Measurement of Particle Transport Coefficients on Alcator C-Mod

by

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Abstract

The study of particle transport is increasingly important for fusion research. During the 1993 and 1994 campaigns of Alcator C-Mod, one observed phenomenon was the divertor detachment. This phenomenon was characterized by reduced particle and energy flows to the divertor plates and is of interest as a solution to the heat loading problem of the first wall. A sharp rise in the central electron density was observed after detachment. The goal of this thesis was to study the behavior of the plasma transport during the divertor detachment in order to explain this density rise.

The measurement of particle transport coefficients requires sophisticated diagnostic tools. A two color interferometer system was developed and installed on Alcator C-Mod to measure the electron density with high spatial (= 2 cm) and high temporal (≤ 1.0 ms) resolution. The system consists of 10 CO2 (10.6 μm) and 4 HeNe (.6328 μm) chords that are used to measure the line integrated density to within 0.08 CO2 degrees or 2.3×1016 m⁻² theoretically.

Using the two color interferometer, a series of gas puffing experiments were conducted. The density was varied above and below the threshold density for detachment at a constant magnetic field and plasma current. Using a gas modulation technique, the particle diffusion, D, and the convective velocity, V, were determined. Profiles were inverted using a SVD inversion and the transport coefficients were extracted with a time regression analysis and a transport simulation analysis. Results from each analysis were in good agreement.
Measured profiles of the coefficients increased with the radius and the values were consistent with measurements from other experiments. The values exceeded neoclassical predictions by a factor of 10. The profiles also exhibited an inverse dependence with plasma density. The scaling of both attached and detached plasmas agreed well with this inverse scaling. This result and the lack of change in the energy and impurity transport indicate that there was no change in the underlying transport processes after detachment. On the contrary, measurements of the Hα radiation and argon transport were consistent with a change in the electron source at the edge. Thus, the rise in central density was due to an increase in the overall electron source or a improvement in fueling efficiency and not due to an improvement in the core particle transport.