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Plasma confinement and pedestal dynamics responses to impurity seeding in HL-2A H-mode plasmas

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In HL-2A H-mode plasmas, the confinement and pedestal response to impurity seeding have been recently investigated [1]. It has been observed that a broadband electromagnetic (EM) turbulence can be driven by peaked impurity density profile at the edge plasma region, and governed by double critical gradients of the impurity density [2]. In addition to the spontaneously accumulated impurity, the electromagnetic turbulence and quasi-coherent EM modes can also be excited by externally seeded impurity in HL-2A [3]. The excited pedestal instabilities can play an important role in the regulation of the pedestal turbulent transport. More recently, the SMBI system has been used for gas impurity seeding (Ar, Ne, etc), which is beneficial for forming an edge radiation layer and avoiding impurity core accumulation. With pure impurity injection, it has been observed that the ELM frequency is increased and the H-mode plasma confinement is improved with a broadened and steepened density pedestal. For the D2 SMBI, it can mitigate ELMs as observed in several devices. Thus, a newly developed SMBI system with mixture impurity gas (D2+Ne or D2+Ar) is used in HL-2A. The impurity gas is mixed with plasma work gas D2 by different ratios. The dedicated experiments show that the ELM behavior, plasma confinement and pedestal structure are varied with the ratio of the impurity mixture. It has been found that large ELMs are replaced by very small bursts with 30% Ne-SMBI seeding. The SMBI pulse length is 2ms. The large ELM is suppressed for a period of about 50ms. Meanwhile, the divertor heat load is significantly reduced. When the ratio changed to 10%, the confinement response is similar to that of the D2 SMBI. However, when the gas was changed to pure Ne, the ELM frequency was increased and the confinement was enhanced. The results suggest that both the pedestal structure and pedestal stability are modified with the amount of impurity and impurity species. Experimental observations indicate that there is an optimal impurity ratio for heat load control. The results suggest that pedestal dynamics and heat loads can be actively controlled by exciting pedestal instabilities and forming a steady edge radiation layer.

[1] W.L. Zhong et al 2017 Plasma Phys. Control. Fusion 59 014030

[2] W.L. Zhong et al 2016 Phys. Rev. Lett. 117 045001

[3] Y.P. Zhang et al 2018 Nucl. Fusion 58 04601

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