UCRL- 92019
PREPRINT

CONF-850310--54

A NEW CONCEPT FOR PUMPING THE EDGE PLASMA

W. L. Barr

This paper was prepared for submittal to the
6th Topical Meeting on the Technology of
Fusion Energy, San Francisco, CA,
March 3-7, 1985.

April 4, 1985

Lawrence
Livermore
National
Laboratory

This is a preprint of a paper intended for publication in a journal or proceedings. Since changes may be made before publication, this preprint is made available with the understanding that it will not be cited or reproduced without the permission of the author.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

M85010180

UCRL--92019

DE85 010180

A NEW CONCEPT FOR PUMPING THE EDGE PLASMA

W. L. Barr
Lawrence Livermore National Laboratory
P. O. Box 5511, L-644
Livermore, CA 94550
(415) 422-9811

ABSTRACT

A new concept is proposed for pumped limiter designs that allows more flexibility and therefore better control of the edge plasma and its recycling at the limiter than previous designs.

INTRODUCTION

Edge plasmas are receiving a lot of attention because of their important effect on confinement and on the control of impurities.^{1,2} Pumped limiters appear to be the most compact and therefore economical way to control the edge plasma. Another option that is also rather compact is to use an internal open divertor, but divertors require more space because they must be located outside of the separatrix. The additional space required is especially great for bean-shaped plasmas. One problem with pumped limiter designs is that the opening into the pumping duct must be determined more by the heat load and sputtering rate at the leading edge than by the pumping needs. The leading edge has to be exposed so that some plasma can pass behind it and into the duct.

Recent experiments have shown that both density and temperature profiles of the core plasmas in divertor machines are improved when the divertor is plugged by a dense edge plasma, so that gas from the divertor cannot escape back to the confinement region.^{3,4} Under these conditions the vacuum in the main chamber is improved, and recycling to the walls by successive charge exchange is reduced. This in turn lowers the density of sputtered impurities.

Low sputtering rates could also be realized if the edge plasma were dense and warm enough to attenuate gas, and yet cool enough so that

atoms recycled from it would have energies below the threshold for sputtering. Experiments are operating⁵ or planned⁶ to test pumped limiter and open divertor designs to see if recycling at an exposed internal surface can produce such a protective edge plasma.

PORTED NEUTRALIZER PLATE CONCEPT

In this paper a new concept is described that may provide the needed control over the recycling of gas at the neutralizer plate. This concept also allows the leading edge to be moved out of the plasma and the surface to be contoured to best handle the heat. Figure 1 shows a pumped limiter of the proposed type. The idea here is to choose a shape for the neutralizer plate that best distributes the heat load, without regard for the vacuum pumping duct. Small pumping ports are then distributed on the surface of the plate to locally control the fraction of the ions being pumped. This is the same idea as used for the recycling halo plasma dump⁷ in MARS (Mirror Advanced Reactor Study),⁸ and beginning testing on TMX-U at Livermore.⁹ Figure 2 shows a recycling halo dump for a tandem mirror device.

In a tokamak, each small port would have its own leading edge, but local heating would not be a serious problem because of the relatively large area for coolant around each port. Since nearly the entire area behind the dump plate is used as a pumping duct, this duct space can be thin (only a few centimeters even in a reactor), making a very compact divertor. Gas is conducted out of the thin duct space by pipes that are shaped to give the least interference with the neutron shielding. This distributed pumping concept can also be applied to divertors and to halo dumps on tandem mirrors.

Gas is produced on the plasma side of the neutralizer plate, and the outer region of the core plasma will be cooled by it. This cool outer region then becomes the edge plasma, and

*Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under contract number W-7405-ENG-48.

Fig. 1. A pumped limiter with a ported neutralizer plate. Although not clear from the figure, the field lines intersect the neutralizer plate at grazing incidence.

Fig. 2. A recycling halo dump for a tandem mirror device (from Ref. 9). On a tandem, the field lines can intersect the plate normally.

it must be dense enough to attenuate the gas and shield the hot core plasma. The feasibility of pumped limiters would appear therefore to depend on their ability to produce a dense edge plasma by recycling at the neutralizer plate. The flexibility offered by individual ports should allow more freedom of design than other limiter configurations.

The analysis of this ported neutralizer plate concept is in progress at LLNL to gain insight into the physics of limiters and their ability to produce a dense, warm edge plasma.

The ported plate concept appears to offer a new approach to pumped limiters, and may allow more compact tokamak designs.

REFERENCES

1. F. Wagner et al., Proc. 9th Internat. Conf., Plasma Physics and Controlled Nuclear Fusion Research, Baltimore, Sept. 1982, IAEA, Vienna, 1983, Vol. 1, 43.
2. H. P. Furth, "The PPPL Tokamak Program", Princeton Plasma Physics Laboratory Report PPPL-2149 (1984).
3. K. Lackner et al., Plasma Physics and Controlled Fusion, Vol. 26, No. 1A, pp.105-115, (1984).
4. S. M. Kaye et al., "Attainment of High Confinement in Neutral Beam Heated Divertor Discharges in the PDX Tokamak", Plasma Physics Laboratory Report PPPL-2056, (1983).
5. M. Shimada et al., "Divertor Studies in High-Power Beam Heated Discharges in D-III", GA Technologies Report, GA-A17623, (July 1984).
6. Karl Schmitter, Max-Planck-Institute fur Plasmaphysik, private communication.
7. The idea of recycling to produce a dense halo plasma was due to B. G. Logan, Lawrence Livermore National Laboratory.
8. B. G. Logan, et al., "MARS - Mirror Advanced Reactor Study Final Report" Lawrence Livermore National Laboratory, Livermore, CA, UCRL-53480 (1984).
9. W. L. Hsu, W. L. Barr, and T. C. Simonen, J. Nucl. Mater., 121, 264, (1984).