§46. Studies of Characteristics of Helicity-induced Alfvén Eigenmodes in LHD Plasmas

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To clarify the characteristics of energetic ion driven MHD instabilities, which can be excited by Alfvénic ions produced by NBI and D-T fusion reaction, and to minimize their effect on energetic ion transport and/or loss are key issues for the realization of DT fusion reactor. Toroidicity induced Alfvén eigenmodes (TAEs) and energetic particle modes (EPMs) are actively and extensively investigated in both tokamak and helical plasmas. The detail of them and their effect on energetic ion transport and/or loss are clarifying. In LHD plasma, TAEs/EMPs and energetic ion loss cause by TAEs/EMPs are also observed in NBI-heated plasmas. Moreover, we observed high frequency mode of which frequency about five times higher than that of TAE in the low magnetic field condition $B < 0.75$ T. The high frequency mode was successfully identified as helicity induced Alfven eigenmodes (HAEs) by the comparison between observed frequency and shear Alfvén spectra where three dimensional magnetic field structures are taken into account. LHD has three-dimensional magnetic field of which strength vary in both poloidal and toroidal direction. The variation of magnetic field strength in the poloidal and toroidal direction simultaneously induce the poloidal and toroidal mode coupling of shear Alfvén spectra. Then HAE gaps are produced and HAE can be existed in HAE gap. The frequency of HAE gap is proportional to toroidal field period N_p and inversely proportional to rotational transform. The rotational transform of LHD increases from plasma core region towards edge. Therefore, the frequency of HAE at plasma edge is lower than 250 kHz in the condition of $B < 0.75$ in LHD plasmas. In FY 2000, HAE has been observed only in the inward shifted magnetic configuration R_{ax}=3.6m of which rotational transform is the highest in the magnetic configuration. The HAE was observed in other configuration in recent experiment campaign because energetic ion beta was increased. Figure 1 shows typical observation of HAE in NBI heated LHD plasmas in the outer shifted magnetic configuration R_{ax} = 3.9 m. We observed a lot of modes including EPM, TAE, GAE for low frequency mode (f < 250 kHz) and HAE for high frequency mode (f > 250 kHz) in Fig.1. Since outer shifted magnetic configuration has low magnetic shear and large shafranov shift, which induce to produce well align spectrum gap. A lot of TAEs with different toroidal/poloidal mode number are simultaneously excited. Figure 2. shows the dependence of observed mode frequency on Alfven velocity obtained from line averaged electron density and impurity for two kinds of HAE with different toroidal mode number each others. Recent development of numerical MHD code to calculate eigenfunction of AE can estimate spatial profile of HAE. We have the plan to compare between the experimentally observed HAE profile and numerical result to clarify the characteristics and HAE. Moreover, we will compere the experimental result of low magnetic shear device and LHD result in order to get unified knowledge of HAE in a helical plasmas.

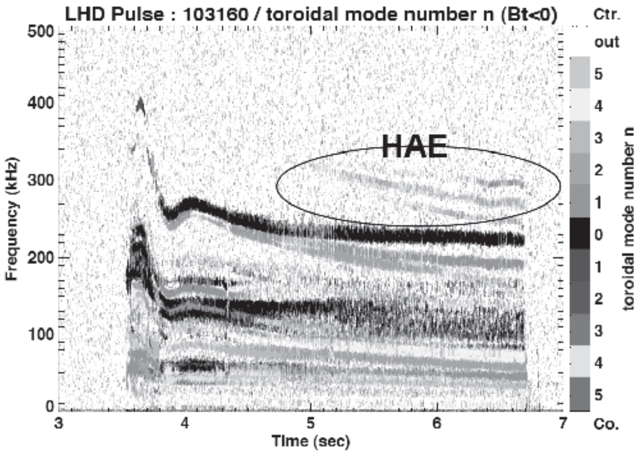

Fig. 1. Time evolution of magnetic fluctuation of HAE in NBI heated LHD plasmas.

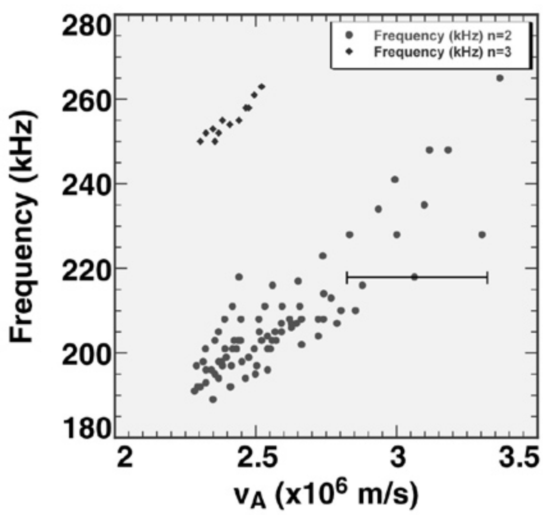

Fig. 2. Dependence of HAE frequency on Alfven velocity.