Princeton Plasma Physics Laboratory
NSTX Experimental Proposal

Title: Edge turbulence and blobs during H-mode		
OP-XP-622	**Revision:** ***2006***	Effective Date: 5 May 06 *(Ref. OP-AD-97)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

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Responsible Division: Experimental Research Operations

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

Scheduling close to a boronization may be necessary to access H-mode at low heating power, ideally down to Ohmic H-modes.

The “base” shot for this XP, #119083 but with 1.6 MW NBI beam power (src. A) should be “tested” before the XP to evaluate its H-mode access capability.

NSTX EXPERIMENTAL PROPOSAL

Edge turbulence and blobs during H-mode OP-XP-622

1. Overview of planned experiment

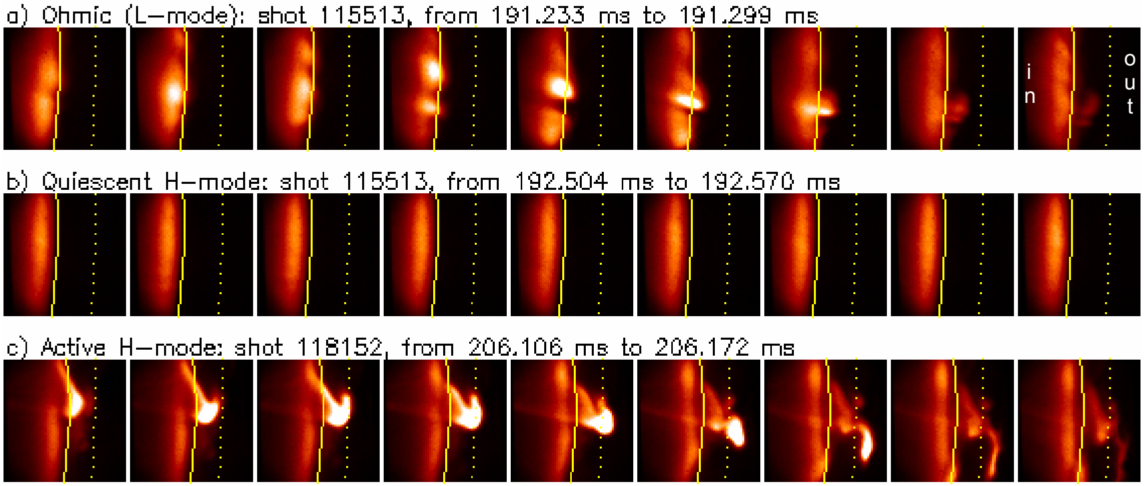
In NSTX the edge turbulence/blobs/intermittency is much reduced during H-modes compared to typical L-mode (or Ohmic) activity. This is typically characterized by a reduction in the blob frequency during H-modes in contrast with a reduction in the density characteristic of the blobs. In addition the blob frequency during H-modes is seen to increase as the time from the transition increases. In the case for instance of Ohmic H-modes this frequency remains low (almost non-existent blobs) through out the H-mode phase. In other cases, this frequency approaches that characteristic of L-mode blobs.

This experiments plans to explore the conditions at which H-modes turbulence/blobs are observed, both in terms of the edge pedestal and in terms of the plasma shape and X-point geometry.

2. Theoretical/ empirical justification

It is well known that the cross-field transport in the edge of tokamaks has a substantial, if not dominant, contribution from intermittent convective processes. Filamentary structures, with a long parallel scale length relative to the magnetic field, have been measured in many experiments. In the National Spherical Torus Experiment (NSTX) the radial vs. poloidal cross section of these filaments, known as 'blobs', is imaged with high spatial and temporal resolution with a diagnostic known as Gas Puff Imaging (or GPI). In this diagnostic, a local gas puff is used to increase the contrast and brightness of the blobs while observing the emitting gas cloud (approximately) parallel to the local magnetic field.

The 'blob' phenomena are observed to be born from edge turbulence which is, in turn, most likely due to drift wave and/or curvature-driven instabilities. In general, in NSTX, both


a) Ohmic (L–mode): shot 115513, from 191.233 ms to 191.299 ms

b) Quiescent H–mode: shot 115513, from 192.504 ms to 192.570 ms

c) Active H–mode: shot 118152, from 206.106 ms to 206.172 ms

Fig. 1 Blob regimes in NSTX. Sequence of images obtained at 120000 frames/s with each image exposed for 3 μs. A deuterium puff is injected from the right and D_α light is imaged. Each image corresponds to ~23 cm x 23 cm (solid line: separatrix, dotted line: antenna limiter shadow).

turbulence and blobs are substantially reduced during H-mode respect to the Ohmic or L-mode (lower confinement) regimes. An example is shown in Fig. 1 in which images from a ~23 cm x 23 cm radial vs. poloidal portion of the edge just above the outer midplane are shown. The characteristics of the H-mode turbulence and blobs in NSTX present a continuum from a turbulence level just above that measurable (a "quiescent" H-mode as in Fig. 1(b)) to that approaching L-mode level (an "active" H-mode, Fig. 1(c)), at least for brief periods of time. The H-mode blobs observed in NSTX seem to be highly localized and are not the same as small (type V) ELMs.

Theoretical predictions from edge turbulence codes like BOUT indicate that the governing process for the edge turbulence blobs, the resisitive ballooning instability, links the activity to the pressure pedestal/gradient. In addition, the X-point geometry/topology is an important factor in the physics behind the edge turbulence.

This experimental proposal will test the predictions of these codes as well as providing important data for benchmarking. The dependence with the pedestal characteristics will be explored, trying to uncouple the temperature and density pedestals as well as exploring the dependence with the magnetic topology (LSN, DN, and USN) and X-point geometry (low and high triangularity/elongation).

3. Experimental run plan

The main scan in this XP is a power (NBI) scan with additional shots taken at the intermediate value of 1.6 MW. Each successful shot will be repeated 2 times. In addition, up to 2 unsuccessful shots (discharge development) will be allowed for each shot.

BASE shot:

The base shot has the following characteristics: 800 kA, 4.5 KG, LSN (d_{rsep} ~ -1.5 cm), low κ, δ, 1.6 MW NBI, with HFS fuelling. Coil configuration should be similar to **shot 119083** with the following changes:

- 1 source NBI, source A (de-rated to 1.6 MW).
- Outer gap adjusted to make best use the 30 channel MPTS.

Shot sequence:

The list below is divided into two groups, in priority order.

NBI source power (MW) indicated in last three columns: **bold** indicates source being used, "c" indicates source being configured for next needed power. (See "Physics Operation Request" section for timing of sources.)

Part 1

#	NBI (MW)	Conf.	Goal	Other	A	B	C
1	0 (Ohmic)	LSN	H-mode		1.6	0.6	2
2	0.6	LSN	H-mode		1.6	**0.6**	2
3	1.6	LSN	H-mode	**This is the base shot.**	**1.6**	c	2
4	1.6	LSN	L-mode	…if not obtained yet during #3.	**1.6**	c	2
5	1.6	LSN	H-mode	High fuelling (add SGI to HFS fuelling).	**1.6**	c	2

6	1.6	LSN	H-mode	Low fuelling (replace LFS for HFS fuelling).	**1.6**	c	2
7	2	LSN	H-mode		c	c	**2**
8	4	LSN	H-mode		c	**2**	**2**
9	6	LSN	H-mode		**2**	**2**	**2**

Part 2

#	NBI (MW)	Conf.	Goal	Other	A	B	C
10	0 (Ohmic)	DN	H-mode	…give it a try.	c	c	2
11	0.6	DN	H-mode	…give it a try.	c	**0.6**	2
12	1.6	DN	H-mode		**1.6**	0.6	2
13	1.6	DN	L-mode	…if not obtained yet during #12.	**1.6**	0.6	2
14	1.6	USN	H-mode	…give it a try.	**1.6**	0.6	2
15	1.6	LSN	H-mode	High κ and δ.	**1.6**	0.6	2

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

Well conditioned walls (as close to boronization as possible) to achieve H-mode access at low NBI power (ideally down to Ohmic H-modes). GDC between shots will be adjusted according to need (7 to 12 minutes). NBI power scanned up to 3 sources (start **B: 0.6 MW, A: 1.6 MW, C: 2.0 MW**).

GPI from time of L-H transition and scanning probe a must.

5. Planned analysis

EFIT/LRDFIT needed.

GPI and scanning probe data will be analyzed to infer characteristics of turbulence/blobs/intermittency.

6. Planned publication of results

If successful, results will be submitted to appropriate journal. Results will also be available for 2006 IAEA meeting.

PHYSICS OPERATIONS REQUEST

Edge turbulence and blobs during H-mode **OP-XP-622**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **4.5 kG** Flattop start/stop (s): **-0.1/1.0**

I_P (MA): **0.8** Flattop start/stop (s): **~0.17/0.35**

Configuration: **Lower Single Null / Upper SN / Double Null**

Outer gap (m): ~**0.06**, Inner gap (m): **~0.04**

Elongation κ: **~2, varied**, Triangularity δ: **~0.5, varied**

Z position (m): **0.00**

Gas Species: **D**, Injector: **Midplane / Inner wall/SGI**

NBI - Species: **D**, Sources: **A/B/C**, Voltage (kV): var., Duration (s): 0.5 (max)

ICRF – Power (MW): 0, Phasing: , Duration (s): _____

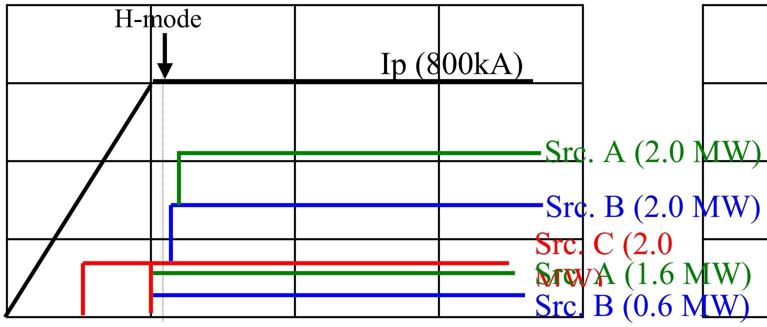
CHI: **Off**

Either: List previous shot numbers for setup: base shot is 800 kA, 4.5 KG, low κ, δ, LSN, 1.6 MW NBI, with HFS fuelling (use 119083 as model).

For USN swap PF3U/L and PF2U/L coil currents.

For DN make these coil currents symmetric.

Or: Sketch the desired time profiles, including inner and outer gaps, κ, δ, heating, fuelling, etc. as appropriate. Accurately label the sketch with times and values.



DIAGNOSTIC CHECKLIST

Edge turbulence and blobs during H-mode **OP-XP-622**

Diagnostic	**Need**	**Desire**	**Instructions**
Bolometer - tangential array		✓	
Bolometer array - divertor		✓	
CHERS	✓		
Divertor fast camera		✓	
Dust detector		✓	
EBW radiometers		✓	
Edge deposition monitor		✓	
Edge pressure gauges		✓	
Edge rotation spectroscopy		✓	
Fast lost ion probes – IFLIP		✓	
Fast lost ion probes – SFLIP		✓	
Filtered 1D cameras		✓	
Filterscopes		✓	
FIReTIP		✓	
Gas puff imaging	✓		Helium puffs preferable.
High-k scattering		✓	
Infrared cameras		✓	
Interferometer – 1 mm		✓	
Langmuir probes - PFC tiles		✓	
Langmuir probes - RF antenna		✓	
Magnetics – Diamagnetism		✓	
Magnetics – Flux loops	✓		
Magnetics – Locked modes		✓	
Magnetics – Pickup coils	✓		
Magnetics - Rogowski coils	✓		
Magnetics - RWM sensors		✓	
Mirnov coils – high frequency		✓	
Mirnov coils – poloidal array		✓	
Mirnov coils – toroidal array		✓	
MSE		✓	
Neutral particle analyzer		✓	
Neutron Rate (2 fission, 4 scint)		✓	
Neutron collimator		✓	
Plasma TV		✓	
Reciprocating probe	✓		
Reflectometer - FM/CW		✓	
Reflectometer - fixed frequency homodyne		✓	
Reflectometer - homodyne correlation		✓	
Reflectometer - HHFW/SOL		✓	
RF antenna camera		✓	
RF antenna probe		✓	
Solid State NPA		✓	
SPRED		✓	
Thomson scattering - 20 channel	✓		
Thomson scattering - 30 channel		✓	Extremely highly desirable
Ultrasoft X-ray arrays		✓	
Ultrasoft X-ray arrays - 2 color		✓	
Visible bremsstrahlung det.		✓	
Visible spectrometers (VIPS)		✓	
X-ray crystal spectrometer - H		✓	
X-ray crystal spectrometer - V		✓	
X-ray PIXCS (GEM) camera		✓	
X-ray pinhole camera		✓	
X-ray TG spectrometer			