Search for Correlation Between Plasma Rotation and Electron Temperature Gradient Scale Length in LOC/SOC Transition at Alcator C-Mod

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Abstract / Motivation

It is proposed that early ITER operations will be without external momentum input. In the absence of momentum injection, the plasma toroidal rotation will be determined by intrinsic rotation in the plasma discharge. It has been observed in tokamaks that the plasma energy confinement time (τE) scales linearly with density. When this linear regime, which is commonly known as linear ohmic confinement (LOC), reaches a critical density, it saturates where the new regime is known as saturated ohmic confinement (SOC). The dependence on the collisionality, Γ (1/λ), here thi/1/2τe, is the convection (momentum pinch). In addition to these diagonal terms, χ is the off-diagonal terms of the stress tensor contributing to the fluid response. The density ramp-up shot which transits from LOC to SOC during 1.5% B of the discharge time.

Theoretical Background

The toroidal momentum flux (JT), in radial direction, can be written as, τE = a(Te)2 + b(Te) + c.

Here (a(Te)2 + b(Te) + c) is the Mach number (a(Te)2 + b(Te) + c) is the normalized rotation gradient, Vn = (Tn)1/2, and V is the convection (momentum pinch). In addition to these diagonal terms, there are off-diagonal terms, T′ which are usually termed as residual stresses. These terms can be present even when rotation and resistivity gradient are zero. The magnitude of T′ should be proportional to gradient scale lengths, i.e., L2, L3, and L4, where T′ = 2Tc

Direct τE, Measurements

FRCCCE is a heterodyne radiometric electron cyclotron emission (ECE) diagnostic that is installed at Alcator C-Mod tokamak. It detects 2nd harmonic x-mode plasma emission in the frequency range 234–306 GHz. This frequency range provides full coverage of the outer half of the plasma for standard C-Mod fields. The high-resolution (100 kHz) and Time (τE) of FRCCCE shows about T′ measurements through the B0 field measurements. For the B0 field technique, a 1.5% change in the toroidal magnetic field shifts the viewing volume of the B0 field in such a direction to the source such that the derived τE measurement is assumed to be independent of any calibration and the laser ramp-up would shift in linearly into convolution. Additionally, the technique eliminates any fluctuation in T′ profiles (i.e. magnetic islands) which can be overlooked in common fitting procedures.

Intrinsic Rotation, Scale Lengths and Confinement

A density ramp-up shot which transits from LOC to SOC during 1.5% B of the discharge time.

Electron density profiles at t = 0.8s, measured with Thomson scattering (Θ), their fit (θ), for LOC/SOC transition shots mentioned above.

Conclusions

> T′ measurements via the B0-jet technique show consistent trends when compared with T′ deduced from fitting of the ion temperature profiles.
> This in turn means that dependence on those scale lengths follow the same trend.
> Core intrinsic rotation behavior shows strong dependence on length scales, however its behavior is eventually found to be a function of confinement regime.

Other Diagnostics

Electron density profiles at t = 0.8s, measured with Thomson scattering (Θ), their fit (θ), for LOC/SOC transition shots mentioned above.

Electron (ne) and ion (ni) temperature profiles. Electron profiles are reported from 100 ms averaging from FRCCCE temperature diagnostic. The T′, shown from LOC to SOC, is correlated to confinement mode.