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Impact of ECH/ECCD on Fast-ion-driven MHD Instabilities in Helical Plasmas & Excitation mechanism of the energetic particle driven resistive interchange mode and strategy to control the mode in Large Helical Device

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A. We discuss the effect of electron cyclotron heating (ECH) and current drive (ECCD) on fast particle (FP)-driven MHD instabilities in stellarator/heliotron (S/H) plasmas obtained in LHD, Heliotron J and TJ-II. We demonstrate that FP-driven MHD instabilities including energetic particle modes (EPMs) and Alfvén eigenmodes (AEs) can be controlled by means of magnetic shear s modified by EC-driven plasma current. EPMs can be controlled by changing continuum damping rate, which is the main damping mechanism of the EPM and depends on s. AEs are significantly affected by the change of structure of the shear Alfvén continuum which can be modified by s. We also find that ECH (non-ECCD) can impact FP-driven MHD instabilities. Candidates to explain the ECH effect on FP-driven MHD instabilities are the variation in the fast ion profile and/or the trapped electron collisional damping.

B. The helically-trapped energetic-particle (EP) driven resistive interchange mode (EIC) observed in the Large Helical Device (LHD) causes large amount loss of EPs. It is destabilized when the precession motion of the helically trapped EP resonates with the pressure driven mode. A velocity modulation caused by the toroidicity of the magnetic field produces this resonance. Strategy and the initial results to suppress the EIC mode based on the knowledge of the EP orbit effects, by the ECH heating and by the RMP application, are presented. EPs having perpendicular velocity components are trapped in the weak magnetic field region of the LHD and making precession motion helically. The rotation frequency of this precession motion is slow enough to interact with the pressure driven MHD modes. If the energy transfer from the EP to the mode is estimated by evaluating the correlation of the fluctuating component of the precession motion and the MHD mode, a resonance is found when the MHD mode rotates poloidally -1.2 times of the poloidal component of the helically trapped EP motion. This resonance disucssed here is consistent with the following observations found in the hydrogen / deuterium experimental campaign. 1) MHD mode rotates in the electron diamagnetic drift direction while the EP moves in the ion diamagnetic drift direction. 2) The mode frequency is almost the same with the precession frequence of the initial velocity of the NB-injected EPs. The EIC modes are succesufully suppressed by the ECH injection and RMP application. The physical mechnism of the stabilization will be discussed.

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