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First application of the island divertor configuration in the J-TEXT tokamak using external RMP coils

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Long-pulse high performance plasma operation of future fusion reactors requires a solution for tolerable plasma exhaust. A large number of studies on classical divertor configuration in tokamaks have confirmed that the higher plasma current, the smaller power decay length of scrap-off layer, and the more peak heat load on divertor target [1]. Compared with divertor configuration, island divertor configuration has a weaker correlation with plasma current and a longer connection length, which contributes to more uniformly distributed heat load and being also easier to enter stable detachment of divertor operation [2]. Therefore, it is of great significance to introduce island divertor configuration into tokamak and leverage its 3D magnetic topologies to control divertor heat-load distribution.

Recently, the establishment of an island divertor configuration has been demonstrated successfully in the J-TEXT tokamak. Edge 3/1 islands were selected to be excited by applying the RMP [3] with dominate m/n=3/1 component to a plasma with edge safety factor q_a >~ 3. After the excitation of edge island, the edge safety factor was decreased by increasing plasma current, so as to move edge islands outwards to intersect with divertor targets and finally form island divertor configuration.

An example of the formation of the island divertor configuration is shown in figure 1. The edge 3/1 islands are excited at t = 0.242 s as indicated by the fast growth of the CIII radiation intensity near the plasma boundary (figure 1(g)) and also the current flowing from divertor target to the ground (figure 1(h)). Additionally, a magnetic oscillation with f ~ 30 kHz (so-called beta-induced Alfvén Eigenmode (BAE) [4]) is excited during the field penetration (figure 1(i)). And then the plasma current increases from 135kA to 170 kA with the feedforward control (figure 1(a)). Simultaneously, the edge 3/1 island is gradually opened by the divertor target, which can be determined by the changing of floating penitential measured by the divertor Langmuir probes (figure 1(j)). It was found that the island divertor configuration was not only beneficial for spreading heat load on the divertor target, but also to provide effective screening of carbon impurities. In addition, an edge island instability, the so-called intermittent penetration of magnetic island, was also observed on J-TEXT.

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References

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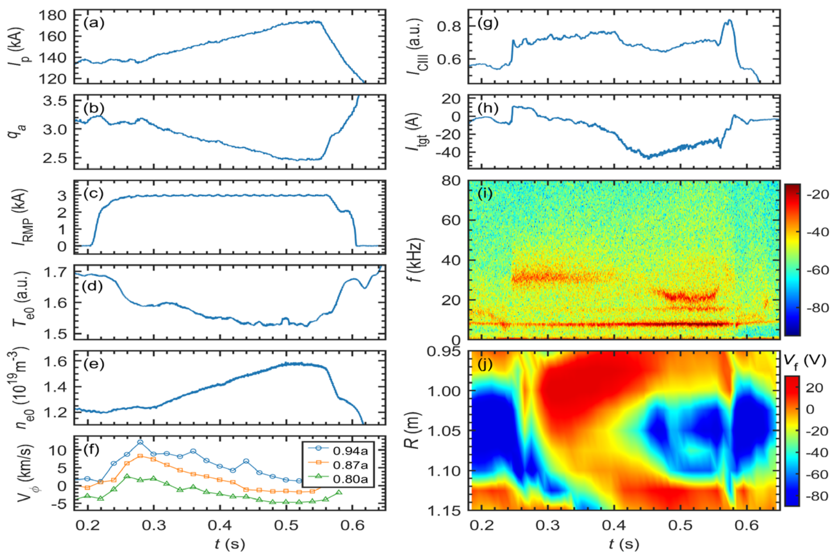

Figure 1. Overview of main plasma parameters for the island divertor configuration experiment on J-TEXT, including (a) the plasma current, (b) the edge safety factor, (c) the RMP coil current, (d) the electron temperature, (e) the electron density, (f) the toroidal rotation, (g) the CIII intensity near the plasma boundary, (h) the current flowing from divertor target to the ground, (i) spectrogram of the Mirnov signal and (j) contour of floating penitential measured by the divertor Langmuir probes.