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Observation of streamer as a trigger of ELM in HL-2A experiments

J. Cheng[1], J. Q. Dong[1,2], K. Itoh[3,4], S. -I. Itoh[4,5], L. W. Yan[1], J. Q. Xu[1], M. Jiang[1], K. J. Zhao[1], Z. H. Huang[1], D. L. Yu[1], K. Ida[3,4], S. Inagaki[4,5], T. Kobayashi[3], X. Q. Ji[1], Z. B. Shi[1], W. L. Zhong[1], X. L. Zou[6], X. T. Ding[1], A. Fujisawa[4,5], Y. Kosuga[4,5], Y. Nagashima[4,5], M. Sasaki[4,5], T. Yamada[4,7], M. K. Han[8], Y. Liu[1], Q. W. Yang[1], M. Xu[1], X. R. Duan[1] , Yong Liu[1] and HL-2A team

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

[2]Institute for Fusion Theory and Simulation, Zhejiang University, 310027, China

[3]National Institute for Fusion Science, Toki 509-5292, Japan

[4]Research Center for Plasma Turbulence, Kyushu University, 816-8580, Japan

[5]Research Institute for Applied mechanics, Kyushu University, 816-8580, Japan

[6]CEA, IRFM, F-13108 Saint-Paul-lez-Durance, France

[7]Faculty of Arts and Science, Kyushu University, Fukuoka 819-0395, Japan

[8]School of Physics and Optoelectronic Technology, Dalian University of Technology, China

In a transition from low (L) to high (H) confinement regime, a transport barrier usually develops in a narrow layer and so called pedestal with high temperature and density gradients forms at tokamak plasma edge [1]. The accumulation of energy and particles inside the pedestal normally leads to an explosive relaxation of the gradients through edge localized mode (ELM) [2-3]. Then the gradients develop again until a next ELM onset under a variety of physics mechanisms. This is a typical self-organization process of edge gradients in magnetic confinement fusion plasmas. Such behaviors as pedestal collapse and re-build in tokamak edge plasmas are very common phenomena in complex nonlinear systems. Understanding the mechanism for ELM onset in particular is essential for future fusion energy development.

In the recent H mode experiments on HL-2A tokamak, electromagnetic fluctuations are routinely observed just before each ELM onset in the edge transport barrier region. The mode frequency and numbers are f~30-70 kHz and m/n=20-24/7-8, respectively. It has strong nonlinear interaction with the ambient turbulence, and the inward particle inducing fluctuations plays a dominant role in the particle balance and increases of local density gradient prior to ELM onset. The transition of the localized mode to streamer structure occurs within a short time scale of a few 10 microseconds. The radial inward extension of fluctuations can reach about 30% of the minor radius [4]. It leads to the start of D_α rise and the global crash of electron temperature. This is a prototypical example of collapse events in high temperature plasmas, and gives illuminating understanding of the triggering mechanism without substantial change of global plasma parameters.

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