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An improved radiating divertor concept by supersonic molecular beam injection

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The optimized divertor is expected to avoid target damage and to achieve particle and impurity control with improved power dissipation and particle exhaust. Increasing divertor closure an potentially achieve divertor detachment with low possible upstream plasma density[1]. Additionally, the "puff-and-pump" radiating divertor condition is also a promising approach for the reduction of excessive thermal power loading on the divertor targets[2]. In this approach, particle flows in divertor area are affected by the injection and pumping rates. Pumping can affect the capacity of the divertor on the heat load and wall loading control [3]. Appropriate injection method such as supersonic molecular beam injection (SMBI) can both increase the power dissipation and reduce the wall recycling.

HL-2A is a middle-sized tokamak (major radius R=1.65m, minor radius a=0.4m) with closed divertor configurations. A supersonic molecular beam injection SMBI system is installed near the lower divertor at the low field side on HL-2A device.

The divertor heat load control experiment is carried out with this "SMBI-and-pump" divertor concept with deuterium or impurity gas injection. The experimental observation in figure 1 indicates that the divertor heat load is soon reduced owing to the strong detachment showing by the fast increase and decrease of the divertor bolometer signal after SMBI.

In addition, heat load control experiments have been conducted in HL-2A L-mode plasma to compare the ability on the heat load control between the divertor gas puffing system and the new divertor SMBI system. Experimental result shows that the time response of divertor SMBI system is about 10 milliseconds, much less than the divertor gas puffing system, whose time response is up to 100 milliseconds. The experimental result indicates that this divertor SMBI system strengthen the ability of divertor heat load control. The divertor detachment in L-mode can be easily reached by the divertor SMBI system on HL-2A even with deuterium injection, which is hard to achieve by deuterium gas puffing. Testing and simulation both shows that fast velocity and large flow rate of SMBI gas enhances the ability of this "SMBI-and-pump" radiating divertor. It is also expected that deeper penetration of the SMBI gas through the magnetic field line in divertor region can further reduce the divertor heat flux, which would be further investigated.

References
[1]A. Loarte 2001 Plasma Phys. Control. Fusion 43 183
[2]T. W. Petrie et al 2009 Nucl. Fusion 49 065013
[3]C.F. Sang et al 2021 Nucl. Fusion 61 016022

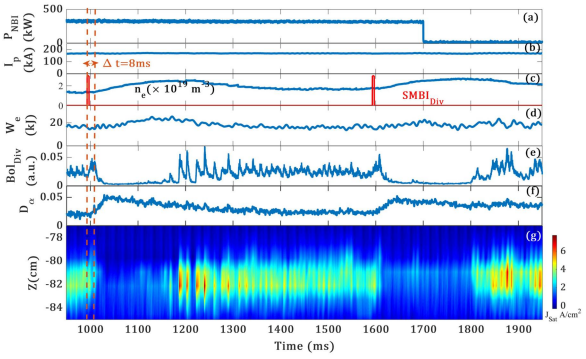

Figure 1. Fast divertor heat load control experiment on HL-2A tokamak.(a) NBI heating power, (b) plasma current, (c) core line-averaged density in the main chamber and the divertor SMBI signal, (d) plasma stored energy, (e) divertor bolometer signal, (f) D_α signal, (g) divertor ion saturated current.