Challenges to control the nonlinear wave-particle interactions using laboratory plasmas

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Wave-particle interactions in magnetized plasmas attract much attention in both space plasma physics and laboratory plasma physics research. Wave excitations and nonlinear behaviours observed in the magnetosphere have been strongly studied so far. Recently, in-situ measurement of the velocity distribution functions of ions and electrons due to satellites significantly progress the study of kinetic dynamics, in particular, article acceleration, particle losses into the loss cone, etc. In the laboratory, the deformation of the velocity distribution function of ions interacting with large amplitude MHD burst was observed, and the energy transfer rate was evaluated [1]. Moreover, the nonlinear transport of energetic ions interacting with Alfven eigenmodes (AE: eigenmode in the double-periodic boundary of the torus geometry) was also identified based on hybrid simulation studies [2]. Recently, external control of such energetic ion transport was successfully demonstrated in torus plasmas [3], which is a very important subject for realizing the stable fusion burning plasmas. In this paper, the laboratory experiments on active control of wave-particle interactions are presented, and the possibility of interdisciplinary collaboration will be discussed.

[Active control of energetic particle transport driven by Alfven eigenmodes]

The electron cyclotron wave obliquely injected onto the resonance layer can drive plasma current locally and change the local magnetic shear in the plasma. This electron cyclotron current drive (ECCD) was applied to the plasma and clear responses of Alfven eignemodes (AEs) were observed in Heliotron J and LHD plasmas [3]. The AE responses observed in both devices may be commonly understood with the magnetic shear effect on the AE damping, while they have different magnetic configurations. In the case that the magnetic shear is enhanced, the mitigation of energetic ion transport is observed as well as the AE mitigation.

[Effect of electron cyclotron heating on AE activities]

The AE responses to the application of the electron cyclotron heating (ECH) was observed in DIII-D tokamak, TJ-II, Heliotron J, LHD plasmas [4,5]. However, a variety of AE responses were observed, some cases enhanced the AE, some mitigated, and others made no impact. A kinetic effect of trapped electrons was proposed theoretically, but the mechanism of the complicated AE-responses is not understood yet.

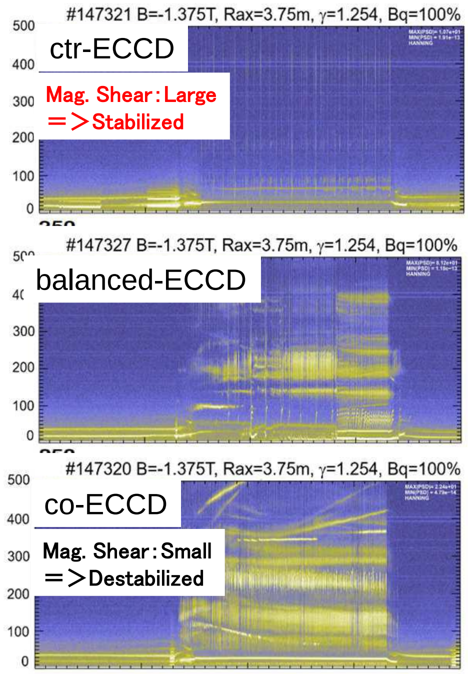

Fig. 1 AE response to the application of ECCD on LHD experiment. []

In conclusion, active control of wave-particle interaction opened a new door in plasma physics. It was also found that the ECCD application is effective to the active control of profile stiffness of energetic particles, which is realized nonlinear excitation of AEs, which will be reported elsewhere. It is noted that active control of wave-particle interaction in both space and laboratory plasmas will significantly enhance deep understanding and new applications of the plasma physics.

References

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