§22. Excitation Experiment of Alfvén Eigenmodes by AC Current Flowing along the Magnetic Field Line

Matsunaga, G., Takechi, M. (Dep. Energy Eng. Science, Nagoya Univ.)
Toi, K. and CHS Group

Energetic particles such as α particles and fast ions can destabilize Alfvén eigenmodes (AEs). If these modes become unstable, the loss of α particles is enhanced and consequently prevents ignition. AEs destabilized by NBI- or RF-produced energetic ions were identified in several tokamaks and helical systems.

In the heliotron / torsatron device CHS, the toroidicity-induced Alfvén eigenmodes (TAEs), driven by energetic ions created by NBI, were observed for the first time.[1] They are localized in the plasma core region where the magnetic shear is fairly low. In order to know the stability of energetic-ion-driven AEs in a next generation helical system, it is required to evaluate the damping rate of AEs without energetic ion drive.

For this reason, we installed a set of external loop antennas for direct excitation of AEs in CHS.[2] Four antennas are set up in the CHS vessel, 90 degrees apart. In this experiment these antennas were used as electrodes inserted into the plasma edge r/<a>~0.9, to induce AC current flowing along the magnetic field line of CHS. The AC current in the range of 10~250kHz is fed between a pair of two "electrodes" which are connected by the magnetic field line with particular rotational transform. This method can induce small magnetic perturbations ($\delta B/B \sim 10^{-5}$) to the plasma and is able to excite AEs. Moreover, these perturbations may interact with Alfvén resonances near the plasma edge because the rotational transform increased toward the plasma edge. By switching the relative current phases among the "electrodes", toroidal mode number of n=1 or n=2 can mainly be excited.

Excitation experiment of AEs was carried out in an after-glow of NBI heated plasma, so that the drive of AEs by energetic ions would be suppressed and only external AC current contributes to excite AEs. In the after-glow phase, the electron density is monotonously decreased. Figure 1 shows the time evolution of magnetic fluctuations and line averaged electron density, where the excitation frequency is kept constant. It clearly shows a peak amplitude in magnetic fluctuations. The peak is shifted to the lower density phase in the after-glow, with increase in the frequency. As shown in Fig.2, the frequency is varied to be inversely proportional to the square root of the electron density at the predicted Alfvén resonance layer near the edge. It is thought that these magnetic fluctuations are to be Alfvénic waves. Around the fluctuation peak, magnetic fluctuations with n=1 structure start to propagate in the opposite direction of the toroidal magnetic field, while except this phase fluctuations exhibit the |n|=1 standing wave. When the n=2 fluctuations were excited, the similar phenomena were also observed. Note that the excitation frequency is about half of TAE gap frequency and the fluctuations around the peak are not related to TAEs. Magnetic fluctuations induced by AC current flowing near the edge seem to be enhanced by Alfvén resonances near the edge.

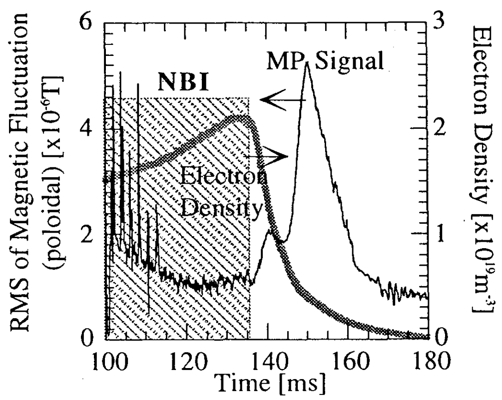

Fig. 1 Time evolution of magnetic fluctuations and line averaged electron density, where the frequency of the AC current is kept constant (180kHz).

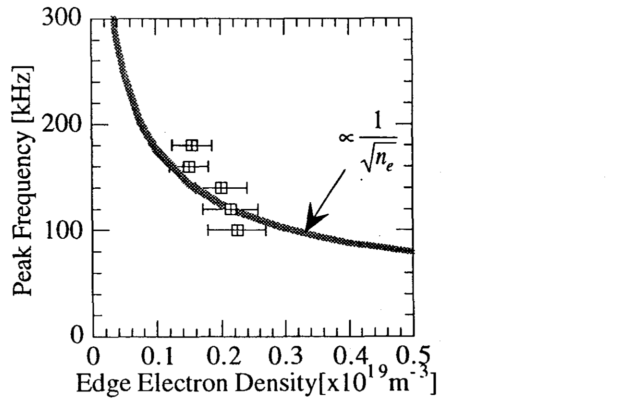

Fig. 2 Excitation frequency as a function of the edge electron density when the amplitude peak in magnetic fluctuations appears.

Reference
1) M.Takechi et al., to be published in Phys. Rev. Lett. (1999)
2) G.Matsunaga et al., annual report of NIFS (1997).