Turbulence and zonal flows in edge plasmas of the HL-2A tokamak

K J Zhao¹, J Q Dong¹,²,⁵, L W Yan¹, W Y Hong¹, A Fujisawa³, C X Yu⁴, Q Li¹, J Qian¹, J Cheng¹, T Lan², A D Liu⁴, H L Zhao⁵, D F Kong⁴, Y Huang¹, Yi Liu¹, X M Song¹, Q W Yang¹, X T Ding¹, X R Duan¹ and Yong Liu¹

¹ Southwestern Institute of Physics, PO Box 432, Chengdu, People’s Republic of China
² Institute for Fusion Theory and Simulation, Zhejiang University, Hangzhou, People’s Republic of China
³ Research Institute for Applied Mechanics, Kyushu University, 6-1 Kasuga-Kouen, Kasuga, 816-8580, Japan
⁴ Department of Modern Physics, University of Science and Technology of China, Hefei, People’s Republic of China

E-mail: jiaqi@swip.ac.cn

Received 18 June 2010, in final form 28 July 2010
Published 15 November 2010
Online at stacks.iop.org/PPCF/52/124008

Abstract
Measurements with a toroidally and poloidally displaced three-dimensional set of Langmuir probe arrays have revealed details of turbulence, geodesic acoustic modes (GAMs), zonal flows and their interactions in the edge region of HL-2A tokamak plasmas. The coexistence of intensive low frequency zonal flows (LFZFs) of \( f < 4 \text{ kHz} \) and the GAMs of \( 7 \text{ kHz} < f_{\text{GAM}} < 20 \text{ kHz} \) has been unambiguously demonstrated. The poloidal and toroidal symmetries of the flows, including the GAMs, are verified experimentally. In particular, the coherency of the flows over a large toroidal scale of \( 2100 \text{ mm} \) at a magnetic flux surface is emphasized. The LFZF packets are shown to propagate outward and inward as equally likely events, whereas the predominantly outward propagation of the GAM packets is analyzed. The nonlinear three-wave coupling of the flows with ambient turbulence is shown with a bicoherency analysis and an envelope modulation of the latter by the former. The intensity of the LFZFs is observed to increase and decrease with increases in ECRH power (\( \sim 300-700 \text{ kW} \)) and safety factor \( q \sim (3.5-6.2) \), respectively, whereas the intensity of the GAMs increases with increases in both ECRH power and \( q \).

(Some figures in this article are in colour only in the electronic version)