§58. Indication of Bulk-ion Heating by Energetic Particle Driven Geodesic Acoustic Mode

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A bursting up-chirping instability which associates an enhancement of low energy neutral particle flux, is observed for low density plasmas ($n_e(0)<1.0x10^{18}[m^{-3}]$) on LHD with the Bt=-1.5T and Rax=3.75m configuration. This mode is only observed when the Electron Cyclotron resonance Heating (ECH) is intensively applied to LHD plasmas and the energetic particles are produced by tangentially injected Neutral Beam (NB), simultaneously. By using a Mirnov-coil array, the toroidal mode number of the instability is identified to be zero, while the poloidal mode number is two, i.e., n=0/m=2.

In Fig.1 typical wave forms of signals from a Mirnov-coil and Neutral Particle Analyzer(NPA) are shown for a single bursting event. As shown here, the mode was excited at around t=1.792s. The initial mode frequency was 50kHz. From its electron temperature dependence and its toroidal mode number, the mode is considered as a Geodesic Acoustic Mode exited by the NB produced energetic particles. At the initial phase of the mode, it grew very quickly and its effective growth rate (γ_{eff}), which is evaluated from the e-holding time of the mode amplitude, was $4.6x10^3[s^{-1}]$. When the mode amplitude reaches to certain level, the growth rate became smaller ($\gamma_{eff}=2.3x10^2[s^{-1}]$) and the ion temperature, which is evaluated from the slope of NPA, started to increase simultaneously. The mode amplitude and ion temperature reached their maximum values at around t=1.795s and started to decrease gradually after the timing. What was interesting is the mode frequency reached to 80kHz, which is almost comparable to the orbital frequency(ω_0) of the energetic particles as is defined $\omega_0=v_{b0}\iota/2\pi R$ where v_{b0} is the initial velocity of the beam ions. What was more is the up-sweeping rate of the mode frequency was changed from 13.4 [MHz/s] to 3.4 [MHz/s] at the timing of amplitude maximum.

The ion temperature behavior in correlation with the temporal behavior of the mode-activity indicates that there seems to be an energy transferring channel from GAM to bulk ions as predicted in Ref.[1].

[1] M.Sasaki, et.al., PPCF **53**(2011)085017

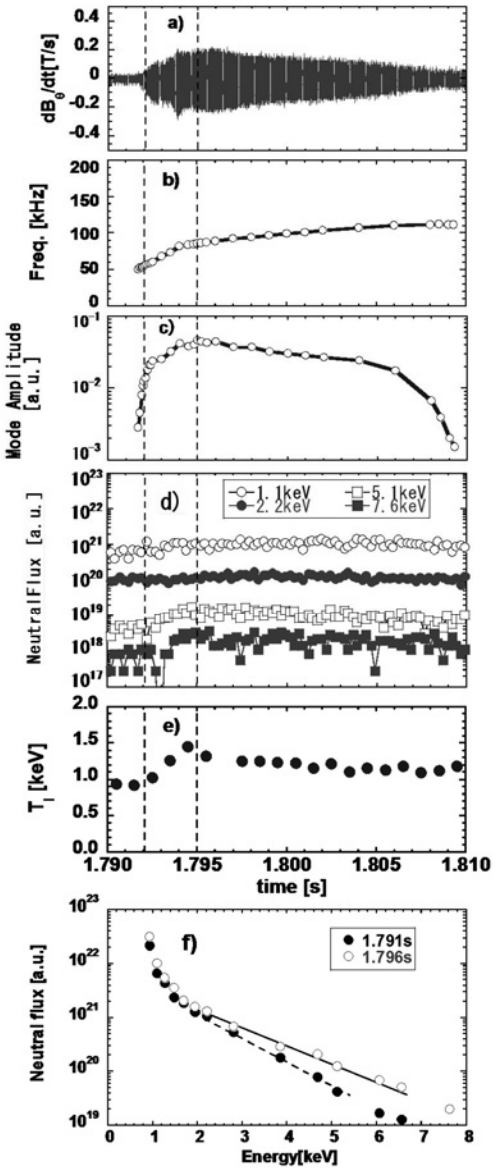

Fig.1 Typical waveforms of Mirnov coils and NPA signals for a single bursting event. (a)Waveform of a Mirnov coil, (b)frequency and (c) amplitude of the bursting event. (d)Neutral particle flux for 1.1keV(○), 2.2keV(●), 5.1keV(■) and 7.6keV(□) at the event. (e)Temporal behavior of ion-temperature evaluated by the exponential fitting of the NPA-spectra. (f)The energy spectra measured by tangential NPA at t=1.791s(●) and (1.796).