REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	10/5/95	Annual Progress - 9/1/94 - 8/31/95

4. TITLE AND SUBTITLE
PIC Simulation of Surface Waves

5. FUNDING NUMBERS
N00014-93-1-1389

6. AUTHOR(S)

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8. PERFORMING ORGANIZATION REPORT NUMBER
442472-23133

9. SPNSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research
Code 251:EF
Ballston Tower One
800 North Quincy Street
Arlington, VA 22217

10. SPONSORING /MONITORING AGENCY
Office of Naval Research

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Surface waves are being investigated via electrostatic particle simulation of a warm, unmagnetized, bounded 2½d plasma.

14. SUBJECT TERMS
surface waves, electrostatic particle simulation

15. NUMBER OF PAGES
2

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
unlimited	unlimited	unlimited	unlimited

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PIC Simulation of Surface Waves

AASERT Annual Progress Report
9/1/94 - 8/31/95

Charles K. Birdsall, Principal Investigator
David Cooperberg, Graduate Student Researcher

Office of Naval Research

N00014-93-1-1389

Annual Report

AASERT Award for Proposal

Grant No. N00014-93-1-1389

PIC Simulation of Surface Waves

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This is a description of work David Cooperberg has done as a graduate student in the last year supported by an ONR AASERT in Professor C. K. Birdsall's Plasma Theory and Simulation Group.

Surface waves are being investigated via electrostatic particle simulation of a warm, unmagnetized, bounded $2\frac{1}{2}$d plasma. Our study focuses on a slab configuration in which the plasma is periodic in the y direction and is bound in the x direction by grounded, absorbing, conducting walls. Our prior simulation has produced dispersion relations and eigenfunctions for surface waves analogous to the Gould-Trivelpiece[1] waves in cylindrical systems for which the $k_y = 0$ cut-off of the asymmetric mode defines the series resonance and secondary branches[2] whose cutoffs represent Tonks-Dattner resonances[3][4]. The current work involves studying 2 species, low voltage, collisional systems sustained both by uniform ionization, for which the randomly excited surface wave modes remain in a linear regime, and also by resonant interaction with surface waves which are excited beyond the linear regime by applied voltages of order kT_e. This investigation is important for both basic sheath understanding and for applications such as large area plasma processing, new light sources, lasers, and ion sources. Electromagnetic simulations are also being initiated to verify our results.

In order to further our study of surface waves as a mechanism for sustaining plasma discharges, work has been performed in modifying the Monte Carlo collision code written by Vahid Vahedi. Enhancements have been made by allowing simulation particles to have their own variable weights. The reasoning for this work is as follows.

In order to use particle-in-cell (PIC) simulation codes for modeling collisional plasmas, such as self-sustained discharges, it is necessary to add interactions between charged and neutral particles. A Monte-Carlo collision (MCC) package for particles of various weights has been developed and is being tested. This scheme can in general reduce the number of computer particles needed to represent selected species which allows for a significant reduction in simulation size at runtime, as in the case of highly electronegative discharges where the ion densities may be far greater than the electron density. Also, by choosing a constant number of computer particles to be used through the duration of the run, a consistent level of numerical fluctuation may be maintained. We have tested this scheme to simulate O_2 discharges at low powers and high pressures and have made some analysis of regimes in which anomalous heating might degrade the performance of the variable weight approach.

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