

Alcator C-Mod Mini-Proposal

MP No. ___472

Subject: Continued Studies of Turbulence in Low Density Ohmic Plasmas

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Group: Transport

Date: March 8, 2007

Approved by:

Date Approved:

1. Purpose of Experiments

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

The experimental objective is study how density fluctuation characteristics (\tilde{n} , f , k) scale with typical plasma parameters (n_e, B) and identify the dominant driving mechanism (ITG/TEM/ETG), as well as their correlations with the global transport parameters (τ_E, χ_E).

2. Background

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

In a recent search for the high-k turbulence, of the ETG range, in the low density ohmic plasmas (MP 400a¹), we have observed fluctuations with frequencies up to 500 kHz and wavenumbers up to 20 cm⁻¹, which corresponds to $k_R \rho_s \sim 1.6$. Furthermore, as the density increases in ohmic plasmas, the observed relative density fluctuation level decreases with density in the “linear” ohmic regime (low density, Alcator scaling, $\tau_{\text{kin}} \propto n_e$), whereas it increases with density in the “saturated” ohmic regime.²

In the previous campaign, only the high-k setup configuration was used for the phase contrast imaging (PCI) diagnostic and localization studies with the masking plate were not carried out. Hence the dominant direction of propagation (electron vs. ion diamagnetic) of the density fluctuations was not resolved. Moreover, Δk_R was not resolved with enough accuracy to determine the fine wavenumber structure of the dominant low-k turbulence.

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.

We propose to repeat the experiments and in the first phase of this proposal, use the PCI medium-k configuration with increased wave-number resolution to study k_R structure of the turbulence as the density is varied. Moreover, we will use the localizing setup³ to determine the direction of propagation of the dominant components of the observed turbulence, which will possibly allow us to resolve its driving mechanism (ITG vs. TEM). This study will be carried out at two different toroidal magnetic fields: $B = 5.2$ and 2.6 T, where I_p is changed to keep q_a constant: 0.8 and 0.4 MA, respectively. The field variation at the same q should give a clear variation of the wavelengths as predicted by the linear dispersion relationship of ITG/TEM modes. If this relationship is not observed, then we have clear evidence for a strongly nonlinear phenomenon.

In addition to the above study on the low-k turbulence, we also propose further studies of the high-k (ETG range) but now with localization techniques. In this study, the PCI will be configured but with the masking plate operational for localization measurements. Thus, the direction of propagation of the ETG (?) modes will be determined. The measurements can be compared with the results from the past density scan.

Besides the above experimental studies, in the future we will compare the experimental results with gyro-kinetic code predictions (GS2, GYRO).

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

Toroidal Field: 2.6 T and 5.2 T

Plasma Current: 0.4 MA and 0.8 MA

Working Gas Species: D

Density: $\bar{n}_e = 0.4 - 1.6 \times 10^{20} \text{ m}^{-3}$

Equilibrium configuration (if possible, refer to database equilibria): 1050819028

4.2 Auxiliary Systems

RF Power, pulse length, phasing: None

Pellet Injection (species): None

Impurity blow-off injection: None

Diagnostic Neutral Beam: None

Special gas puffing: None

Non-axisymmetric Coils (Connections, Current); Yes

Other:

4.3 Diagnostics

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

TCI, ECE, GPC, TS, and other standard diagnostic for n_e and T_e . The main fluctuation diagnostic will be PCI, but reflectometer is desired. Different PCI configurations are requested, see the experimental plan for the detail.

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.

Two days are required. The first day is needed to study the low/medium-k turbulence at B = 5.2 T and 2.6 T, respectively. The second day is required to study the high-k turbulence at 5.2 T, including localization measurements with the masking plate, and this needs to be done on a different week for retuning and optimizing the PCI configuration over the weekend. Moreover, we need a well boronized machine to obtain very clean discharges.

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.

On the first day, begin the first half run at B = 5.2 T and $I_p = 0.8$ MA, scan \bar{n}_e shot to shot from 1.6×10^{20} to $0.4 \times 10^{20} \text{ m}^{-3}$ (~10 shots), as on 1050819. The PCI will be configured in the localizing and medium-k ($k_{\max} \sim 12 \text{ cm}^{-1}$) setup. For the second half run, repeat at B = 2.6 T and $I_p = 0.4$ MA, scan \bar{n}_e shot to shot from 1.6×10^{20} to $0.4 \times 10^{20} \text{ m}^{-3}$ (~10 shots).

For the high k setup, on the second day, repeat the 5.2T scenario listed above. The PCI will be configured in the high-k setup ($k_{\max} \sim 30 \text{ cm}^{-1}$). Optimizing localization measurements will require repeated shots as the density is varied. This experiment may require previous piggyback work to understand the signal to noise level with the masking plate at high k, and should not be scheduled in the first 3 week operating period.

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 results will allow us to identify the turbulence driven mechanics (ITG/ETG) in low density ohmic plasmas. They will also allow us to study thermal transport contribution of the short wavelength turbulence in the ETG range. In addition, by comparing the experimental results with the gyrokinetic modeling (GS2/GYRO), it will provide both validations and constraints on the numerical works. All these will contribute to the thesis work by Liang Lin.

7. References

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

¹ M. Greenwald, et al., <http://www.psfc.mit.edu/cmmod/operations/miniproposals/400a.pdf>

² L. Lin, M. Porkolab, et al., Bull. Am. Phys. Soc. **50** (8), 73 (2005).

³ L. Lin, M. Porkolab, et al., Rev. Sci. Instrum. **77**, 10E918 (2006).