Investigation of ELM mitigation with supersonic molecular beam injection on the HL-2A tokamak.

Z.B.Shi[1),],Z.C.Yang[1)], W.L.Zhong[1)], B.Y.Zhang[1)], C.Y.Chen[1)], M.Jiang[1)], P.W.Shi[1)], W.Chen[1)], Z.T.Liu[1)], D.L.Yu[1)], Y.Zhou[1)], B.B.Feng[1)], X.M.Song[1)], X.T.Ding[1)], Q.W.Yang[1)], X. Min[1)], and X.R.Duan[1)]

[1)]*Southwestern Institute of Physics, P. O. Box 432, Chengdu 610041, China*

Corresponding Author's e-mail address: shizb@swip.ac.cn

Abstract: In this work, the edge localized mode (ELM) mitigation by using supersonic molecular beam injection (SMBI) has been studied in the HL-2A H-mode plasmas. The role of SMBI deposition into the H-mode pedestal in ELM mitigation and the underlying turbulence characteristics are reported experimentally. When the location of SMBI source is about 20% into the pedestal, the distinct ELM mitigationeffect is achieved, which is identified by a significant increase of the ELM frequency and also adecrease of the ELM amplitude. A sand-pile model is developed to simulate the ELM burst and explain the mitigation effect for different particle source locations. It is found that the gradient of the pedestal is one of the key parameters in the process of the ELM mitigation, and there should be a local maximum gradient threshold in the middle of the pedestal. When the deposition of SMBI is close to this position, a best ELM mitigation effect can be obtained, which is in well agreement with the experimental observation [1].

The turbulence plays an important role during ELM mitigation [2]. The density fluctuations and the radial electric field are measured by a multi-channel Doppler reflectometer [3]. The 2D structures of the temperature fluctuations are measured by the 384-channel electron cyclotron emission imaging (ECEI) [4]. After SMBI injection, the small-scale 2D structures of the temperature fluctuations are increased. The density fluctuation grows first, followed by the rapid decrease of the radial electric field. When the density fluctuation is higher than a threshold, the density fluctuation dramatically increases follow by a rapid increase of the ELM frequency and a decrease of ELM amplitude. Then the density fluctuation gradually decreases with the recovery of the radial electric field. The suppression of ELM is kept for several tens milliseconds, until appearance of the inward propagation of the turbulence. The increase of turbulence and drop of the radial electric field prior to the ELM mitigation suggest that the ELM mitigation is a result of the turbulence transition, and the sustainment of ELM mitigation is highly correlated with the suppression of inward propagation of the turbulence.

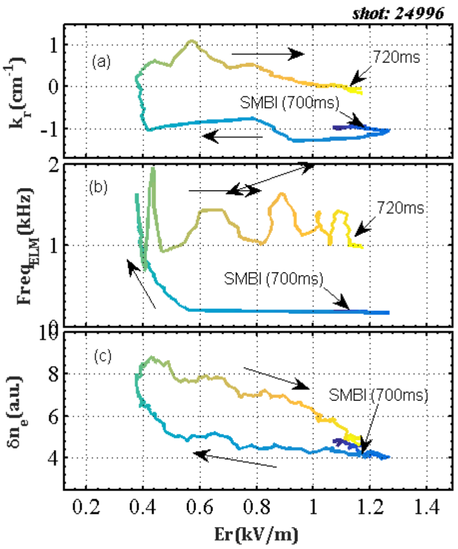

Figure 1: Trajectories plots in phase space of (a) radial wavenumber of turbulence, (b) ELM frequency, and (c) density fluctuation with the radial electric field (Er). The color line denotes time trace of the plot.

[1]Z.C.Yang, et al., Phy. Plasmas **23**, 012515 (2016)
[2]Z.B.Shi, et al., submitted to Nuclear Fusion, 26th IAEA FEC, EX/P7-22
[3]Z.B.Shi, et al., Rev. Sci. Instrum. **87**, 113501 (2016)
[4]M.Jiang, et al., Rev. Sci. Instrum. **86**, 076107 (2015)