Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: **Edge Turbulence Characterization**

OP-XP-224	**Revision: 1**	Effective Date: *(Ref. OP-AD-97)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Authors: S. Zweben, R. Maqueda, J. Boedo, C. Bush, S. Kaye, S. Kubota, F. Levinton, R. Maingi, D. Swain, J. Wilgen, et al	Date 4/22/02
ATI - Task Force Leader: D. Darrow and D. Stutman	Date
RLM - Run Coordinator: R. Maingi	Date

Responsible Division: Experimental Research Operations

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

Edge Turbulence Characterization

1. Overview of planned experiment

The goal of this experiment is to measure the detailed 2-D structure and time evolution of edge turbulence during H-mode and density limit discharges in NSTX. The principal diagnostic will be the new Princeton Scientific Instruments PSI-4 camera, which is capable of capturing 28 successive frames with 80x160 pixels at a framing rate of up to 1 million frames/sec. The results will be compared with recent theoretical simulations of edge turbulence, e.g. BOUT, DBM, and the "blob" model.

2. Theoretical/ empirical justification

It is well known that a high edge temperature is necessary for ignition in ITER or FIRE, since the edge determines the boundary condition for marginal stability of ITG modes in the core. The edge temperature is very likely determined by the edge turbulence, since the observed transport at the edge is large and the neoclassical transport at the edge is small. Therefore an understanding of edge turbulence is important for tokamak research in general.

Specifically, the underlying physics of H-modes seems to be associated with a suppression of edge turbulence due to poloidal shear flows, which can be either large scale DC flows or small scale AC "zonal flows" driven by the turbulence itself. A clear change in the 2-D structure of edge turbulence was seen previously during H-modes in NSTX using the Kodak 1000 frame/sec camera. This XP will measure this 2-D structure on a much faster timescale using the PSI-4 camera. The results will be compared with other edge turbulence measurements on NSTX, e.g. reflectometry and the scanning Langmuir probe (if available). The results might give a clue as to the mysterious trigger mechanism for the H-mode, and should be useful for testing existing theoretical models.

The density limit may also be associated with changes in edge turbulence which increase turbulent transport at high collisionality rather than suppress it. This idea was proposed by Rogers and Drake (PRL '98) based on the DBM code results, and some evidence for increased edge turbulence near the density limit has been reported from Langmuir probes in C-Mod (LaBombard, PoP '01). More recently, an increase in the edge turbulence and transport was calculated by BOUT near the density limit (Xu, TTF '02). This XP will measure this 2-D structure of edge turbulence near the density limit in NSTX using the PSI-4 camera. The results will be compared with other edge turbulence measurements and should be useful for testing theoretical models.

3. Experimental run plan (1 + 0.1 run days)

There are 2 desired conditions for the main part of this XP, one for the density limit condition and one for the H-mode condition. In addition, there a third case using Argon puffing instead of Helium puffing in the GPI diagnostic which requires just a few discharges on a separate run day.

A. Density limit case (1/2 run day):

1. Reproduce shot #107479 as well as possible to obtain a discharge **near the density limit** (2-4 shots) [see Physics Operations Request for waveforms]
2. Add small He puff (≈ 1 torr-liter) to discharge above and take GPI data with the PSI-4 camera starting at a framing rate of 200,000 frames/sec (i.e. 5 μsec/frame). Adjust puff duration and/or framing rate if necessary to obtain good signal levels and good turbulence image motion near the "density limit" time of the discharge (3-6 shots)
3. Change the timing of the PSI camera to capture an earlier time in the same discharge when the density is **≈30-50% below the density limit**. Adjust puff duration and framing rate if necessary to obtain good signal levels (3-6 shots)
4. If time permits, try to increase the density further using a stronger He puff than used in step #2. (finish Part A no later than 1 PM).

B. H-Mode case (1/2 run day):

1. Reproduce shot #107396 as well as possible to obtain an H-mode which lasts at least 10 msec (2-4 shots) [see Physics Operations Request for waveforms]
2. Add small He puff (≈ 1 torr-liter) to discharge above and take GPI data with the PSI-4 camera starting at a at a framing rate of 200,000 frames/sec (i.e. 5 μsec/frame). Adjust puff duration and/or framing rate if necessary to obtain good signal levels and good turbulence image motion **during the H-mode phase** of the discharge (3-6 shots)
3. Repeat step #2 but trigger the camera **during the L-mode phase** of the discharge (3-6 shots)
4. If time permits, try to trigger the camera during the H-L or L-H transition time using the "H-mode trigger".

C. Argon puffing with GPI (3-4 shots on another run day)

1. Reproduce shot #107479 or one from Density Limit run of Part A (1-2 shots)
2. Add small Ar puff (same valve settings as small He puff) during middle of density limit shot Vary puff size and/or framing rate until good GPI images are seen in Argon (2 shots)

4. Required machine, NBI, RF, CHI and diagnostic capabilities

This XP requires an operational NBI system for part B (H-mode), as well as the capability of generating lower-single null diverted discharges with the plasma control system. No RF or CHI will be used during this experiment. The GPI gas bottle and GPI optical filter will be in Helium as usual for parts A and B, but switched to Argon for Part C.

5. Planned analysis

The 2-D movies from the PSI camera will be analyzed for their k-spectrum and time evolution. The results will be compared with data from other edge turbulence diagnostics and with theoretical simulations from BOUT and DBM (through DEGAS simulation of GPI)

6. Planned publication of results

The results will be presented at the EPS ’02 meeting, HTDC ’02, and APS ’02 and written up.

7. Response to chits:

a) we will ask the reflectometer diagnosticians to take about half the shots for profile information and half the shots for fluctuation data

b) we will ask the TS to trigger at the time of the PSI camera trigger

c) we will ask the passive spectroscopy people to use microsecond in their trigger times

PHYSICS OPERATIONS REQUEST

Title: Edge Turbulence Characterization XP No. 224

Part A: Density Limit Case:

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **3.0 KG** Flattop start/stop (s): _____/_____

I_P (MA): **0.75-0.8** Flattop start/stop (s):**0.15/0.25**

Configuration: **Double Null Diverted**

Outer gap (m): **10-15 cm** Inner gap (m): **0 cm**

Elongation κ: **1.5** Triangularity δ:

Z position (m): **0.00**

Gas Species: **D_2**, Injector: **Inner Wall and Outer Midplane ?**

NBI - **N/A**, Sources:, Voltage (kV): Duration (s):<**0.5s**

ICRF – Power (MW): **0**, Phasing: **N/A** Duration (s): _____

CHI: **Off**

Either: List previous shot numbers for setup: **107479**

Part B: H-Mode Case:

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **3.5 KG** Flattop start/stop (s):

I_P (MA): **0.9** Flattop start/stop (s): **0.18-0.38**

Configuration: **Single Null Diverted**

Outer gap (m): **5-10cm** Inner gap (m): **2-8 cm**

Elongation κ: **1.8-1.9** Triangularity δ:

Z position (m): **0.00**

Gas Species: **D_2**, Injector: **Inner Wall and Outer Midplane**

NBI - Species: **D**, Sources: **A/B/C**, Voltage (kV): **80**, Duration (s):<**0.5s**

ICRF – Power (MW): **0**, Phasing: **N/A** Duration (s): _____

CHI: **Off**

Either: List previous shot numbers for setup: **107396**

DIAGNOSTIC CHECKLIST

Title: Effect of Triangularity and Divertor Configuration on H-mode Access Conditions and Performance **No. 220**

Diagnostic system	**Need**	**Desire**	**Requirements** (timing, view, etc.)
Magnetics	✓		
Fast visible camera	✓		
VIPS-1		✓	
VIPS-2		✓	
SPRED		✓	
GRITS		✓	
Visible filterscopes	✓		
VB detector		✓	
Midplane bolometer		✓	
Diamagnetic flux	✓		
Density interferometer (1mm)		✓	
FIReTIP interf'r/polarimeter		✓	
Thomson scattering	✓		
CHERS		✓	
NPA		✓	
X-ray crystal spectrometer		✓	
X-ray PHA		✓	
EBW radiometer		✓	
Mirnov arrays	✓		
Locked-mode detectors		✓	
USXR arrays		✓	
2-D x-ray detector (GEM)		✓	
X-ray tangential camera		✓	
Reflectometer (4 ch.)		✓	
Neutron detectors		✓	
Neutron fluctuations		✓	
Fast ion loss probe		✓	
Reciprocating edge probe		✓	
Tile Langmuir probes		✓	
Edge fluctuation imaging	✓		
H-alpha cameras (1-D)		✓	

Divertor camera (2-D)		✓	
Divertor bolometer (4 ch.)		✓	
IR cameras (2)		✓	
Tile thermocouples			
SOL reflectometer		✓	