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NBIによるTS-4 FRCプラズマの安定性と閉じ込めの改善
Stability and Confinement Improvement of FRC Plasmas in the TS-4 NBI Experiment

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The first investigation of tangential neutral beam injection (NBI) to oblate field-reversed configurations (FRCs) has been made in the TS-4 plasma-merging experiment [1]. For this experiment, we developed an economical high-power pulsed NBI system by use of a washer-gun plasma source and finally attained the maximum beam power of 0.6 MW (15 kV, 40 A) for its pulse length of 0.25 ms, which is longer than the FRC lifetime in TS-4 [2].

Since low-n global mode is unstable in oblate FRC in MHD regime, the oblate FRCs produced from light gases often suffer from destructive tilting or other low-n instabilities [3]. The co-NBI with injection power of 0.6 MW largely extended the magnetic energy decay time of oblate FRCs from ~ 15 μs to ~ 30 μs, while no improvement is observed in the counter-NBI case. In the latter case, the fast ions are not confined inside the separatrix. These results indicate that the fast ions produced by the NB stabilized the low-n global modes and prolonged the discharge duration, as predicted in numerical work [4].

Oblate FRCs produced from heavier gases such as argon and krypton reveal better stability against the low-n modes due to kinetic or two-fluid effects. Figure 1 shows time evolutions of trapped magnetic flux, total loss power, thermal pressure, and effective resistivity at the magnetic axis of argon FRCs with and without NBI. The NBI significantly extended the flux decay time from ~ 30 μs to ~ 200 μs while the injection power is much smaller than the maximal loss power of 11 MW. The reduced total loss power of less than 5 MW indicates that NBI not only heats FRC plasma but also changes the stability properties.

With the NBI, the thermal pressure outside of the magnetic axis increases significantly from that without NBI, as expected from the orbit calculation of fast ions produced by the NB. The NBI was observed to modify the current density profiles, suggesting that a diamagnetic plasma current is spontaneously driven by the modified pressure profile in the FRC with NBI. Though these modifications were localized outside the magnetic axis, the flux decay was suppressed in a wide area of the FRC, to provide significant extension of gross decay time. These results indicate that NBI improves significantly the FRC confinement probably by active control of pressure and current profiles as well as electron heating.

References

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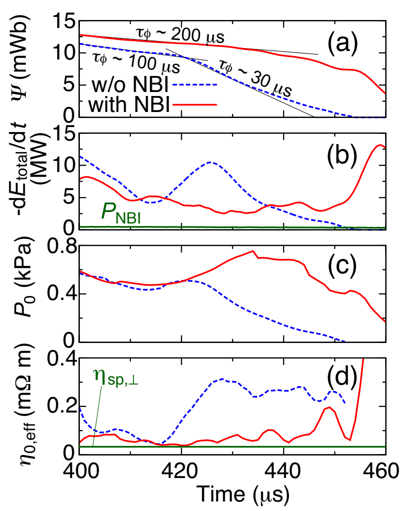

Fig. 1. Time evolutions of (a) trapped magnetic flux, (b) total loss power, (c) thermal pressure, and (d) effective resistivity at the magnetic axis of argon FRCs with and without NBI.