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Sawtooth induced heat pulse propagation in the ADITYA tokamak

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Sawtooth remains one of the active areas of research in thermonuclear fusion physics, considering removal of high-Z impurities like Tungsten (W), helium ash from the plasma core and its impact on triggering Neoclassical Tearing Mode instabilities [1]. The sawtooth cycle consists of periodic rise and collapse of plasma temperature and density in the core region. With sawtooth crash, heat is observed to deposit beyond inversion radius and it is transported diffusively to the edge region. Based on this assumption, it has been widely used to understand and test the theoretical models for the transport of heat in tokamak device [2-4].

To match the experimental observed fast propagation of the sawtooth induced heat pulse, higher values of the electron heat thermal diffusivity, about two to ten times that of estimate from power balance analysis is required [4]. To explain higher values of thermal diffusivity, stochastization of magnetic field was proposed to be responsible. This study was first initiated four decades ago in ORMAK device [2], however, till date no clear experimental observation indicating role of stochastization of magnetic field in fast propagation of sawtooth induced heat pulse is reported.

Interestingly, in ADITYA discharges, we observe corresponding to every sawtooth crash, immediate rise in mirnov signal amplitude followed by the inverted sawtooth in the H_α spectral line emission emitting from the edge region of plasma as shown in figure 1.

The time-lag analysis of soft X-ray and H_α signal shows that sawtooth pulse propagates from core to edge region within 200 μsec. The sawtooth induced heat pulse is tracked using electron cyclotron emission diagnostics. The transport of this heat pulse is found to be diffusive in nature. The estimate of electron heat diffusivity of heat pulse χ_e^{hp} is found to be around 58 m^2/s, which is larger by a factor of 10 compared to that implied by power balance estimate.

The MHD mode analysis shows presence of m/n = 3/2 & 2/1 modes. These modes overlap immediately after sawtooth crash and form a stochastic magnetic field region. Thus, this clearly gives experimental evidence supporting Fredrickson et al [5] prediction, that stochastic magnetic field is responsible for fast transport of sawtooth induced heat pulse.

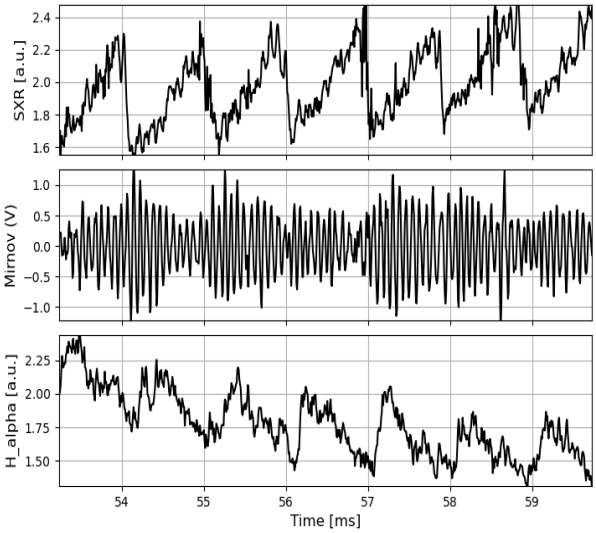

Figure 1. Time series plot of Soft X-Ray emission, Mirnov oscillation, and H_α spectral emission.

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