Abstract

In order to obtain three dimensional data on the formation and evolution of the ablation striations, we have constructed a stereoscopic imaging system which is currently being installed on B-Port of Alcator C-Mod. The system consists of two 24mm camera lenses, with a field of view of 9.4 degrees, mounted 9.56 inches above the plasma axis. The images from the lenses are passed to PSI IV high speed CCD camera, via a bifurcated fiber bundle, where they are imaged onto the high speed imaging (max frame rate = 500 kHz) system. Inserted Li pellets into Alcator C-Mod during the 2003 campaign identified the presence of poloidally moving striations in the pellet's ablation cloud. The analysis of the striations is made possible through the high spatial, ~1mm, and temporal, 2 s, resolution.

Parks Theory

Paul Parks has proposed a theory that the striations are formed by Maksay-Hughes instability when the cloud is unstable. This instability is driven by radial electric field in the ablation column, which rises due to an ablation of the lithium cloud extending through the ablation column. The instability, which gives rise a near uniform rotation of the ablation column due to the \( \omega \times \mathbf{B} \) drift. Parks' theory predicts that the instability will set in when the rotation frequency, \( \omega_r \), reaches a critical level, and that the frequency of the resulting instability, \( \omega_I \), will be some fraction of \( \omega_r \).

As the instability grows, the displaced cloud could become fully detached so that it would no longer be fed by ablating pellet material and would appear to be displaced substantially with respect to the unperturbed cloud. This is expected to be the case for the Li pellet, which has a density of \( 10^{17} \text{cm}^{-3} \) and a temperature of \( 10^4 \text{K} \) and a characteristic frequency less than 100 kHz. A mode of this magnitude, \( |\mu| \approx .1 \), and a temporal variation much slower than 100 kHz would be consistent with zonal flows observed in tokamaks.

L-Mode Shots

Analysis of the six pellets injected into L-mode plasmas indicates that the striation velocity range from \(+/- 3000 \text{m/s}\) and varied in magnitude due to a large range of instability, \( f \approx 10^{-4} \text{Hz} \), in the presence of a reverse magnetic shear in the order of 10's of \( 10^{-4} \text{Hz} \). Previous work relating the stability of ions in zonal flows, with a time resolution of \( 10^{-7} \text{s} \), has shown that the instability is driven by a radial electric field on a spatial scale of \( 10^{-4} \text{cm} \), which is consistent with the observations.

H-Mode Shots

Analysis of the six pellets injected into H-mode plasmas shows that the striation velocity range from \(+/- 1000 \text{m/s}\) and varied in magnitude due to a large range of instability, \( f \approx 10^{-4} \text{Hz} \), in the presence of a reverse magnetic shear in the order of 10's of \( 10^{-4} \text{Hz} \). Previous work relating the stability of ions in zonal flows, with a time resolution of \( 10^{-7} \text{s} \), has shown that the instability is driven by a radial electric field on a spatial scale of \( 10^{-4} \text{cm} \), which is consistent with the observations.

Radial Electric Fields

An alternative explanation for the evolution of the striations would be the presence of a spatially varying electric field along the column axis of the column. A radial electric field that varied in spatial scale from \( 10^{-4} \text{cm} \) to \( 10^{-2} \text{cm} \) and had a magnitude from \( -40 \text{kV/m} \) to \( 40 \text{kV/m} \) would be consistent with the observations. If the electric field was spatially uniform, a characteristic frequency \( f \approx 10^{-4} \text{Hz} \) would be consistent with zonal flows observed in tokamaks. However, the analysis of the Li pellet suggests that the striations are driven by a radial electric field on a spatial scale of \( 10^{-4} \text{cm} \), which is consistent with the observations.

Experimental Objectives

To obtain three-dimensional data on the formation and evolution of the ablation striations, we have constructed a stereoscopic imaging system which is currently being installed on B-Port of Alcator C-Mod. The system consists of two 24mm camera lenses, with a field of view of 9.4 degrees, mounted 9.56 inches above the plasma axis. The images from the lenses are passed to PSI IV high speed CCD camera, via a bifurcated fiber bundle, where they are imaged onto the high speed imaging system. Inserted Li pellets into Alcator C-Mod during the 2003 campaign identified the presence of poloidally moving striations in the pellet's ablation cloud. The analysis of the striations is made possible through the high spatial, ~1mm, and temporal, 2 s, resolution.

References