Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: Tearing & kink stability of low-li plasmas with reduced error field

OP-XP-221	**Revision: 0**	Effective Date: 4/12/2002 *(Ref. OP-AD-97)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Author: J. Menard	Date
ATI - Task Force Leader: J. Menard, E. Fredrickson	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)

Tearing & kink stability of low-li plasmas with reduced error field

1. Overview of planned experiment

The goal of this experiment is to generate reduced-li discharges through modifications to the early plasma bore, shape, and I_P ramp-rate in order to study the tearing and/or kink instabilities which either terminate the ramp-up or interrupt the flat-top. A useful by-product of the experiment is a determination of the operational limits of the maximum I_P ramp-rate and early elongation (and hence plasma volume) in a configuration with significantly reduced error fields and impurity levels and higher triangularity. In addition, discharges developed during this experiment can be used as targets for early HHFW heating in XP-222.

2. Theoretical/ empirical justification

Many high-current and/or low-field operating scenarios in NSTX are ultimately limited in performance by crossing q(0)=1 during the flat-top phase. Crossing q(0)=1 can lead to sawteeth and NTM generation and at worst leads to a large internal disruption. Delaying the onset of q(0)=1 by relatively modest intervals in the range of 50ms can lead to significant improvements in performance. In addition, most proposed "advanced" operating regimes in NSTX have significantly lower li ≈ 0.4-0.6 than previously found optimal in lower q(0) higher current discharges which typically have li ≈ 0.7-0.9.

This experiment will focus on recent higher-field long-pulse experiments with higher q(0) which have suffered from persistent n=1 tearing modes (likely 2/1 modes) which can often lock and disrupt the plasma when the toroidal field is reduced or the current is raised. A broader current profile and higher triangularity in the LSN configuration will be developed as a means in increasing the central and edge safety factor to study the impact on MHD stability. Further, long-pulse operation may benefit from even small reductions in consumed flux as a result of lower-li. Finally, there has been no systematic scan of allowable early I_P ramp-rates and plasma bore during this run despite significant operational improvements including PF5 corrections and bake-out. Experiments similar to this proposal performed prior to machine improvements routinely suffered from double tearing modes, locked modes, or kink mode disruptions as the early ramp-rate and bore were increased. Thus, for a variety of reasons, results from this experiment are directly relevant to the MHD experimental task group.

3. Experimental run plan (1 run day – 30 shots total)

1) Generate reference discharge:
   a) Start from long-pulse reference discharge free of reconnection events with $\beta_P \geq 0.8$:
      i) Use 4.5kG, 800kA shot 107494 or best equivalent from XP-207, 219, 220 – **2 shots**
2) Modify early gap, elongation, and triangularity of reference discharge
   a) Decrease outer gap from 16cm to 8cm by 100ms – **5 shots**
      i) Use smallest gap which retains H-mode access free of locked-mode disruptions, then
   b) Increase elongation from 1.65 to 1.8 by t=50ms, and 1.9 by 100ms – **5 shots**
      i) Use largest κ which retains H-mode access free of locked-mode disruptions, then
   c) Generate early LSN (almost DN) plasma with increased triangularity – **5 shots**
      i) Increase lower δ from 0.4 to 0.7 from 100ms through remainder of discharge and increase upper triangularity as high as possible, preferably also above 0.6.
      ii) Generate divertor discharge starting at t=100ms, reduced from 200ms.
      iii) Use largest δ and timing which retains H-mode access free of LM disruptions, then
3) Modify I_P ramp-rate in larger bore, higher κ, higher δ discharge – **6 shots**
   a) Nominal I_P ramp-rate of reference discharge is 4MA/s
   b) Decrease 800kA flat-top initiation time to scan average I_P ramp-rate:
      i) Use 5, 6, 7 MA/s
      ii) PF coil timing will need to be modified for each ramp-rate, and the assumed cost is 1 shot per ramp-rate, for a total of 6 shots.
4) Toroidal field scan to assess impact of modified current profile – **7 shots**
   a) Starting from optimized discharge, add TF ramp-down between t=200ms and 400ms. Decrease from 4.5kG to 4.25kG, 4.0kG, and 3.75kG if possible. Perform NBI-only comparison to assess influence of enhanced shaping on discharge evolution of lowest field shot which is tearing mode disruption free.

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

This XP requires an operational NBI system, as well as the capability of generating lower-single null diverted and double-null diverted discharges with the plasma control system. No CHI or HHFW will be used during this experiment.

5. Planned analysis

Stability and confinement analysis will be performed utilizing EFIT and TRANSP output.

6. Planned publication of results

The results will be presented at the EPS conference, IAEA conference and/or in APS talks and published within 1 year in a journal article.

PHYSICS OPERATIONS REQUEST

Title: Tearing & kink stability of low-li plasmas with reduced error field **XP No. 221**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **24-52** Flattop start/stop (s): **-0.05/0.9s**

I_P (MA): **0.8** Flattop start/stop (s): **0.12/0.4s**

Configuration: **LSN, almost DN**

Outer gap (m): **8-10cm** Inner gap (m): **1-5cm**

Elongation κ: **1.7-2.1** Triangularity δ: **0.4 increased to 0.65**

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): < **1.0s**

ICRF – Power (MW): **0MW**, Phasing: **N/A** Duration (s): **< 1.0s**

CHI: **Off**

Either: List previous shot numbers for setup: **107494 or other from XP202, 219, 220**
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

Title: Tearing & kink stability of low-li plasmas with reduced error field No. 221

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		✔	