§43. Application of RMP to High-beta Plasmas

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The application of the RMP to control of MHD mode is expected to be attractive for the production of higher beta plasmas. In this study, the effect of the RMP on the equilibrium and stability have been investigated. Figure 1 shows typical RMP ramp-up discharges in the B_t = -1 and -0.425 T cases. The tangential NBs were injected from 2.3 to 4.3 s to produce and maintain the plasma. Also the vertical NB was intermittently applied at 100 ms intervals. The I_{RMP} was temporally increased from 2.7 s and approached 0.76 kA for 2 s in both discharges. In the case of B_t = -1 T, the volume averaged beta value, $<\beta_{dia}>$, approached about 2.25 % at 3.12 s and the electron density is about 3.3 × 10^{19} m^{-3} then. The normalized m/n = 1/1 radial component of the magnetic field on the ι/2π = 1 resonance, b_{r11}/B_t, and the toroidal angle where the O-point is located in the midplane of the low field side, $\phi_{O\text{-point}}$, were estimated by saddle loop arrays. As shown in Fig.1 (c) and (d), the small b_{r11}/B_t existed till 3.95 s and then $\phi_{O\text{-point}}$ is out of phase with that given by RMP field, at least, from 3.3 s. This suggests that the m/n = 1/1 perturbation current shielding RMP field is induced on the resonance, and the b_{r11}/B_t due to the shielding current is almost the same as given RMP field strength. At 3.9 s, the m/n = 1/1 component rotates in the electron diamagnetic direction, and b_{r11}/B_t drastically increased when $\phi_{O\text{-point}}$ approached the position of the RMP island. The threshold of the mode penetration is about -0.53 kA/T. Subsequently, $<\beta_{dia}>$ was lost by 39 %. The maximum b_{r11}/B_t at 4.3 s is about twice larger than that given by RMP field. Figure 1 (e) shows the time developments of the plasma boundary with T_e = 0 and the locations of the ι/2π = 1 resonance in vacuum and the flattening of T_e profile. While the plasma boundary in the high-field side was constantly located at R ~ 2.6 m, that in the low-field side seems to gradually decrease from 4.65 m at 2.6 s to 4.55 m at 4.3 s. Note that the plasma boundary is different from the last closed flux surface because the pressure sufficiently stays in the stochastic region. The profile flattening appeared around the vacuum ι/2π = 1 resonance when the b_{r11}/B_t was increased. The $<\beta_{dia}>$ degradation was caused by reduction of core pressure due to an extension of the profile flattening. The flattening inside and outside ι/2π = 1 resonance was hardly observed during the discharge.

In the case of B_t = -0.425 T, the $<\beta_{dia}>$ approached about 3.9 % at 3.12 s. The b_{r11}/B_t indicates that the m/n = 1/1 shielding current appeared at 3.45 s. The $\phi_{O\text{-point}}$ started to change at 3.89 s and the b_{r11}/B_t is significantly increased at 3.92 s. The threshold of the penetration is -1.15 kA/T, which is much higher than the B_t = -1T case. The $<\beta_{dia}>$ was lost by 38 % and continued to decrease with the growth of b_{r11}/B_t, and the b_{r11}/B_t approached more than three times larger level than the prediction. The many flattening structures appeared outside ι/2π = 1 surface before the mode penetration compared to the B_t = -1 T case, which may be due to enhanced MHD modes excited outside the ι/2π□ = 1 as discussed later. Also the flattening extended the plasma boundary further compared to the B_t = -1T discharge. The flattening near the vacuum ι/2π = 1 surface was extended with an increment of the b_{r11}/B_t.

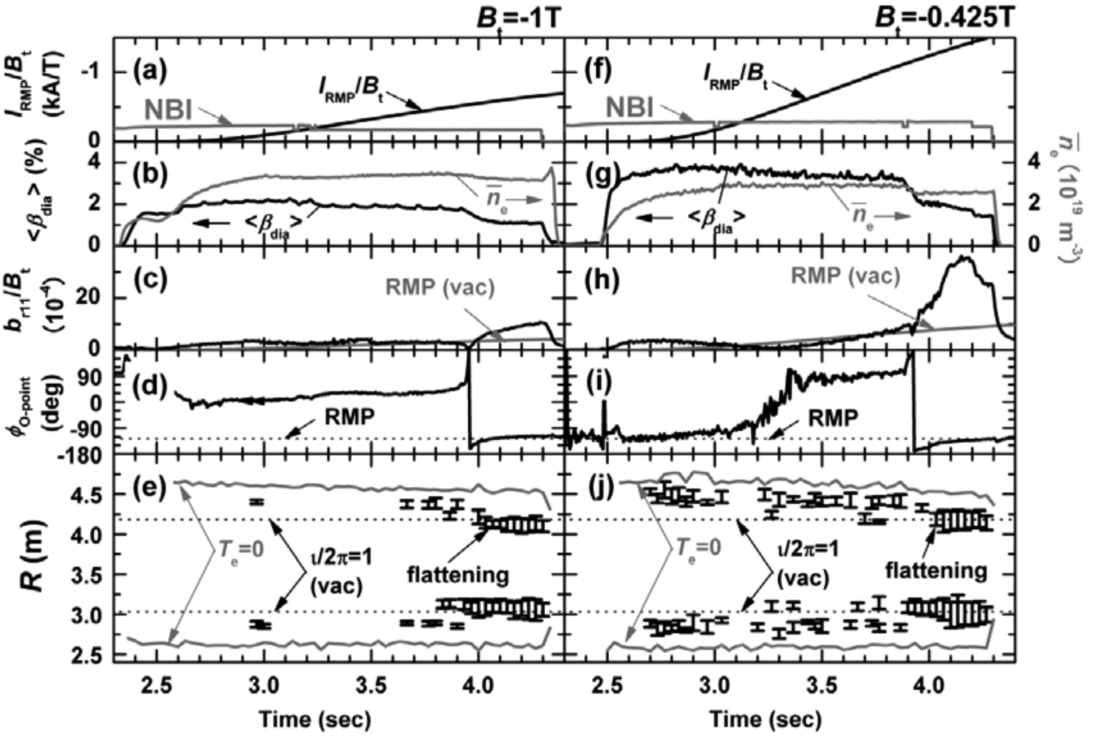

Fig. 1. RMP ramp-up discharges in configurations with Bt = -1T and -0.425 T.