§48. Large Potential Oscillations Due to Geodesic Acoustic Modes Excited by Energetic Ions in the Core Region of a Reversed Shear Plasma on LHD

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In LHD, the reversed magnetic shear (RS-) plasma having an negative sign of the curvature of the safety factor ($q''(r_o) < 0$, r_o: zero shear position) is routinely produced by intense counter neutral beam current drive in neon doped plasma. In thus produced RS-plasmas, reversed shear Alfvén eigenmodes (RSAEs) with characteristic frequency sweeping was for the first time detected together with energetic ion driven n=0 mode in a helical plasma [1]. The frequency of the n=0 mode agrees with that of the geodesic acoustic mode (GAM), and was identified to be energetic ion driven GAM (which is also called EGAM [2]). Interestingly, a multitude of frequency sweeping modes generated through nonlinear mode coupling between the energetic ion driven GAM and RSAE [1, 3]. The energetic ion driven GAM will generate potential fluctuations as same as the GAM excited through nonlinear coupling of drift waves such as ITG.

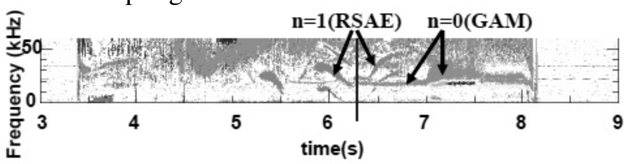

Fig.1 A typical spectrogram of toroidal mode number derived from a magnetic probe array, where ECH is applied from t=7s to t=7.5s. The vertical line indicates that the minimum of the rotational transform passes 1/3, and is the reference time to adjust the timing of several repetitive shots.

The plasma potential has been measured with heavy ion beam probe in the core region of the RS plasmas where a typical time evolution of the toroidal mode number *n* and frequency is shown in Fig.1. The radial profile of potential oscillations due to the GAM in the plasma core region is shown in Fig.2, where the data are taken at 0.2 s before the reference time defined in Fig.1. The potential fluctuations has a peak around *r/a*=0.1 - 0.2, and is thought to be more inside for that of electron temperature fluctuations due to GAM which is at r/a~0.3 as shown in Fig.3 in ref. [1]. It should be noted that the relative *rms*-amplitude to electron temperature ϕ_{rms}/T_e exceeds ~30% in the plasma core region (*r/a* < 0.4). That is, the instantaneous amplitude of the potential fluctuation is close to ~50 % of T_e. The radial profile shape of the potential fluctuations due to GAM indicates the generation of zonal flow having a characteristic frequency around ~18 kHz. It should be noted that the potential fluctuations come from plasma displacement due to GAM is very small. The shear of poloidal

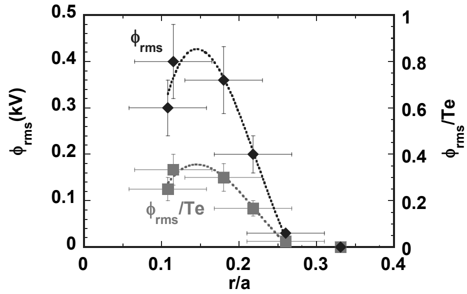

Fig.2 Radial profiles of the *rms*-potential fluctuation of GAM and the relative amplitude to T_e. .

velocity is estimated to be in the range of ~ 1×10^4 s^{-1}. So far, it is not clear whether or not this range of shearing rate would affect background micro-turbulence.

When the electron temperature is increased by ECH, the frequency of the GAM is also increased exhibiting bursting character and rapid upward frequency-chirping, as shown in Fig.3(a). Relaxation oscillations with repetitive large negative pulses which reach up to 1.5 kV are excited in the potential signal near the plasma center, as shown in Fig.3(b). Each negative potential pulse synchronizes with each GAM burst in the range of ~30 kHz, where the potential signal exhibits only GAM fluctuations. Enhanced transport of energetic ions by TAE bursts should be discussed, because TAE bursts are synchronously excited with large GAM bursts (Fig.3(b)). These negative pulses may indicate enhanced radial transport of energetic ions. Enhanced transport of energetic ions by EGAM is also reported from DIII-D [4].

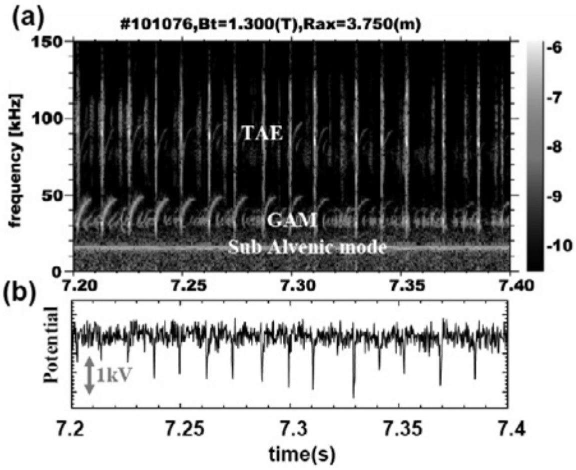

Fig.3 Spectrogram of magnetic probe signal db_θ/dt (a) and plasma potential at *r/a*~0.18 (b). Each negative potential pulse synchronizes with the GAM burst

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[3] K. Toi et al., Proc. 35th EPS Plasma Physics Conference, 9-13 June 2008, Crete, Greece, Paper No. P1.054.
[4] R. Nazikian et al., Phys. Rev. Lett. **101**, 185001(2008).