Study of the L–I–H transition with a new dual gas puff imaging system in the EAST superconducting tokamak

The intermediate oscillatory phase during the L–H transition, termed the I-phase, is studied in the EAST superconducting tokamak using a newly developed dual gas puff imaging (GPI) system near the L–H transition power threshold. The experimental observations suggest that the oscillatory behaviour appearing at the L–H transition could be induced by the synergistic effect of the two components of the sheared m, n = 0 E × B flow, i.e. the turbulence-driven zonal flow (ZF) and the equilibrium flow. The latter arises from the equilibrium, and is, to leading order, balanced by the ion diamagnetic term in the radial force balance equation. A slow increase in the poloidal flow and its shear at the plasma edge are observed tens of milliseconds prior to the I-phase. During the I-phase, the turbulence recovery appears to originate from the vicinity of the separatrix with clear wave fronts propagating both outwards into the far scrape-off layer (SOL) and inwards into the core plasma. The turbulence Reynolds stress is directly measured using the GPI system during the I-phase, providing direct evidence of kinetic energy transfer from turbulence to ZFs at the plasma edge. The GPI observations strongly suggest that the SOL transport physics and the evolution of pressure gradient near the separatrix play an important role in the L–I–H transition dynamics. To highlight these new physics, the previous predator–prey model is extended to include a new equation for the SOL physics. The model successfully reproduces the L–I–H transition process with several features comparing favourably with GPI observations.