Time-resolved evolution of low frequency oscillation in the edge plasma at L-I-H transition of HL-2A Tokamak

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Triggering mechanism of L-H transition in fusion device has been a crucial issue since the first H-mode was found on the ASDEX [1]. Due to the rapid L-H transition, it is difficult to find a causal relationship for explaining L-H transition. Theoretically, a predator-prey mode was proposed by Kim-Diamond [2], which predicts L-H transition should pass through an intermediate limit-cycle oscillation (or intermediate confinement phase, labeled as I-phase) if input power gradually rises. Experimentally, this oscillation was widely observed in AUG [3], DIII-D [4], TJ-II [5], EAST [6], NSTX [7], etc. The interaction of shearing flow and turbulence in I-phase and the critical role of limit-cycle oscillation (LCO) on L-H transition were studied in detail. The study of LCO time-resolved evolution in density, potential, electron pressure gradient, and energy transfer rate, etc, at L-I-H transition, is helpful to understand the LCO nature and clarify the hidden physics mechanisms for L-H transition.

In this paper, we report the time-resolved evolution of LCO with 2-3 kHz at L-I-H transition, measured by a four-step Langmuir probe array in the HL-2A edge plasma. In L-phase, there is weak correlation between radial electric field (Er) and turbulence amplitude. In I-phase, Er and density envelope (20-100 kHz) have a limit-cycle relation, and the former lags the latter about $\pi/2$, consistent with predator-pray model [2]. Meanwhile, the Reynolds stress is modulated by 2-3 kHz oscillation. Turbulence is periodically suppressed, where energy is transferred from turbulence to the low frequency flow (<5 kHz). When plasma enters H-mode, the LCO disappears, and a higher frequency electrostatic oscillation appears with $f = 55$-60 kHz and $m$~15-18, which has kinetic ballooning mode characteristic.

References


