Propagation of Turbulent Structures in the SOL of Alcator C-Mod

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Abstract

The strong convective flux of ions into the low-numbered layer (LHL) is generated by a variety of transport mechanisms, including electron temperature fluctuations. In the formation of structures, which appear as striations along the magnetic field, but are strongly localized in the poloidal plane, commonly called “blobs,” in the context of transport, the propagating properties of modes are of particular interest. In this work, the authors investigate the propagation properties of these modes across the LFCS, allowing for an investigation of the radial propagation properties of plasmas propagation through both high beta and complex turbulence. Imaging of the plasma fluctuations with both framing cameras provides information of both propagation in the poloidal plane across the LCFS (Ref. 2). Additionally, conducting edge current balances in poloidal sections forming poloidal instabilities and identifying poloidal instabilities in poloidal sections can reveal the poloidal signature of these instabilities. These two methods are coupled with poloidal fluctuations observed in poloidal imaging. The authors demonstrate that the poloidal movement observed in poloidal images is due to poloidal instabilities and not to radial transport. This finding is supported by the simulations and the observed poloidal fluctuations observed in poloidal images, which indicate a poloidal instability.

Gas Puff Imaging

Experimental Setup and Diagnostics

Gas Puff Imaging Diagnostics - Poloidal Plane

Discharge Parameters (Ohmic)

$T_e = 630 k\text{eV}$

$B_t = 6.4 T$

$\eta = 6$

$\Delta n/d\Omega = 8 \times 10^{10} m^{-3}$

$\Delta n_{LCS} = 5 \times 10^{10} m^{-3}$

$T_{e LCS} = 500 V$

Fluctuation Structures along B

Parallel Correlation Measurements

Correlation Measurement Setup

Normalized Correlation Functions

Comparison with 2D Model

model equations

$$\frac{d\Delta n}{dt} + nC(\phi) - C(nT) = \nu_T\nabla^2 \Delta n - \sigma_T(n - 1) + S_n$$

$$\frac{\partial \Delta n}{\partial t} + \Delta n = C(\phi) - C(nT) - \nu_T\nabla^2 \Delta n - \sigma_T(n - 1) + S_n$$

simulation domain / diagnostics

phase shift between density and potential is $\pi/2$

simulation suggests that correlation across LCFS is due to relaxation of density profile in response to transport event (blob)

Gas Puff Imaging Fast Framing Camera (PS5)

Diagnostics - Poloidal Plane

profiles

diodes / camera

$D_0 \sim n^2 T^2$

fluctuations

$I_{\text{heat}} \sim n\sqrt{T}$

$\Phi_{\text{heat}} \sim \Phi_0 + \alpha T$

Parallel Correlation Measurements

Poloidal phase shift of $\pi/2$ between density and potential fluctuations observed

Propagation Velocity

radial velocity from radial (1D) diode array

radial/poloidal velocities from camera images

radial / poloidal velocity distribution

Displacement, $\Delta t = 8 \mu s$ gives radial / poloidal velocity (PIV)