Enhanced H-mode Pedestals with Increased Density Fluctuations During Lithium Aerosol Injection in DIII-D*

Z. Yan¹, T.H. Osborne², G.L. Jackson², R. Maingi¹, G.R. McKee¹, D.K. Mansfield³, B.A. Grierson¹, C.P. Chrobak², A.G. McLean⁵, S.L. Allen², D.J. Battaglia³, A.R. Briesemeister³, M.E. Fenstermacher³, P.B. Snyder², and the DIII-D Team

¹University of Wisconsin-Madison, 1500 Engineering Dr., Madison, WI 53706, USA
²General Atomics, P.O. Box 85608, San Diego, CA 92186-5608, USA
³Princeton Plasma Physics Laboratory, P.O. Box 451, Princeton, NJ 08543-0451, USA
⁴University of California San Diego, 9500 Gilman Dr., La Jolla, CA 92093-0417, USA
⁵Lawrence Livermore National Laboratory, 700 East Ave, Livermore, CA 94550, USA
⁶Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, TN 37831, USA

Periods of ELM free H-mode with increased pedestal pressure and width were observed in the DIII-D tokamak associated with enhanced density fluctuations localized to the pedestal region. Injection of a powder of 44 μm diameter lithium particles dramatically extends the duration of the enhanced fluctuations up to 350 ms and the likelihood of a transition to such phase, which results in strongly increased pedestal pressure and width. The amplitude of density fluctuations measured with 2D beam emission spectroscopy (BES) increases substantially across the pedestal in the frequency range 40 kHz to 120 kHz (Fig.1), peaking at a relative magnitude of \( \hat{n}/n \approx 8\% \) just inside the separatrix. These fluctuations with wavenumber, \( k_\rho \approx 0.1-0.2 \), propagate in the electron diamagnetic drift direction in the plasma frame. The onset of such fluctuations happens on a very fast time scale (<10 ms) and is correlated with the pedestal expansion. The fluctuations are bursty in time with duration of a few hundred μs and frequency changing rapidly within each burst, so named the “Bursty Chirping Mode (BCM)”. 2D velocimetry analysis of this mode demonstrates that it drives particle transport, consistent with a subsequent transient increase in the recycling \( D_\alpha \) emission. This results in a flattening of the pressure profile just inside the separatrix. This localized flattening allowed higher overall pedestal pressure because of the improved peeling-ballooning stability limit, which is higher than expected under the EPED model due to reduction of the pressure gradient below the “ballooning critical profile”. These results demonstrate how manipulation of the pedestal height can lead to higher performance.

*This work was supported by the U.S. Department of Energy under DE-FG02-89ER53296, DE-FG02-08ER54999, DE-FC02-04ER54698, DE-AC02-09CH11466, DE-FG02-07ER54917, DE-AC52-07NA27344, and DE-AC05-00OR22725.