Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: Scoping Study of Ohmically Heated H-mode Plasmas		
OP-XP-442	**Revision:**	Effective Date: *(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)

NSTX EXPERIMENTAL PROPOSAL

Scoping Study of Ohmically Heated H-mode Plasmas **OP-XP-442**

1. Overview of planned experiment

The goal of this experimental proposal is to study the characteristics of Ohmically heated H-modes (OH H-modes) in NSTX, documenting the parameter/configuration dependence of OH H-mode access and behavior, including their triggering, reproducibility, and robustness. This also includes gaining sufficient understanding of these plasmas to be able to develop a follow-up XP aimed at exploiting the OHH-mode as a target plasma for early injection and for advanced ST configurations, especially combined edge/core transport barriers.

2. Theoretical/ empirical justification

Usually on tokamaks, the H-mode has occurred most frequently in auxiliary heated plasmas. It is mainly due to this observation that studies of threshold powers for triggering H-modes were undertaken. However, it is now known that the picture of H-mode access and behavior is not simply a matter of power dependence but that many factors such as density temperature, magnetic configuration, etc., play a part. Also, initially it was thought that for large tokamaks, H-modes would occur only in diverted plasmas. However, on TFTR, a circular limiter tokamak, H-modes were obtained frequently and reproducibly. On the other hand the power threshold was higher than for diverted tokamaks and OHH-modes were never obtained (however, ohmic plasma runs were extremely infrequent).

More recent, in STs (MAST and NSTX) H-modes were also first observed in beam-heated plasmas. However, with inner wall gas puffing, OHH-modes were first observed on MAST. Recently, after field modifications, wall conditioning and inner wall gas puffing OHH-modes are now obtained often on NSTX. The first of these being observed April 24, 2004 on shot number *111292* during a run shortly after a fresh inner wall boronization with low background vacuum conditions (see Figure 1 for a similar discharge). OHH-modes have

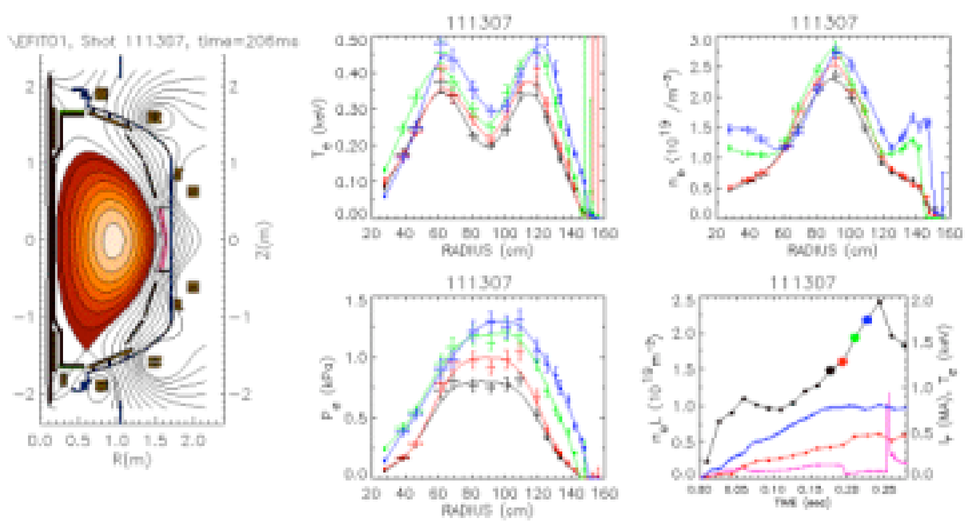

Figure 1 – OHH-mode in LSN configuration.

now been

observed in both lower single Null (LSN) and double Null (DN) divertor configurations on NSTX. Finally, OHH-modes allow expanded access space to the H-mode in that lower (and a continuum of) powers can be realized. Study of OHH-modes will allow a better understanding of fundamental H-mode physics and ways of utilizing these plasmas in helping to achieve NSTX programmatic goals.

This experiment has two points of interest, first the basic scoping and physics goal and secondly, it is important that enough information be obtained so that a path for exploiting the OHH-mode can be determined. The two can be fairly independent in that the main application part involves NBI into a limited set of OHH-modes. Therefore a part of the target plasma application can be at the beginning of the experiments. That is, decide on an OHH-mode target early and optimize the beam heating of this target using the best early heating scenarios, diverting timing and NBI heating turn on at several times after the ohmic L-H transitions.

This XP does not require beams and can be done when NBI is not available. In that case, we have some guidance from randomly occurring OHH-modes and a mini-I_p, 500 and 600 kA, OHH-mode scan (Kaye, shots 111571, 111571, 111575, 111581) in which H-modes were triggered at P_{OH} ~ 500 and 600 KW respectively. Another important factor is that the n_e profiles for the OHH-modes are generally lower and more peaked. This allows additional long wavelength turbulence measurements in the core plasma during the scoping studies (Peebles, XP# 439). We must also document the plasma to the extent that we can determine if there are significant differences between triggering of OHH-modes and NBI heated H-modes in view of absence of beam fueling and momentum input. In NBI heated H-modes we are often concerned about separating heating and fueling effects of the beam. With OHH-modes we must keep in mind that input power generally depends directly on Ip. Therefore, we want to be able to separate Ip and power effects. Much of the physics understanding is expected to be attained through thorough documentation of the fluctuations from those at the edge to those in the core.

3. Experimental run plan

Plan: (Do XP shortly after a boronization and machine well conditioned)

(I) Scoping/Physics are to be emphasized.

<u>Scoping/Physics:</u> (Fully diagnosed, especially main diagnostics; see Sec 4)

A. **Consider DND and LSN targets. Examples:**
1) Reproduce 111588 or best shot available (DND) - **4 shots**
   If difficult to obtain go to 2)
2) Reproduce 111307 or best shot available (LSN) - **4 shots**
3) If difficult to obtain, add other techniques including Ip ramp-rate, pause in Ip ramp-up, and Ip ramp-down similar to TFTR

Note: for a 1 day experiment we choose to do remainder of XP in LSN.

B. **Parameter Scans (in LSN)**

1) Ip scan	600 kA, 900 kA	2+2 =	**4 shots**
2) Bt scan	0.30 T, 0.45 T	2+2 =	**4 shots**

Chose to limit parameter scans to Ip and Bt.
Ip because transition easier at low Ip and Bt because $P_{LH} \sim Bt$

C. **Repeat shots for key diagnostics documentation if necessary** **4 shots**

D. **Optimize time of transition for long duration (in LSN) -** **8 shots**
For physics but with application in mind. Adjust -
Divert time
Time of Ip flat spot
(Ip ramp down ala TFTR H-mode trigger also available)

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

A clean, well conditioned chamber with low recycling walls is necessary, and running of the XP shortly after a boronization would be desireable. Best techniques for maintaining these conditions (such as alternate high power helium conditioning discharges) should be available if needed. RF and CHI are not required. The diagnostics to be emphasized for this XP are the ERD (edge rotation diagnostic), reflectometry (Peebles, Kubota), MPTS, GPI, FIReTIP, CHERS, ultrasoft X-ray arrays, and the reciprocating probe. Although NBI heating would not be required for most shots, it would be good to have beam blips for CHERS measurements. However, we must make sure the beam blips do not affect the transition. For higher spatial resolution edge diagnosis, plasma position jog shots will be provided for MPTS, FIReTIP and other diagnostics.

5. Planned analysis

Plasma analysis requires EFIT and TRANSP.

6. Planned publication of results

The results will be presented to the NSTX research team. A poster presentation of the results will also be made at the next APS-DPP meeting. The results are expected to be suitable for a Journal article. The plasma is to be well documented allowing the main physics issues to be addressed.

PHYSICS OPERATIONS REQUEST

Scoping Study of Ohmically Heated H-mode Plasmas OP-XP-442

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **53 kA** Flattop start/stop (s): **0.0/0.5**

I_{P} (MA): **500 – 900 kA** Flattop start/stop (s): **0.2/0.5**

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

Outer gap (m): _____, Inner gap (m): _____

Elongation κ: _____, Triangularity δ: _____

Z position (m): **0.00**

Gas Species: **D / He**, Injector: **Midplane / Inner wall / Lower Dome**

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

ICRF – Power (MW): ____, Phasing: **Heating / CD**, Duration (s): _____

CHI: **Off**

Either: List previous shot numbers for setup: **(111292) or as suggested by operators.**

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.

DIAGNOSTICS CHECKLIST

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Diagnostic	Need	Desire	Instructions
Bolometer – tangential array		✓	
Bolometer array - divertor		✓	
CHERS	✓		
Divertor fast camera		✓	
EBW radiometer		✓	
Edge pressure gauges		✓	
Edge rotation spectroscopy	✓		
Fast lost ion probes		✓	
Filterscopes	✓		
FIReTIP	✓		
Gas puff imaging	✓		
H_a camera - 1D		✓	
Infrared cameras		✓	
Interferometer - 1 mm		✓	
Langmuir probe array	✓		
Magnetics - Diamagnetism	✓		
Magnetics - Flux loops	✓		
Magnetics - Locked modes	✓		
Magnetics - Pickup coils	✓		
Magnetics - Rogowski coils	✓		
Magnetics - RWM sensors		✓	
Mirnov coils – high frequency		✓	
MSE		✓	
Neutral particle analyzer		✓	
Neutron measurements		✓	
Plasma TV	✓		
Reciprocating probe		✓	
Reflectometer – core	✓		
Reflectometer - SOL		✓	
SPRED		✓	
Thomson scattering	✓		
Ultrasoft X-ray arrays	✓		
Visible bremsstrahlung det.		✓	
Visible spectrometer (VIPS)		✓	
X-ray crystal spectrometer - H		✓	
X-ray crystal spectrometer - V		✓	
X-ray GEM camera		✓	
X-ray pinhole camera		✓	