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Study of Alfven Eigenmodes in the TJ-II stellarator with Heavy Ion Beam Probing

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The study of Alfven Eigenmodes (AEs) induced by fast particles in toroidal plasmas is of a great importance for future fusion reactor with plasma, dominating by fusion alphas. AEs as electromagnetic waves have electric and magnetic components also inducing the pressure (density) component. The talk presents the direct application of the Heavy Ion Beam Probing[1,2] (HIBP) for measuring the plasma electric potential, magnetic potential and density oscillations excited by AEs and reviews the results of the AEs study in the TJ-II stellarator[3,4]. The AEs are experimentally characterized with the absolute values of the plasma potential and density components, the mode spatial location and the poloidal mode numbers. On top of that, the turbulent particle flux, induced by individual AEs are found to be either outward or inward (or zero), depending on the individual characteristics of AEs[5]. Both AEs with continuous and bursty character (chirping modes) are investigated [6,7] along with their variation with magnetic configuration during a single shot[8,9]. Tiny variation of the induced ohmic current causes the dramatic changes of the AE frequency up to a factor of 7[10]. The radial propagation of the individual burst of the chirping AE is found [11]. It is determined the non-zero frequency limit for AEs, linked to Geodesic Acoustic Mode frequency[12], as shown in Fig 1. Experimental studies combined with numerical modeling by AE3D, STELLGAP and FAR3D codes allow to identify the observed modes as helicity induced AEs and global AE. The effect of the Electron Cyclotron heating and Current Drive on the AE dynamic was also studied. 2D mapping of the AEs shows the mode localization and poloidal structure (ballooning character) in the plasma cross-section, as presented in Fig.2

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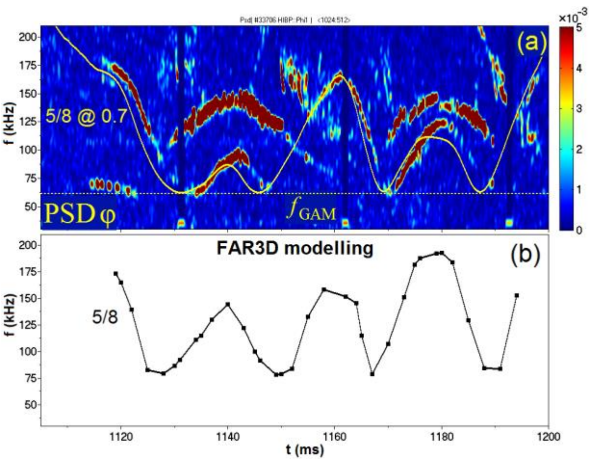

Figure 1. (a) Power spectrogram of plasma potential fluctuations measured by HIBP in the shot with iota sawtooth variation compared with the analytical interpretation for $f_{min} = f_{GAM}$ = 62 kHz (dotted line), which results in AE mode with m/n=5/8@ρ_{AE}=0.7 (yellow curve), reproducing the observed time evolution of f_{AE} and local minima at t=1130, 1145, 1170, 1185 ms, that correspond to $k_{//} \sim (m\iota - n) = 0$; (b) modeling of the AE frequency by the FAR3D code results in 5/8 mode, which reproduces the mode frequency sweeping.

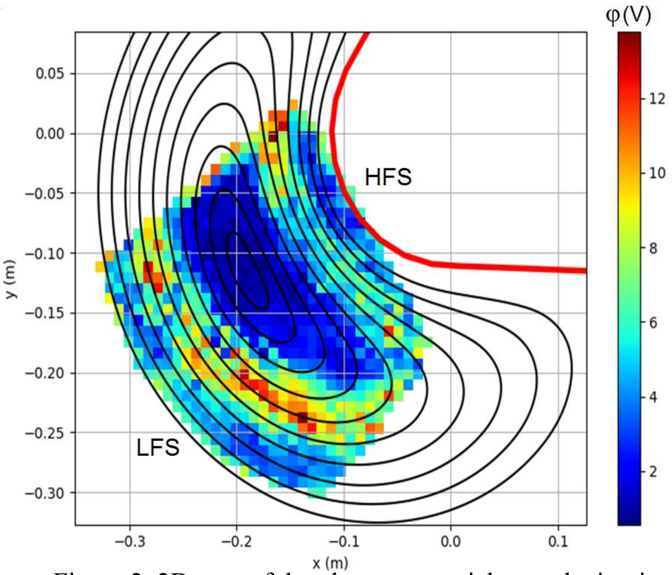

Figure 2. 2D map of the plasma potential perturbation in the TJ-II vertical cross-section in the AE frequency range. AE-mode fits to the flux surface, having a ballooning feature, dominating at LFS with a factor of 1.5 respect to HFS.