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Analysis of plasma fluctuation observed in low q tokamak HYBTOK-II with resonant magnetic perturbation

低qトカマクHYBTOK-IIにおける共鳴摂動磁場印加時のプラズマ揺動解析

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In order to understand the interaction between externally applied resonant magnetic perturbation (RMP) field and plasma instability, magnetic signals have been measured in a discharge with low plasma surface safety factor in a small tokamak device HYBTOK-II. The m/n = 2/1 RMP field suppressed the m/n = 3/2 mode. Moreover the fluctuation induced by the RMP was enhanced due to the response of plasma instability.

1. Introduction

For fusion reactors, it is important to avoid so-called magnetic islands induced by tearing instability, which has an unfavorable effect on plasma confinement and can be the direct cause of minor and major disruptions. Externally applied resonant magnetic perturbation (RMP) field coils are installed in many large tokamak devices in order to control the particle transport in the pedestal region for edge localized mode (ELM) mitigation [1]. RMP coils also play a role in suppressing the growth of magnetic islands [2].

It is important to understand the interaction between RMP field and tokamak plasma [3]. So far, the penetration processes of RMP field into the plasma have been studied in the small tokamak HYBTOK-II. Although RMP field was shielded and enhanced due to the effects of plasma rotation and Alfvén wave, the relation between RMP penetration and plasma instability has not been discussed [4, 5].

In this study, in order to understand the effects of RMP penetration process on plasma instability, magnetic signals when applying the RMP in the low q discharge have been measured and analyzed on a small tokamak device.

2. Experimental Setup

Experiments were performed in HYBTOK-II, which is a circular, small sized, limiter tokamak device with a major radius of 40 cm and a minor radius of 11cm. As shown in Fig. 1, the RMP coils are installed outside the vacuum vessel with the poloidal and toroidal mode numbers of m = 2 and n = 1, respectively. These coils are powered independently with a phase difference of 90 degree in order to rotate the perturbation field in the

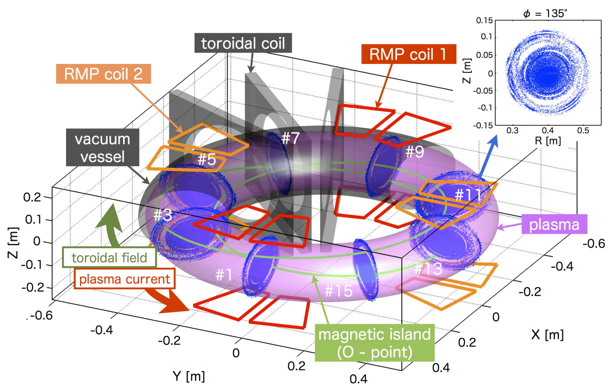

Fig. 1 m/n = 2/1 RMP coils on HYBTOK-II.

directions of clockwise (CW) and counter-clockwise (CCW) with respect to the plasma current. The radial profiles of RMP in the plasma were obtained with a magnetic probe array measuring the radial component of magnetic field B_r. In addition, another magnetic probe array is also installed to measure the poloidal component of magnetic field B_θ for the q profile.

3. Experimental Results

Fig. 2 shows the time evolution of (a) plasma current I_p, (b) plasma surface safety factor q_a, (c) mode frequency calculated by externally installed magnetic probes, and amplitudes of (d) m/n = 2/1 mode and (e) m/n = 3/2 mode for ion and electron diamagnetic drift directions. Here, the directions of ion diamagnetic (i.d.) and electron diamagnetic (e.d.) drift are corresponding to CW and CCW directions, respectively. The RMP was applied from 11 to 17 ms with the frequency of 1 kHz in the CW direction. Before applying the RMP, the m/n = 3/-2 mode fluctuation is dominant, as shown in Fig. 2 (c) and (e). When applying the RMP, however, the growth of m/n = -2/1 mode was observed due to the RMP field. This result indicates that the m/n = 3/-2 mode is suppressed by applying the RMP.

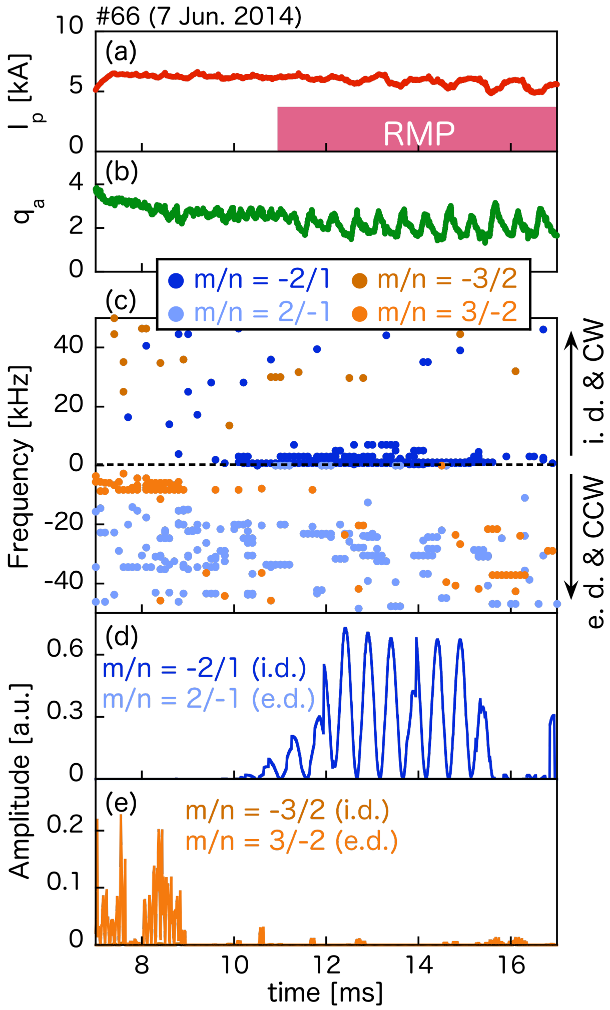

Fig. 2 Time evolution of (a) plasma current I_p, (b) plasma surface safety factor q_a, (c) mode frequency, amplitudes of (d) m/n = 2/1 and (e) m/n = 3/2.

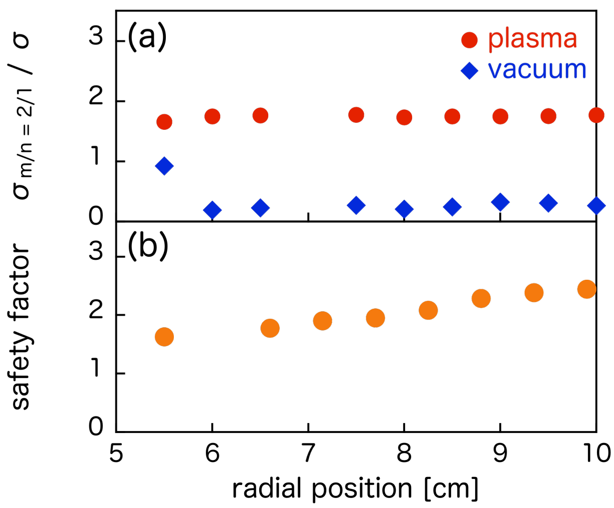

Fig. 3 Radial profile of (a) normalized standard deviation of B_r and (b) safety factor.

In order to investigate the RMP penetration process, the frequency components of m/n = 2/1 have been picked up from B_r signals obtained by magnetic probe array using the analytical technique of band-pass filter. Fig. 3 (a) shows the radial profile of standard deviation of B_r, the components of m/n = 2/1 mode. Furthermore this is normalized by the standard deviation of original B_r signals σ. The profiles of m/n = 2/1 components between with and without plasma are compared in Fig. 3 (b). Although the current with RMP was same in both cases, the fluctuation induced by RMP in the plasma is larger than that in the case of vacuum. This enhancement would be caused by the response of plasma instability.

Acknowledgments

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