

# Alcator C-Mod Mini-Proposal

MP No. 513

**Subject:** LHCD Effects on Stable Alfvén Eigenmodes

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**Group:** MHD

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**Approved by:**

**Date Approved:**

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## 1. Purpose of Experiments

Include immediate goal of the experiments, scientific importance and/or programmatic relevance. Refer to any relevant program milestones.

Use lower hybrid current drive both early in the current rise and later in the flattop to modify the current density profile and simultaneously excite stable Alfvén eigenmodes with the Active MHD antennas to look for changes in the stable modes due to changes in the q profile.

## 2. Background

Discuss Physics Basis of the proposed research. Prior results at Alcator or elsewhere, and any related work being carried out separately.

NOVA-K calculations indicate that the damping rate of TAEs is very sensitive to even small changes in the q profile [1]. A 10% change in q(r) can lead to an order of magnitude change in the calculated damping rate. If such small changes in q(r) do indeed change the damping rate substantially, then the measured damping rate of stable modes should be a very sensitive measure of even small changes in the q profile. If the changes in q(r) are small enough, there should be little change in the resonant surface position of the excited modes so that coupling of the antennas to the resonant surface should not change significantly. If, on the other hand, a hollow q profile can be developed, then multiple modes may be excited at different radial locations for the same resonant q value.

## 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 Active MHD antennas will be swept in frequency with pre-programming throughout the current rise and flattop of the discharges. Then, discharges will alternate with and without LHCD both in the current rise and flattop phases. Excited stable TAEs will be compared with and without LHCD to look for changes in the damping rate and character of the modes. Choose low density ( $n_{l04} = 4 \times 10^{19} \text{ m}^{-2}$ ) plasma conditions where LHCD should significantly modify the q profile. Vary the plasma current shot to shot and the

LH phasing from 60° to 90° to 120° to change the deposition profile of the LHCD and look for changes in the excited stable AE character and damping rate.

## 4. Resources

### 4.1 Machine and Plasma Parameters

Give values or range for:

Toroidal Field: 4.5 T  
Plasma Current: 0.5 – 1.0 MA  
Working Gas Species: Deuterium  
Density:  $4 \times 10^{19} \text{ m}^{-2}$   
Equilibrium configuration (if possible, refer to database equilibria): 1070523014

### 4.2 Auxiliary Systems

RF Power, pulse length, phasing: LH up to 500 kW, 60, 90, and 120° phasing  
Pellet Injection (species): None  
Impurity blow-off injection: None  
Diagnostic Neutral Beam: Yes  
Special gas puffing: No special puffing  
Non-axisymmetric Coils (Connections, Current); Normal configuration in feedback  
Other:

### 4.3 Diagnostics

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

Fast magnetic pick-up coils are required with sampling of 2.5 MHz. Active MHD antennas. HIREX for rotation profiles. Thomson for density profiles. MSE for q profiles.

## 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.

One run should be sufficient to measure the effects of LHCD induced changes in the q profile on stable Alfvén eigenmodes. Running the startup at 4.5 T may be more difficult as breakdown conditions will be affected but LH accessibility should not be a problem at this low a density.

### 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.

Preprogram the Active MHD antennas to sweep through the expected Alfvén Cascade frequencies up to the TAE frequency to look for resonances in the current rise. Then, preprogram sweeps through the TAE frequency during the flattop as well. Allow a number of Ohmic shots to tune up the startup at 4.5 T (5 shots). Program the LHCD to start early in the current rise from 0.02 s to 0.3 s then off until 0.5 s and on until 1.5 s. Start with  $I_p = 0.75 \text{ MA}$  and  $n_{l04} = 4 \times 10^{19} \text{ m}^{-3}$  with 90° phasing of LHCD (2 shots).

Increase  $I_p$  to 1 MA (2 shots). Reduce  $I_p$  to 0.5 MA (2 shots). Repeat with  $60^\circ$  phasing (6 shots). Repeat with  $120^\circ$  phasing (6 shots). Finish with 1 – 2 Ohmic shots to look for reproducibility of the excited TAEs.

## 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.

Varying the deposition of the LHCD as well as the plasma current should lead to significant variations of the  $q$  profile at different radial locations and this should lead to significant changes in the measured damping rates of the excited stable Alfvén eigenmodes. Modeling with NOVA-K will be used to attempt to explain the results. This should lead to conference proceedings and perhaps a journal paper.

## 7. References

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

[1] J A Snipes, N N Gorelenkov, J A Sears, *Nucl. Fus.* **46** (2006) 1036.