FINAL TECHNICAL REPORT

GRANT: DE-FG02-97ER54451

HAMPTON UNIVERSITY
HAMPTON, VA 23668

PI: A. PUNJABI
COPI: N. JALUFKA

PERIOD: SEPTEMBER 15, 1997 TO SEPTMBER 14, 2004

DATE: NOVEMBER 4, 2004

The research carried out on this grant was motivated by the high power emission from the CIV doublet at 155 nm in the DIII-D divertor and to study the characteristics of the radiative divertor. The radiative divertor is designed to reduce the heat load to the target plates of the divertor by reducing the energy in the divertor plasma using upstream scrape-off-layer (SOL) radiation. In some cases, particularly in Partially Detached Divertor (PDD) operations, this emission accounts for more than 50% of the total radiation from the divertor. In PDD operation, produced by neutral gas injection, the particle flow to the target plate and the divertor temperature are significantly reduced. A father motivation was to study the CIV emission distribution in the lower, open divertor and the upper baffled divertor.

Two Vacuum Ultra Violet Tangential viewing Television cameras (VUV TTV) were constructed and installed in the upper, baffled and the lower, open divertor. The images recorded by these cameras were then inverted to produce two-dimensional distributions of CIV in the poloidal plane. Results obtained with these cameras are summarized below.

1. Comparison of the 2D profiles of the CIV vacuum ultra violet radiation with the 2D profiles of visible CIII radiation confirmed that the CIV and CIII emission originated from nearly the same geometrical region for both attached and detached plasmas. These profiles were obtained from both high triangularity and low triangularity discharges. This result had been anticipated but verification was needed to show that CIII emission was a reliable indicator of the location of CIV emission.

2. In PDD operation the maximum emission from CIV is located near the X point and geometrically near the region of maximum CIII radiation.

3. The 2D distributions of CIV are generally in agreement with those regions of maximum emission as measured by the bolometer for both attached and detached plasmas.

4. The 2D profiles of VUV CIV were compared to distributions generated by the UEDGE code. The UEDGE predictions agree well with experimentally measured distributions of Da, however, the agreement is not as good for carbon.

5. Comparison of the VUV CIV 2D profiles from the upper and lower divertors produced some interesting results. It was expected that the effect of baffling in the upper divertor would be to entrain neutrals, producing a higher density-lower temperature divertor plasma than the lower, open divertor. If this were the case, the CIV profiles from the upper divertor should have been consistent with lower temperature by showing CIV emission farther out of the divertor legs. However, actual comparison indicates an attached outer leg in the upper, baffled divertor.

   For the same discharge conditions, the lower, open divertor shows a detached outer leg. The results for the upper divertor contradict expectations. The upper, baffled case at higher power, lower density and lower X-point location, all support the attached outer divertor.

6. Comparison of the upper, baffled vs. lower, open 2D divertor profiles of CIV radiation in high triangularity discharges shows significant differences in distribution for both attached and detached plasmas.

   Reversal of the toroidal field direction reverses the direction of both the ion $\nabla \mathbf{B}$ drift and the **E X B** particle drifts in the divertor. For $\nabla \mathbf{B}$ into the divertor, the particle drifts are from outer to inner leg and the CIV radiation is strongest in the outer leg. For $\nabla \mathbf{B}$ out of the upper divertor, the particle drifts are from inner to outer leg and the CIV radiation is strongest in the outer leg. No data for $\nabla \mathbf{B}$ out of the lower divertor was available.

8. We also investigated the effect of the neutral beam power on the CIV emission. Increasing the neutral beam power at constant density moves the CIV radiating region towards the divertor floor.

Publications and Conference Presentations

1. Nilson,D.G.; M.E. Fenstermacher; G. Brewis; N. Jalufka; and R. Ellis; *A Tangentially Viewing VUV-TV System f0r the DIII-D Divertor*, Conference on High Temperature plasma Diagnostics, Princeton, NJ, June 1998.

2. Nilson, D.G.; Fenstermacher, M.E.; Ellis, R.; Brewis, G.; Jalufka, N.; and Snider, R.T.
   A Tangentially Viewing Vacuum Ultraviolet TV System for the DIII D Divertor,
   Rev. Sci. Instrum., vol. 70, p. 738, Jan. 1999.

3. Jalufka, N.; Donalies, M.; Punjabi, A.; Fenstermacher, M.E.; Meyer, W. Nilson, D.G.; and Wood, R.D.
2-D Profiles of 155 nm CIV Radiation in a Radiative Divertor in DIII-D,
Bull. Amer. Phys. Soc., vol. 43, p. 1889, Nov. 1998.

4. Donalies, M.; Jalufka, N.; Fenstermacher, M.E.; Meyer, W.H.; Nilson, D.G.; and Wood, R.D.,
Reconstruction of 2-D Profiles of Vacuum Ultraviolet Emission from Tangential Images of the Divertor in DIII-D,
Bull. Amer. Phys. Soc., vol. 43, p. 1889, Nov. 1998.

5. Fenstermacher, M.E.; Jalufka, N.; Meyer, W.H.; Nilson, D.G.; Gafert,J.; Hogan, J.; Lasnier, C.J.; Leonard,A.W.; Pitts, R.A.; Porter, G.D.; and the DIII-D Team
Evolution of 2-D Visible and VUV Divertor Emission Profiles During DIII D H-mode Detachment Transitions,
Proc. Of the 26th European Physical Soc. Conf. Controlled Fusion and Plasma Physics, Maastricht, Netherlands, vol. 23J, p. 1197, June, 1999.

6. Jalufka, N.; Boney, Q.; Fenstermacher, M.E.; Leonard, A.W.; and Colchin, R.J.
Poloidal Profiles of CIV Emission in the DIII-D Divertor During PDD Operation,
Bull. Amer. Phys. Soc., vol.44, p. 1999, Nov. 1999.

7. Jalufka, N.; Fenstermacher, M.E. ; Porter, G.D. ; Colchin, R.A. ; and Leonard, A.W.
Comparison of 2D VUV Emission Profiles with Simulations at High and Low Triangularity in DIII-D,
Bull. Amer. Phys. Soc., vol. 45, p. 155, Oct. 2000.

8. Jalufka, N.; Fenstermacher, M.E.; Porter,G.D.; Wolf,N.S.; Leonard,A.W.; Petrie,T.W.; Ellis,R.; and Meyer,W.
Comparison of 2D Profiles of CIV Vacuum Ultra Violet Radiation from the Upper and Lower Divertors of DIII-D,
Proceedings of The International Atomic Energy's Technical Committee on Divertor Concepts, Aix-en-Provence, France, September 11-14, 2001.

9. Jalufka,N.W.; Fenstermacher,M.E.; Leonard,A.W.; Petrie,T.W.; and Meyer,W.
Comparison of 2D Profiles of CIV VUV Radiation from the Upper and Lower Divertors of DIII-D for Normal and Reversed Magnetic Fields,
Bull. Amer. Phys. Soc., vol. , p. 304 , Nov. 2002.