Momentum transport calculations on Alcator C-Mod in the L-H mode transition

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Multiple forms of the convective pinch can be used in order to calculate the transport needed to achieve the simplified model of diffusion.

L-H mode discharges appear to have a non-diffusive momentum source highly correlated with the difference in the temperature gradient.

L-H mode plasmas have similar rotation changes to H-mode plasmas, but appear to have vastly different source and gradient shapes.

-Cyrokinetic simulation work of H-mode rotation profiles is ongoing.

Overview

- Rotation Research and Motivation
- Overview of the Experimental Set-up
- Description of Source Calculations
- H-mode and I-mode Momentum Transport
- Progress in Gyrokinetic Simulations
- Discussion and Acknowledgements

Introduction

Torroidal plasma rotation has been seen to have a variety of beneficial effects on tokamak operation and physics including:

- suppressing instabilities such as the resistive wall mode, reducing the necessity for internal stabilizing coils
- rotation can break tearing modes, which causes rotation barriers and improves confinement
- rotation measurement allows calculating the radial electric field in a plasma, which is an important part of understanding H-mode physics

The goal of this work is to identify the non-diffusive and convective terms in the momentum transport equation during L-H modes.

Experimental Set-up

The key to identifying the velocity profile at C-Mod has been seen to have a variety of beneficial effects on tokamak operation and physics including:

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Description of Calculations and Results

The method used in this research to analyze momentum transport is the application of a modified form of momentum transport (3) to the plasma, in order to infer local plasma parameters. Data from Thomson scattering measurements, and the previously listed assumptions allow for the determination of the gradients in (3), as follows:

\[
\frac{\partial T_{\parallel}}{\partial T_{\parallel}} = \frac{\partial p}{\partial T_{\parallel}} - \frac{\partial P}{\partial T_{\parallel}} + \frac{\partial P_{\parallel}}{\partial T_{\parallel}} - \frac{\partial P_{\perp}}{\partial T_{\parallel}} + \frac{\partial P_{\parallel}}{\partial T_{\perp}} - \frac{\partial P_{\perp}}{\partial T_{\perp}}
\]

In this study, Galilean invariance of the convective term is ignored, as done, however, suggest that \( \partial T_{\parallel} \). The right-hand side of the equation of (2) is assumed to be the source term in the following equation. We assume that the momentum diffusion is approximately equal to the ion thermal diffusion (\( \partial T_{\parallel} \)). The ion diffusion terms are calculated using the TRANSP code. Values of the convective term are calculated under a variety of assumptions. In this work, the convective terms were either set to zero, taken from Fotenos et al. [4], or from Yoon et al. [7]

Differences in plasma gradients from the L-H mode transitions, are measured by taking the differences of the average steady-state portions of the H-mode (3.0-2.2 s) and L-mode (3.1-1.4 s).

H-mode Rotation Profile

During H-modes, it has been observed that the plasma develops an intrinsic rotation in the direction of the edge with the amount of rotation spin up proportional to \( \Delta T_{\perp} / T_{\perp} \).

I-mode Rotation Profiles

Repeating the H-mode approach for the L-I mode transitions yields the following graphs. Times used for the steady-state I-mode were 0.8-0.95 and L-mode times were 0.4-0.8.

All calculated source profiles appear to have a peak around 0.25. The differences in the gradients of \( T_{\perp} \) and \( T_{\parallel} \) and pressure have peaks around 0.25, suggesting that the gradient is in T driven rotation.

Discussion

- Fully space and time varying diffusive and convective profiles of momentum transport have been implemented in the simplified model of H-region physics
- Significant improvements in convective terms are observed in the density and current profiles
- Multiple forms of the convective pinch can be used in order to calculate the source needed to achieve the simplified model of diffusion
- L-H mode discharges appear to have a non-diffusive momentum source highly correlated with the difference in the temperature gradient
- L-I mode plasmas have similar rotation changes to H-mode plasmas, but appear to have vastly different source and gradient shapes

-Cyrokinetic simulation work of H-mode rotation profiles is ongoing.

Using the CVID [4] gyrokinetic code, it is possible to simulate plasma energy and momentum transport in the plasma from turbulence. Several simulations have been carried out in order to match the gyrokinetic predictions to a set of measured momentum flux in an H-mode plasma. This will allow comparing actual to turbulence predictions rotation profiles. Example profiles of energy and momentum fluxes are shown below.

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