Heat load and ELM control with impurity mixture SMBI seeding for ELMy H-mode plasmas in the HL-2A tokamak

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In standard high confinement regime (H-mode) of tokamak plasmas, the edge-localized mode (ELM) usually produces high transient heat loads on plasma facing components. Over the years, intensive effort has been dedicated to find an optimal technique for heat load and ELM control. Specifically, supersonic molecular beam injection (SMBI) [1], an effective fuelling tool has been first demonstrated for ELM mitigation in HL-2A [2], and then in EAST and KSTAR. In addition, impurity seeding has been used to mitigate ELMs in several devices. It can reduce the heat load by converting the heat into impurity seed radiation. Moreover, it can control the ELM activities by affecting the pedestal dynamics and instabilities.

On HL-2A, the impact of fuelling and impurity on pedestal dynamics and instabilities has been studied, recently [3]. It has been observed that a broadband electromagnetic (EM) turbulence can be excited by peaked impurity density profile at the edge plasma region, and governed by double critical gradients of the impurity density [4]. Recently, experiments have been performed in HL-2A with impurity SMBI, which can inject a mixture of gas including D_2 and light impurity gas (Ne or Ar, etc). The SMBI impurity seeding is beneficial for forming an edge radiation layer and preventing impurity core accumulation. It has been observed that with pure impurity SMBI injection, the H-mode plasma confinement has been improved. For mixture impurity seeding, the ELM behavior or plasma confinement varies with the ratio of the impurity gas to D_2. It has been found that large ELMs are mitigated to very small bursts with 30% Ne-SMBI seeding. Experiments in HL-2A seem to indicate that there should be an optimal impurity ratio for ELM and heat load control, and suggest that pedestal dynamics and heat loads can be actively controlled by exciting pedestal instabilities and forming a steady edge radiation layer.

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