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L TO H MODE TRANSITIONS AND ASSOCIATED PHENOMENA IN DIVERTOR TOKAMAKS

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September 1990

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FINAL REPORT FOR THE FISCAL YEAR 1990

**PROJECT TITLE: L to H Mode Transitions and Associated
Phenomena in Divertor Tokamaks**

PRINCIPAL INVESTIGATOR: Dr. Alkesh Punjabi

**INSTITUTION: Hampton University
Hampton, VA 23668**

September 1990

This is the final report for the research project titled " L to H Mode Transitions and Associated Phenomena in Divertor Tokamaks ". The period covered by this report is the fiscal year 1990. This project is funded by Lawrence Livermore National Laboratory under the HBCU Program of DOE. This report covers four aspects of the work done during this period. Each one is described in detail in the following:

I Publication:

During this period the PI published one paper in the international referred journal. The paper is :

A Catastrophe Theory Study of a Two Chamber Model for a Tokamak Scrape-Off and Divertor
Alkesh Punjabi
Journal of Plasma Physics, vol. 42, 1989, p 59-74.

The reprint of this paper is attached with this report.

II Contributed Papers:

One contributed paper was presented at the American Physical Society Division of Plasma Physics 1989 Annual Meeting on the research done in this project. Details are:

Catastrophe Theory Study of Advanced Two Chamber Model
Maria Lam and Alkesh Punjabi
Bull. Am. Phys. Soc., 34, 2137 (1989)

A copy of the abstract of this paper is also attached with this report.

III Research Seminars:

The PI presented one seminar at the Research in Physics at Hampton University, Department of Physics on September 21, 1990. The part of this research seminar given by the PI included the research done in this project. Details are:

Catastrophes and Bifurcations in Toroidal Plasmas
Alkesh Punjabi
Research in Physics at HU
Dept. of Physics Seminars
Sept. 21, 1990

IV Development of Advanced Two Chamber Model:

The theoretical work on the development of advanced two chamber model for plasma transport in the main plasma and divertor scrape-off region is now complete. This advanced model includes the effects of charge exchange and radiative

loss processes. We have also developed a computer code to solve the equations of this model. At present, we are testing and debugging this code. A brief discussion of this advanced model is given below.

The advanced two chamber model equations are:

$$\frac{d}{ds}(nu) = S \quad (1)$$

$$\frac{d}{ds}(mnu^2 + p) = -mnn_0 \langle \sigma v \rangle_{cx} (u + v_0) \quad (2)$$

$$\frac{d}{ds} \left[q^* + \left(5nT + \frac{1}{2} mnu^2 \right) u \right] = W_{ion} + W_{cx} + W_{rad} \quad (3)$$

Here the new terms for charge exchange and radiative losses are included in the two chamber model equations. These terms in energy transport equation are given by

$$W_{cx} = - \left(\frac{3}{2} T - E_0 \right) nn_0 \langle \sigma v \rangle_{cx} \quad (4)$$

and

$$W_{rad} = - n^2 Q. \quad (5)$$

Q is the radiation power parameter. For the neutral transport, we use the Post model:

$$\frac{d}{ds}(n_0 v_0) = -S \quad (6)$$

The integration of equations (1) - (3) with the help of equation (6) will yield:

$$b_4 T_1^4 + b_3 T_1^3 + b_2 T_1^2 + b_1 T + b_0 = 0 \quad (7)$$

where

$$b_i = b_i(x, y, n_0, f_{pump}) \quad (8)$$

Here x and y are defined as

$$x = \frac{n_2}{n_1} \quad (9)$$

and

$$y = \frac{T_2}{T_1} \quad (10)$$

Thus with given values of x , y , n_0 and f_{pump} , one can solve the quartic equation and then solve for the recycling parameter R and the heat flux Q_1 from main plasma scrape-off to the divertor.

Catastrophe Theory Study:

The above analysis can be performed in the set-up of catastrophe theory by considering the parameters $C = (R, Q_1)$ as control vector and the variables $X = (n_2, n_1, T_1, T_2)$ as the state or behavior vector. Then behavior of X as a function of C will yield the equilibrium surfaces. A study of these surfaces can yield catastrophic behavior of the system.

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