Princeton Plasma Physics Laboratory **NSTX Experimental Proposal**			
Title: **Edge Electrode Biasing for SOL Control**			
OP-XP-806	Revision: **v. 2**	Effective Date: **1/15/08** 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

TITLE: **Edge Electrode Biasing for SOL Control**	No. **OP-XP-806**
AUTHORS: **S. Zweben, R. Maqueda, L. Roquemore, Y. Raitses, R. Marsala, R. Kaita**	DATE: **1/24/2008**

1. Overview of planned experiment

This XP will use the newly installed upgrades to the Biased Electrode and Probe system (BEaP) to continue tests of whether a local poloidal electric field can affect the SOL transport in NSTX. The electrode hardware is essentially the same as used for XP#744 in 2007. Upgrades for 2008 include increased bias current capability (from 10 to 30 Amps), a radial probe array between two electrodes, and a capability to view BEaP with fast cameras. This XP will use these new capabilities, try electrode biasing with NBI, and try a new ‘floating double-probe’ bias configuration.

2. Theoretical/ empirical justification

This XP will continue to test one of the very few existing theoretical ideas for modifying the SOL in magnetically confined plasmas. If successful, this could lead to methods to control and reduce the peak particle and heat flux in any magnetic fusion device.

The theory and its previous application to the MAST experiment has been described in: R.H. Cohen et al, “Plasma Convection Induced by Toroidal Asymmetries of the Divertor Plates and Gas Puffing”, Nucl. Fusion 37 (1997) 621 ; D.D. Ryutov et al, “On the Possibility of Inducing Strong Plasma Convection in the Divertor of MAST”, Plasma Phys. Cont. Fusion 43 (2001) 1388 ; G.F. Counsell et al, “Reduction of Divertor Power Loading in MAST”, 30th EPS Conference (2003) paper P-3.202 ; and R.H. Cohen et al, “Current and Potential Distribtion in a Divertor with Toroidally-Asymmetric Biasing of the Divertor Plate”, Plasma Phys. Cont. Fusion 49 (2007) 1. The basic idea is very simple: the application of a local poloidal (DC) electric field will cause a local Vr = Epol x B drift in the radial direction, which can in principle move and/or broaden the SOL. The electric field needed to do this in NSTX should be quite low (~ 10 V/cm) since the B field is quite low. This field level can be created by the small electrode set installed in the shadow of the RF antenna for this run. The main physics question is how far the potential induced by the electrodes penetrates along and across the B field. Some success was obtained by using a (somewhat differently designed) electrode set in MAST. A secondary physics question is to determine whether the application of this local bias affects the edge turbulence locally, which could cause additional changes in the SOL width.

The first results of BEaP were described in a poster a the APS DPP meeting in 2007. There was evidence for a change in the floating potential of adjacent probes during positive electrode biasing up to the maximum voltage and current tried (50 V/8 Amps), and a slight change in the GPI signals during positive electrode biasing. There were no deleterious plasma effects.

3. Experimental run plan

The run plan is based on repeating the plasma conditions used in XP-744 ("Edge Electrode Bias for SOL Control"), either shot #124062 (B= 4.5 kG, I=0.8 MA, or, if a slightly longer pulse length is needed, shot #124688 (B= 3.5 kG, I=0.6 MA Ohmic). These condition have the proper B field line angle for connecting the biased electrodes to the GPI diagnostic.

This nominal ½ day XP will be divided into 4 one hour parts. Between the 1st and 2nd parts, about 1 hour is needed to check the alignment of the GPI and BEaP. Between the 3rd and 4th parts, at least a few hours are needed for biasing hardware reconfigurations in the test cell.

For the Ohmic parts the outer gap slowly reduced from ~ 5 cm to ~ 1 cm over the 0.3 sec duration of the discharge, as in XP=744. For the NBI parts the same I,B will be used but with an outer gap of 5 cm. In both cases the biasing will be applied from 0.1-0.3 sec, as in XP-744.

<u>1st part (~1 hour):</u> positive electrode voltage scan up to +100 V (≤ 30 A)
monitor BEaP probe array, local D_α light at BEaP, GPI images
look for effects on plasma (impurities, radiation, divertor)
after this, check probe-GPI correlations for alignment

shot #	**plasma type**	**bias voltage (1,2,3,4)**	**comments**
1	OH, 0.8 MA, 4.5 kG or 0.6 MA, 3.5 kG	0, 0, 0, 0	Repeat #124062 or #124688
2	same	0, -25, +25, 0	
3	same	0, -50, +50, 0	
4	same	0, -75, +75, 0	stop if near 30 amps
5	same	0, -100, +100, 0	stop if near 30 amps

We may need ~1 hour for data analysis between the 1st and 2nd parts to check the alignment of GPI and BEaP probes

2nd part (~ 1 hour): optimize alignment based on shots #1-5 (i.e. adjust I_p) and use four electrode biasing +/-/+/- (V_{ExB} outward at BEaP probe array)

shot #	**plasma type**	**bias voltage (1,2,3,4)**	**comments**
6	Same	0, 0, 0, 0	Repeat #124688 or #124062
7	Same	+25, -25, +25, -25	
8	Same	+50, -50, +50, -50	
9	Same	+75, -75, +75, -75	stop if near 30 amps
10	same	+100, -100, +100, -100	stop if near 30 amps

3th part (~ 1 hour): repeat plasma of shots 1-10 but with one source NBI using ~5 cm gap

shot #	**plasma type**	**bias voltage (1,2,3,4)**	**comments**
11	NBI with 5 cm gap	0 , 0, 0, 0	check GPI & BEaP probe signals
12	NBI with 5 cm gap	+25, -25, +25, -25	
13	NBI with 5 cm gap	+50, -50, +50, -50	
14	NBI with 5 cm gap	+75, -75, +75, -75	stop if near 30 amps
15	NBI with 5 cm gap	+100, -100, +100, -100	stop if near 30 amps

Several hours of controlled access are needed between the 3rd and 4th parts to reconfigure the BEaP connections

4th part (~ 1 hour): reconfigure for floating-double-probe biasing (pending review and biasing hardware reconfiguration), use best conditions from the first 3 hours with two floating supplies

shot #	**plasma type**	**bias voltage (1,2,3,4)**	**comments**
16	either OH or NBI	0, 0, 0, 0	Repeat #124688 or #124062
17	either OH or NBI	+25, -25, +25, -25	
18	either OH or NBI	+50, -50, +50, -50	
19	either OH or NBI	+75, -75, +75, -75	
20	either OH or NBI	+100, -100, +100, -100	

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

Ohmic plasmas, for 1st and 2nd parts, one source NBI for 3rd, but with 5 cm outer gap.

Necessary Diagnostics:

GPI with gas puff and fast camera with close-up view of BEaP electrodes(Maqueda),

Fast camera to view electrode region from the other side of the machine (Roquemore)

SPRED to monitor plasma for possible iron influx from electrodes (Robinson).

Desirable diagnostics:

Divertor Dalpha views to monitor effects at divertor strike point.

CHERS and edge rotation diagnostics.

5. Planned analysis

The effect of the electrodes on the local SOL can be determined by the GPI and by the Langmuir probes mounted in the biased electrode holder. If there is a fast radial convection induced by the electrode bias, the GPI gas cloud should also move radially (as seen in the MAST experiment). The turbulence radial speed can also be measured by the GPI images. The edge turbulence fluctuation levels, correlation lengths, and autocorrelation times between the electrodes can be measured by the local probes. The results will be directly compared with the analytical models mentioned above. Comparisons with the XGC code of CS Chang will be attempted. Comparison with the MAST results will also be made.

6. Planned publication of results

The results will be used in a contributed paper in the PSI 2008 conference and (probably) a paper at the 2008 Diagnostics conference.

They will also be written as a full-length paper in Phys. Plasmas, NF, or PPCF.

PHYSICS OPERATIONS REQUEST

Title Edge Electrode Biasing for SOL Control **OP-XP-806**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): 4.5 or 3.5 kG Flattop start/stop (s):

I_P (MA): 800 or 600 kA Flattop start/stop (s):

Configuration: **Shots #1-10** #124062 (0.8 MA, 4.5 kG)

or #124688 (0.6 MA, 3.5 kG)

Shots #11-15 same as # 1-10 but 5 cm gap with one NBI source

Shots #16-20 either OH or NBI plasma from #1-15

Outer gap (m): **down to ~ 1 cm for OH cases, 5 cm for NBI cases**

Inner gap (m):

Elongation κ: Triangularity δ:

Z position (m):

Gas Species: Injector(s):

NBI - Species: **D** Sources: Voltage (kV): Duration (s):

ICRF – Power (MW): Phasing: Duration (s):

CHI:

Previous shots for setup: #124062 (0.8 MA) or #124688 (0.6 MA)

DIAGNOSTIC CHECKLIST

Title **Edge Electrode Biasing for SOL Control** **OP-XP-806**

Diagnostic	**Need**	**Desire**	**Instructions**
Bolometer – tangential array		**X**	
Bolometer – divertor		**X**	
CHERS – toroidal			
CHERS – poloidal			
Divertor fast camera		**X**	
Dust detector			
EBW radiometers			
Edge deposition monitors			
Edge pressure gauges			
Edge rotation diagnostic		**X**	
Fast ion D_alpha - FIDA		**X**	
Fast lost ion probes - IFLIP			
Fast lost ion probes - SFLIP			
Filterscopes		**X**	
FIReTIP		**X**	
Gas puff imaging	**X**		
Hα camera - 1D		**X**	
High-k scattering			
Infrared cameras		**X**	
Interferometer - 1 mm		**X**	
Langmuir probes - divertor		**X**	
Langmuir probes – RF antenna		**X**	
Magnetics – Diamagnetism		**X**	
Magnetics - Flux loops		**X**	
Magnetics - Locked modes		**X**	
Magnetics - Pickup coils		**X**	
Magnetics - Rogowski coils		**X**	
Magnetics - RWM sensors		**X**	
Mirnov coils – high frequency		**X**	
Mirnov coils – poloidal array		**X**	
Mirnov coils – toroidal array		**X**	
MSE			
NPA – ExB scanning			
NPA – solid state			
Neutron measurements			
Plasma TV		**X**	
Reciprocating probe		**X**	
Reflectometer – 65GHz		**X**	
Reflectometer – correlation		**X**	
Reflectometer – FM/CW		**X**	
Reflectometer – fixed f		**X**	
Reflectometer – SOL		**X**	
RF edge probes		**X**	
Spectrometer – SPRED	**X**		
Spectrometer – VIPS		**X**	
SWIFT – 2D flow		**X**	
Thomson scattering	**X**		
Ultrasoft X-ray arrays		**X**	
Ultrasoft X-ray arrays – bicolor		**X**	
Ultrasoft X-rays – TG spectr.		**X**	
Visible bremsstrahlung det.		**X**	
X-ray crystal spectrometer - H			
X-ray crystal spectrometer - V			
X-ray fast pinhole camera			