1. Purpose of Experiments

The objective of the experiment is to extend the examination of edge electron density \( n_e \) profiles in Alcator C-Mod by paying careful attention to the case of L-mode plasmas. Of interest is the behavior of the L-mode \( n_e \) pedestal as density is varied and the extent to which the target L-mode profiles affect the subsequent H-mode pedestal. Also, by obtaining L-mode and H-mode plasmas with similar values of edge \( n_e \), we hope to better understand the processes governing particle transport in either confinement regime. Measurements of \( n_e \) and electron temperature \( T_e \) profiles in the pedestal region and scrape-off layer (SOL) will be used to evaluate neutral-plasma interaction at the edge and to determine whether any correlation exists between neutral penetration length and \( n_e \) pedestal width. Also, the potential exists to compare SOL profile measurements in the upper chamber with those nearer the machine midplane.

2. Background

Interactions between plasma and neutral atomic species at the tokamak plasma edge are potentially important factors in determining the particle, energy and momentum transport in the vicinity of the H-mode transport barrier. In addition, edge neutral fueling may influence the profiles in the edge pedestal region, in particular the plasma density profile. Because edge pedestal quantities directly affect core plasma confinement, it is important to evaluate neutral-plasma interactions and to assess their influence on the pedestal. Of particular interest is the application of diffusive transport modeling that predicts an \( n_e \) pedestal width \( \Delta n \) scaling with the neutral mean free path at the plasma edge, or roughly as the inverse of edge \( n_e \), a result that should be equally applicable in both L- and H-mode. [1]
Though the characteristic neutral penetration length in the C-Mod H-mode pedestal is of the same order as $\Delta_n$, the opposite trend with pedestal density $n_{e,PED}$ has been observed experimentally. In particular, in enhanced-D$_{alpha}$ (EDA) H-modes, $\Delta_n$ increases with higher edge $n_e$, yielding similar values of maximum $\nabla n_e$ over a range of discharge parameters. [2] There are indications that a similar trend exists in L-mode $n_e$ pedestals. A dedicated experiment in 2002 [3] sought to test the trend in H-modes at fixed plasma current $I_p$, toroidal field $B_T$ and magnetic equilibrium, varying only line-integrated target density $n_e L$. The results suggested that absolute $n_e$ did not significantly affect transport barrier $\Delta_n$. However, the range of density obtained in the prior experiment was narrow, and a definitive conclusion was not made. At the same time, it remains to be determined what trend exists in L-mode $n_e$ pedestals, given all parameters other than edge $n_e$ fixed.

Given complete profiles of $n_e$, $T_e$ in the pedestal region and SOL, it should be possible to quantify any correlation of $\Delta_n$ and $n_{e,PED}$ in L-mode plasmas, and to compare the pedestals of L- and H-modes with the similar values of $n_{e,PED}$. Though numerous low density H-modes and high density L-modes have been seen already it is desirable to compare directly L- and H-mode pedestals formed under fixed plasma parameters (e.g. $I_p$, $B_T$) and machine conditions. In addition, it is important to diagnose the SOL profiles properly, and we are in the process of refocusing Thomson scattering (TS) optics in order to increase measurement sensitivity in the SOL. TS measurements of $n_e$, $T_e$ are made at the top of the C-Mod chamber. A secondary goal of this experiment is to compare carefully these profiles with those measured by scanning Langmuir probes near the midplane.

3. Approach
Describe the methodology to be employed; explain the rationale for the choice of parameters, etc. Describe the analysis techniques to be employed in interpreting the data, if applicable. If the approach is standard or otherwise self-evident, this section may be absorbed into the Experimental Plan.

The technique will involve scanning density shot by shot while maintaining fixed $I_p$, $B_T$ and magnetic geometry. H-modes will be triggered by application of RF heating. In order to match $n_{e,PED}$ between confinement regimes, it will be necessary to obtain H-modes of relatively low density, and L-modes of relatively high density. A low $I_p$ of 600 kA is required, both to promote EDA operation and to minimize the value of H-mode $n_{e,PED}$. We will begin with a target $n_e L$ of $4 \times 10^{19}$, and then increase in steps of $1 \times 10^{19}$. As the scan progresses, high density L-mode edges will match H-mode edges obtained at lower target $n_e L$. As $n_e L$ increases, it may be desirable to apply RF heating to the L-mode phase in order to reduce the edge cooling effect.

Insertion of scanning probes close to the last closed flux surface (LCFS) should be obtained, both before and after the L-H transition, in order to compare (and, when possible, connect) SOL profiles with those obtained by the edge TS system, under a range of plasma densities. Trends in pedestal $\Delta_n$ can be evaluated directly. Furthermore, with complete profiles over a wide range densities, analysis of neutral interactions and calculation of ionization sources will be obtained using a kinetic neutral code, KN1D. [4]

4. Resources
4.1 Machine and Plasma Parameters

Give values or range for:

**Toroidal Field:** 5.4 T

**Plasma Current:** 600 kA

**Working gas species:** $D_2$

**Density:** target $n_e L$ from $4 \times 10^{19}$ to $1.6 \times 10^{20}$

**Equilibrium configuration** (if possible, refer to database equilibria): Lower single null. (e.g. 1021106001)

**Pulse length, typical current & density waveforms, etc.** Refer to database or sketch desired waveforms:
Standard pulse length, flat density, current and field program.

4.2 Auxiliary Systems

**RF Power, pulse length, phasing:** 1-3 MW, flat, 0.8–1.2 s. An increasing two-step RF trace might be required on some higher density shots, to heat the L-mode phase and then to trigger and sustain H-mode.

**Pellet Injection (species):** None.

**Impurity blow-off injection:** None.

**Diagnostic Neutral Beam:** Not needed.

**Special gas puffing:** None.

**Other:** None.

4.3 Diagnostics

List required diagnostics, and any special setup or configuration, e.g. non-standard digitization rate.

Edge TS and scanning probe plunges are critical for obtaining plasma edge profiles. The run should be scheduled only after the TS optics are adjusted to maximize the SOL sensitivity of the edge TS system. All standard diagnostics such as TCI, ECE and visible continuum are desired. Edge Lyman alpha measurements are also useful for comparison with calculations.

5. Experimental Plan

Both sections must be filled in.

5.1 Run sequence plan

Specify total number of runs required, and any special requirements, such as consecutive days, no Monday runs, extended run period (10 hours maximum), etc.

This experiment, assuming well-behaved operation, could be accomplished in one half run day.
5.2 Shot sequence plan

For each run day, give detailed specification for proposed shot sequence: number of shots at each condition, specific parameters and auxiliary systems requirements, etc. Include contingency plans, if appropriate.

Shots should be programmed as described in Sec. 4, with density scanned shot by shot, from $4 \times 10^{19}$ to $1.6 \times 10^{20}$ in steps of $1 \times 10^{19}$; a total of 13 good shots, having useful edge TS profiles and probe plunges, required.

6. Anticipated Results

Discuss possible experimental outcomes and implications. Indicate if the program may be expected to lead to publications, milestone completions, improved operating techniques, etc. Indicate if the experiments are intended to contribute to a joint research effort, or an external database.

The addition of these profiles to our existing data set, and the analysis of neutral-plasma interactions should improve our understanding of edge particle transport in both L- and H-mode. The results will support a presentation at the September 2003 IAEA transport barrier workshop and a concurrent journal article. The experiment also will contribute to Hughes’s PhD thesis work.

7. References

Include references both to external and internal literature or communications which bear on this proposal. See Section 2.