Princeton Plasma Physics Laboratory **NSTX Experimental Proposal**		
Title: Edge Electrode Biasing for SOL Control		
OP-XP-	Revision: **v. 2**	Effective Date: **5/25/07** Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS	
Responsible Author: Zweben, Bush, Maqueda, Roquemore	Date 5/25/07
ATI – ET Group Leader: Soukhanovskii	Date
RLM - Run Coordinator: D. Gates	Date
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-**

AUTHOR: **Zweben, Bush, Maqueda, Roquemore** DATE: **5/25/07**

1. Overview of planned experiment

This XP will use the newly installed edge electrodes to test the theory of Cohen and Ryutov concerning the effect of a local poloidal electric field on the SOL transport. The electrode hardware has been successfully tested with XMP-051 (completed May 10, 2007). This XP will extend these test results to higher electrode voltages and currents, will vary the plasma conditions from the single case tried in XMP-051, will try a positive biased electrode, and will (if there is any extra time available) try electrode biasing in an Ohmic H-mode.

2. Theoretical/ empirical justification

The main justification for this XP is 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.

3. Experimental run plan

The run plan is based on repeating the plasma condition used in XMP-051 (Checkout of Biased Probe and Electrodes), e.g. shot #124062 (B= 4.5 kG, I=0.8 MA, Ohmic, outer gap slowly reduced from ~ 10 cm to ~ 1 cm over the duration of the discharge). This condition had the proper B field line angle for connecting the biased electrodes to the GPI diagnostic.

shot 1: set electrode #1 and #2 voltages to -100 V / -50 volts (compared with -70 volts/ -35 volts used previously in XMP-051), and increase the density with extra gas puffing to <ne>~ $4x10^{13}$ cm^{-3}. Electrodes #3 is at zero volts and electrode #4 is hard grounded.

shot 2: repeat shot #1 with electrodes #1 and 2 to -50 V/ -100 V to change sign of local B. Increase density further if possible. Keep electrodes #3 and at zero volts and #4 hard grounded.

shot 3: repeat shot 1 or 2 if some effect of biasing is seen in probes or GPI.

shot 4: change to B=3.5 kG, I=620 kA to see effect of increased Vr due to lower B; Ohmic plasma, moderate density, same outer gap as part (1). Set electrode #1 and #2 voltages to -100 V / -50 volts, and keep electrodes #3 and 4 at zero volts and hard grounded.

shot 5: using the same B=3.5 kG shot above, switch electrodes #1 and 2 to -50 V/ -100 V to change sign of local B. Keep electrodes #3 and 4 at zero volts and hard grounded.

shots 6: using either the B=4.5 kG or B=3.5 kG shots above, keeping electrodes #1 and 2 at -50 V / -100 V, now set electrode #3 at +10 volts (if hardware allows), to see effect of electron collection in electrodes.

shot 7: same as shot 6, but electrode #3 voltage to +70 volts to collect electron saturation.

shot 8: if any of the shots 1-7 make a clear change in the local SOL, as determined by the GPI or probe measurements, then repeat that shot.

only if extra time is available:

shots 9-12: repeat shot #117260 to create Ohmic H-mode, but with outer gap slowly reduced from ~ 5 cm to ~ 1 cm, and try various electrode configurations (as above) to modify the SOL.

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

Ohmic plasmas, no NBI or RF or CHI

Necessary Diagnostics: Langmuir probes mounted in the biased electrode holder (Bush)
GPI with gas puff (Maqueda), fast camera to view electrode region from the other side of the machine (Roquemore).

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 move outward 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 could be published as a full-length paper in Phys. Plasmas, NF, or PPCF.

PHYSICS OPERATIONS REQUEST

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

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): 4.5 kG and 3.0 kG Flattop start/stop (s):

I_P (MA): 800 KA Flattop start/stop (s):

Configuration: **Shots #1-3 exactly same as #124062 , except for higher density**

Shots #4-5 B=3.5 kG, I=620 kA

Shots #9-12: exactly like #117260, but with outer gap to 1 c

Outer gap (m): **down to ~ 1 cm** 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:

Either: List previous shot numbers for setup: **#124062 (shots #1-8), #117260 (#9-12)**

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 **OP-XP-**

Diagnostic	**Need**	**Desire**	**Instructions**
Bolometer – tangential array		**X**	
Bolometer – divertor		**X**	
CHERS – toroidal		**X**	
CHERS – poloidal		**X**	
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			