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On-demand destabilization of edge turbulence and robust ELM elimination with Boron powder injection in EAST[1]

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We report the achievement of highly reproducible H-mode discharges with elimination of edge-localized modes (ELMs) with boron (B) powder injection in EAST. A key ingredient of the observed ELM elimination is the destabilization of a continuous edge harmonic oscillation above a threshold B edge concentration; the enhanced turbulence drives transport to maintain constant line-average density with modest confinement improvement. The observed mode exists in the pedestal region ρ ˜0.89-1, peaking in amplitude inside the separatrix, while also being manifest on the open field lines at the divertor targets. We hypothesize that the density perturbation induced by the B ablation generates an oscillation with features of a geodesic-acoustic mode that increase pedestal particle transport via orbit loss. This ELM-stable regime has controlled core impurity concentration, and no strong wall conditioning or hysteresis: ELMs resume within 0.5 s of termination of B powder injection. The operating window for this scenario persists over a wide range of plasma conditions, wider by far than any other ELM control method, and seemingly insensitive to normalized pedestal electron collisionality $\nu^*_{\mathrm{e,\,ped}}$, edge safety factor q_{95}, plasma toroidal rotation that was varied by the mix of auxiliary heating schemes, and even main ion species. In contrast to ELM elimination by lithium powder injection in tokamaks, B powder injection does not result in reduced recycling and enhanced wall retention. The applicability to future devices includes projecting the minimum B injection rate for ELM elimination, which was measured to increase with heating power in EAST, and control of injected particle inventory; modeling-based assessment to future devices has commenced.

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