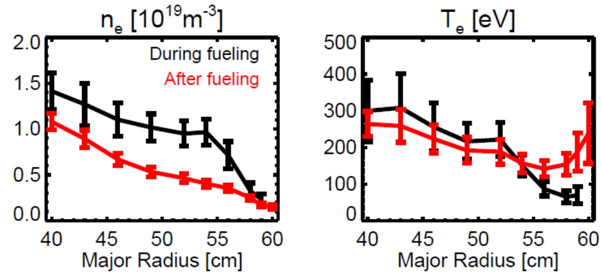

Figure 2: Hot edge, flat T_e profile observed with liquid Li

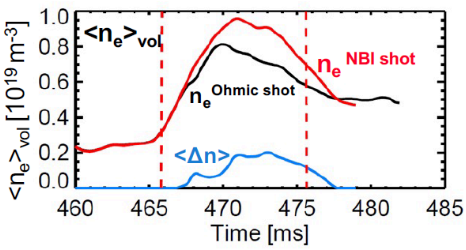

Figure 3: NBI increases n_e compared to ohmic shot

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