Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: Relationship between Type I ELM Severity and Perturbed Electron Transport in NSTX		
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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

Relationship between Type I ELM Severity and Perturbed Electron Transport in NSTX OP-XP-624

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1. Overview of planned experiment

This XP is an investigation of the Type I ELM and corresponding T_e perturbation as it scales with the current profile. One goal of this experiment is to distinguish between the edge localized effect of the fast timescale MHD perturbation, and the fast thermal transport which is responsible for the global decline of the electron temperature profile. We plan to change the thermal electron transport by modifying the plasma current profile and measure the effect this has on the propagation of the electron temperature perturbation. Finally, we plan to probe the response of the electron temperature profile to carbon pellet injection in the same plasma discharges to provide a comparison to a reference edge perturbation.

2. Theoretical/ empirical justification

Type I ELM activity on NSTX can have a large effect on the electron temperature profile and the plasma total stored energy ($\Delta W_{tot} \sim$ - 10-15%). Much of the decrease in T_e and W_{tot} occurs over timescales (few 100μs – few ms) that are longer than that of the ELM perturbation (<50μs). The edge localized perturbation apparently triggers a cold pulse with a front that propagates to the core of the plasma in a few 100μs. The recently developed DND, high triangularity, long pulse plasmas tend to show a marked reduction in ELM severity compared to the lower triangularity, LSN plasmas where much of the previous ELM/pellet work has been done. There exist other XPs to investigate the relevance of shape (Kaye) and drsep (Maingi) on ELM severity and pellets should be used for reference perturbations in those XPs as well. This XP is focused on two main experiments: (1) shooting reference pellets into the LSN discharges, both in the reference, giant ELM regime, and also the modified lower power and DND smaller ELM regime; (2) modifying the current profile in the "reduced perturbation" DND plasmas and measuring the effect on ELM severity.

Because the stored energy loss appears primarily due to electron thermal losses, this XP will attempt to modify the electron thermal transport in equilibrium and measure how this affects the ELM induced perturbation. Large Type I ELMs are common in high power (4-6MW) LSN discharges, while moving to DND or lowering the power to <4MW leads to smaller Type I ELMs or even Type III ELMs which cause a lesser perturbation to the plasma. Pellets will be injected into these different ELM regimes to try and correlate the ELM severity with the inferred perturbed electron transport. XP612 has indicated that changing the beam heating and timing can change the current profile by modifying the current diffusion. Shots with different current profiles show substantial differences in their response to both ELM and pellet perturbations in these DND discharges. A scan of beam timing will be used as the primary tool to modify the current profile and, therefore, the electron transport and corresponding perturbation.

Lithium pellet injections into H-mode plasmas have demonstrated a response quite similar to that of the ELM perturbation. The electron density remains largely unaffected while the electron temperature, as measured by Thomson scattering, shows a global decrease across the plasma profile of ~10-20%. Also, the timescale of the evolution of the electron temperature profile appears to follow that of the Type I ELM phenomena, which is consistent with an edge perturbation that initiates a propagating cold front. Also, the reduced ELM severity in the DND plasmas corresponded to a reduced effect of the Li pellets in the same discharges. For this XP, we plan on using spherical, vitreous C pellets, which have been sorted by mass, to provide a known and repeatable reference perturbation to compare to the ELM perturbation.

The beam timing scan will also be performed at a lower Ip and higher TF to investigate any relevance to the magnitude of the q profile and to help isolate any effects of coupling to internal MHD activity on the perturbation propagation.

3. Experimental run plan

The first series of shots will explore the electron transport in the high power LSN discharge and then the corresponding lower power and DND plasma.

The first shot will be a duplication of 117410 (119083 with higher beam power)

0.8MA, 4.5kG, LSN, NB 5.5MW 2 shots (get the pellet timing correct)

This shot should exhibit a series of large Type I ELMs. The pellets will be fired after/during the large ELM period late in the discharge (0.5-0.6)

The next shot will be the same shape and current, but lower beam power (119083)

0.8MA, 4.5kG, LSN, NB 4W 1 shot

This shot should fewer but larger Type I ELMs.

The next shot will be the same shape and current, but lower beam power (beam C @ 60-65kV)

0.8MA, 4.5kG, LSN, NB 3W 1 shot

This shot should contain smaller Type V or Type III ELMs.

The next shot will be converted into a DND shape by copying the PF1aL/PF2L/PF3L? waveforms to the corresponding upper coils. (117432)

0.8MA, 4.5kG, DND, NB 6MW 1 shot

This shot should contain smaller Type V or Type III ELMs.

Total shots part 1: 6 (includes a contingency shot)

The next set of shots uses the neutral beam timing to scan the current profile. The reference shot is 120430.

1MA, 4.5kG, DND, NB 6MW 2 shots

This shot should exhibit small Type I ELM behavior late in the discharge. The pellets will be fired between 0.6 and 1 second before the onset of large MHD mode activity and between or after the large ELM periods.

The next set of shots will involve moving the beam timing to change the current profile. The ELMs should at some point become larger and move earlier in the discharge. The pellet timing may need to be moved if large MHD modes also move forward in time.

1MA, 4.5kG, DND, NB 4→6MW @ 0.55s 1 shot

1MA, 4.5kG, DND, NB 4→6MW @ 0.35s 1 shot

1MA, 4.5kG, DND, NB 4→6MW @ 0.25s 1 shot

1MA, 4.5kG, DND, NB 4→6MW @ 0.45s 1 shot

Total: 6 shots

The scan will be repeated at 0.8MA and 5.0kG TF to change the magnitude of the q profile.

0.8MA, 5.0kG, DND, NB 6MW 1 shot

0.8MA, 5.0kG, DND, NB 4→6MW @ 0.55s1 shot

0.8MA, 5.0kG, DND, NB 4→6MW @ 0.35s1 shot

0.8MA, 5.0kG, DND, NB 4→6MW @ 0.25s1 shot

0.8MA, 5.0kG, DND, NB 4→6MW @ 0.45s1 shot

Total shots: 5 shots

XP Total: 17 shots

Any remaining time can be used to fill in a fine scan of NB timing (NB C @.2,.3,.4,.5s)

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

The base discharge will be a replication of shot 120430, DND, NB 6MW, which has small ELMs that exhibit only a localized effect on the edge electron temperature. The timing of the third beam will be scanned from that of the base discharge at ~0.15s to 0.45 seconds to alter the current profile of the plasma.

The neutral beams will operate at 4MW→6MW, with this configuration:

4MW: A @ 90kV, B @ 90kV

6MW: A @ 90kV, B @ 90kV, C @ 90kV

For the LSN reference, the beams operate at 5.5MW

6MW: A @ 90kV, B @ 90kV, C @ 80kV

For the reduced power LSN case, the beams operate at 3MW

3MW: A @ 90kV, C @ 60-65kV

Thomson laser timing should bracket the pellet injection +/- ~3ms.

Drsep for the DND shots should be adjusted to match reference shot 120430.

A 12.5 minute shot cycle will be used with a 7.5 minute He glow.

5. Planned analysis

A primary tool will be multi-color X-ray analysis necessary to calculate fast evolution of the electron temperature profile, including the magnitude and propagation velocity of the induced cold pulse. Profile analysis may require fast EFIT/LRDFIT reconstruction (0.1-0.3ms time resolution) to account for any plasma shape change during the perturbation. TRANSP analysis will be needed to calculate the impact of the current scan on the equilibrium electron thermal confinement. The critical gradient model can be applied to both the ELM and pellet induced perturbations for calculation of the perturbed electron transport coefficients. These coefficients will then be related to the equilibrium transport coefficients.

If diagnostic coverage permits, stability calculations will be used to estimate the magnitude and depth of the ELM perturbation to measure the correlation with the reduction in the electron temperature profile.

6. Planned publication of results

The results from this XP will be presented at the 2006 APS meeting in Philadelphia, PA, potentially for an invited talk if it is accepted by the selection committee. Results of significance will be considered for publication in the appropriate journal.

PHYSICS OPERATIONS REQUEST

Relationship between Type I ELM Severity and Perturbed Electron Transport in NSTX**OP-XP-62**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **4.5-5.0kG** Flattop start/stop (s): **-0.02/1.0s**

I_P (MA): **0.8-1.MA** Flattop start/stop (s): **.12-.22/0.8**

Configuration: **LSN & DND (119083, 120430)**

Outer gap (m): 0.05-0.1 Inner gap (m): **0.01-0.06**

Elongation κ: **2-2.5**, Triangularity δ: **0.5-0.7**

Z position (m): **0.00**

Gas Species: **D**, Injector: **Midplane**

NBI - Species: **D**, Sources: **A/B/C**, Voltage (kV): **90kV**, Duration (s): _____

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

CHI: **Off**

Either: List previous shot numbers for setup: 119083 (LSN), 120430 (DND) make sure same drsep as 120430

DIAGNOSTIC CHECKLIST

Relationship between Type I ELM Severity and Perturbed Electron Transport in NSTX**OP-XP-62**

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			Only available by special request of T. Biewer @ MIT
Fast lost ion probes – IFLIP		✓	
Fast lost ion probes – SFLIP		✓	
Filtered 1D cameras			
Filterscopes	✓		
FIReTIP		✓	
Gas puff imaging		✓	
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		✓	Fast ion mode
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		✓	
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 pinhole camera		✓	