Study of Plasma Rotation by Modulating ICRF Power on Alcator C-Mod
C. Gao¹, J. E. Rice¹, Y. Podpaly¹, M. L. Reinke¹, L. Delgado-Aparicio², Y. Lin¹
¹MIT Plasma Science and Fusion Center ²Princeton Plasma Physics Laboratory

Abstract

• X-ray emission intensity and toroidal rotation velocity profiles are studied with modulated ICRF heating using high resolution X-ray spectrometers and analysis tools that provide spatially resolved intensity, ion-temperatures, and rotation profiles. Preliminary analysis shows that modulated intrinsic rotation profiles with modulated stored energy (~2.5 m/s). Fourier analysis indicates the rotation propagates from the edge to the core. Study of the phase and amplitude profiles shows little local correlation between plasma pressure and intrinsic rotation. A sinusoidal model is used to calculate momentum transport coefficients. In the core the diffusivity is ~0.2-0.3 m²/s, and the inward pinch velocity is ~0.5-0.55 m/s. A linear acceleration term associated with the toroidal rotation velocity is observed in this ICRF-modulated L-mode discharges, which may be related to the residual term of momentum flux.

Motivation

In DIII-d minority plasmas with ICRF heating, an increase of intrinsic rotation in the co-current direction is observed in H-mode and J-mode discharges. This rotation change scales with plasma stored energy/θ. Modulated ICRF experiment is suitable for intrinsic rotation study in providing dynamic information of intrinsic rotation. It also provides a method to calculate the momentum transport coefficients using Fourier analysis.

Introduction to Experimental Set-up

High Resolution X-ray spectrometer with Spatial Resolution (HFRxS-SR) is used for ion temperature and rotation profile measurement at Alcator C-Mod. The measurement is based on spherically bent crystal to provide spatial resolution of argon’s helium-like and hydrogen-like spectra.

Modulated ICRF Heating in D(H) plasma

In steady-state ICRF heated H-mode and L-mode discharge, rotation in co-current direction has been observed. The rotation velocity scales with plasma stored energy [θ]. There is no direct momentum input for these discharges.

In ICRF modulation experiments, rotation velocity change is also observed in L-mode with similar scaling law of steady-state ICRF experiments. For L-mode, modulated rotation velocity amplitude also scales with plasma stored energy. The modulation experiment may provide some dynamic information for the absence of intrinsic rotation.

Phases of $V_r$ and $P$

• Here small phase value means heating in phase.
• Phase of $V_r$ indicates the rotation moves to change from the substrate.
• There is no local correlation between the phase of $V_r$ and $P$.

Amplitude of $V_r$, $P$ and $P$

• Amplitude of $V_r$ is very flat.
• There is no local correlation between the amplitude of $V_r$, $P$ and gradient profile inside r/a < 0.5.

Sinusoidal Model

- Core momentum diffusivity ~ 0.2-0.3 m²/s
- Inward pinch ~ 0.5-0.55 m/s

Linear Acceleration Term

- There is a linear acceleration term associated with $V_r$
- This linear acceleration term might be from the residual of momentum flux.
- We can estimate $\frac{dV_r}{dt} = \frac{dV_r}{dt} - \frac{dV_r}{dt}$

Conclusions

- In ICRF modulation experiments, $\Delta V_r$ scales with $\Delta W_p$ (Rice Scaling).
- Momentum transport coefficients ($V_r$ and $V_{tang}$) are determined using a sinusoidal model, $V_r$ is comparable to $V_{tang}$.
- The acceleration term of toroidal rotation may indicate a residual term of momentum flux.

References