Study of nonlinear phenomena in a tokamak plasma using a novel Hilbert Transform technique

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Tokamak plasma is rich in non-linearities of various kinds. The interacting low frequency long wavelength coherent modes are dominant in the core and the confinement regions whereas modes in a broad range of frequencies and wavelengths typically characterize the edge plasma. These interactions have been studied conventionally using a varieties of techniques including Fourier and wavelet transforms.

Recently a new technique as empirical mode decomposition (EMD) has been introduced which allows extraction of a finite number of intrinsic modes from the data. The Hilbert transform of such modes help to determine instantaneous frequencies and sharp changes in the instantaneous frequencies are identified as a signature of nonlinear phenomena in the data. This method is suitable for studying non-linearity present in the transient events.

The plasma transients during start-up and current termination phases in ADITYA tokamak have been studied using this technique. The analysis of signals from an array of Mirnov coils shows that nonlinear interaction among low frequency long wavelength modes plays an important role in current penetration during the start-up phase. On the other hand, interaction among low m modes lead to disruption during current termination phase.

Langmuir probe data from the turbulent edge plasma have also been analyzed using this technique. The data show signatures of intermittency in the form of sporadic bursts of mode energy. The Hilbert spectrum also allows evaluation of the degree of non-stationarity. It is observed that only high frequency signals (exceeding 20 kHz) are non-stationary.