

UNIVERSITY OF CALIFORNIA, BERKELEY

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO



SANTA BARBARA • SANTA CRUZ

COLLEGE OF ENGINEERING
DEPARTMENT OF ELECTRICAL ENGINEERING
AND COMPUTER SCIENCES

BERKELEY, CALIFORNIA 94720

22 August 1990

Dr. Michael F. Shlesinger
Director, Physics Division
Department of the Navy
Office of the Chief of Naval Research
Arlington, Virginia 22217-5000

Re: Annual P3/H report

Dear Dr. Shlesinger:

Our report is enclosed.

We appreciate your continuing support.

A full technical report will be sent to Dr. Charles Roberson soon.

Sincerely yours,

Charles K. Birdsall

Charles K. Birdsall

Professor

cc: Dr. Charles Roberson

Enclosure: the report and lists

DISTRIBUTION STATEMENT A

Approved for public release
Distribution Unlimited

DTIC
ELECTE
AUG 31 1990
S D

AD-A226 086

008

OFFICE OF NAVAL RESEARCH
PUBLICATIONS/PATENTS/PRESENTATIONS/HONORS REPORT
1 Oct 89 through 30 Sept 90

R&T Number: 4127742---05

Contract/Grant Number: N0001490J1198

Contract/Grant Title: Plasma-Sheath-Surface Dynamics

Principal Investigator: Prof. Charles K. Birdsall

C. Birdsall

Mailing Address: Electronics Research Laboratory, Cory Hall
University of California, Berkeley CA 94720

Phone Number: (with Area Code) (415) 643-6631 [(415) 642-3214, messages]

E-Mail Address: birdsall@janus.berkeley.edu

- a. Number of Papers Submitted to Refereed Journal but not yet published: 12
- b. Number of Papers Published in Refereed Journals: 5
(list attached)
- c. Number of Books or Chapters Submitted but not yet Published:
1 (chapter)
- d. Number of Books or Chapters Published: 0 (list attached)
- e. Number of Printed Technical Reports & Non-Refereed Papers: 5
(list attached)
- f. Number of Patents Filed: 0
- g. Number of Patents Granted: 0 (list attached)
- h. Number of Invited Presentations at Workshops or Prof. Society Meetings: 4
- i. Number of Presentations at Workshops or Prof. Society Meetings:
12
- j. Honors/Awards/Prizes for Contract/Grant Employees:
(list attached, this might include Scientific Soc Awards/Offices, Promotions, Faculty Awards/Offices etc)
Fulbright Lactuer/Research Award to Prof. Birdsall, to be used Spring 1991
- k. Total number of Graduate Students and Post-Docs Supported at least 25% this year on this contract/grant:

Grad Students 4 and Post-Docs 1 including

Grad Student Female 2 and Post-Docs Female 0

Grad Student Minority 0 and Post-Doc Minority 0

Minorities include Blacks, Aleuts, AmIndians, Hispanics etc. NB:
Asians are not considered an under-represented or minority group in
science and engineering.

Attachments: list for b; list for e; list of all publications for 1989-1990.

b.

Journal Articles

- K. Theilhaber and C.K. Birdsall, "Kelvin-Helmholtz Vortex Formation and Particle Transport in a Cross-Field Sheath I: Transient Behavior," *Phys. Fluids B*, pp. 2244-2259, November 1989.
- K. Theilhaber and C.K. Birdsall, "Kelvin-Helmholtz Vortex Formation and Particle Transport in a Cross-Field Sheath II: Steady State," *Phys. Fluids B*, pp.2260-2272, November 1989.
- Lou Ann Schwager and C.K. Birdsall, "Collector and Source Sheaths of a Finite Ion Temperature Plasma," *Phys. Fluids B*, pp 1057-1068, May 1990.
- M.J. Gerver, S.E. Parker, and K. Theilhaber, "Analytic Solutions and Particle Simulations of Cross-Field Plasma Sheaths," *Phys. Fluids B*, pp 1069-1082, May 1990.
- I.J. Morey and C.K. Birdsall, "Traveling Wave-Tube Simulation: the IBC Code," *IEEE Trans. Plasma Sciences.*, pp. 482-489, June 1990.

c.

ERL Reports

- J. Verboncoeur, "ES1 Reference Manual" (which is distributed with our PC disk, which is not included here - but free for the asking)
- S.E. Parker, and C.K. Birdsall, "Numerical Error in Electron Orbits with Large $\omega_{ce}\Delta t$," Memo No. UCB/ERL M89/136, December 20, 1989.
- M.V. Alves, M.A. Lieberman, V. Vahedi, and C.K. Birdsall, "Sheath Voltage Ratio for Asymmetric RF Discharges," Memo. No. UCB/ERL M90/56, June 21, 1990.
- V. Vahedi, M.A. Lieberman, M.A. Alves, J.P. Verboncoeur, and C.K. Birdsall, "A One Dimensional Collisional Model for Plasma Immersion Ion Implantation," Memo. No. UCB/ERL M90/60, July 9, 1990.
- J.P. Verboncoeur and V. Vahedi, "PDP1: Plasma Device Planar 1 Dimensional Bounded Electrostatic Code. Reference Manual," August 1990.

STATEMENT "A" per Dr. Michael Shlesinger
ONR.Code 1112
TELECON 8/29/90 VG

Accession For	
NTIS CRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By <i>per call</i>	
Distribution /	
Availability Codes	
Dist	Avail and/or Special
A-1	



Journal Articles

W.S. Lawson, "Particle Simulation of Bounded 1D Plasma Systems," 80 (2), February 1989, pp. 253-276.

K. Theilhaber and C.K. Birdsall, "Kelvin-Helmholtz Vortex Formation and Particle Transport in a Cross-Field Plasma Sheath," *Phys. Rev. Lett.*, 62, pp. 772-775, February 13, 1989.

B.I. Cohen, A.B. Langdon, D.W. Hewett (all at LLNL) and R.J. Procassini (here), "Performance and Optimization of Direct Implicit Particle Simulation", *J. Comp. Phys.*, 81, pp 151-168, March 1989

William S. Lawson, "The Pierce Diode with an External Circuit. I. Oscillations About Nonuniform Equilibria," *Phys. Fluids B*, 1, July 1989, pp 1483-1492.

William S. Lawson, "The Pierce Diode with an External Circuit. II. Chaotic Behavior," *Phys. Fluids B*, 7, July 1989, pp. 1493-1501.

K. Theilhaber and C.K. Birdsall, "Kelvin-Helmholtz Vortex Formation and Particle Transport in a Cross-Field Sheath I: Transient Behavior," *Phys. Fluids B*, pp. 2244-2259, November 1989.

K. Theilhaber and C.K. Birdsall, "Kelvin-Helmholtz Vortex Formation and Particle Transport in a Cross-Field Sheath II: Steady State," *Phys. Fluids B*, pp2260-2272, November 1989.

R.J. Procassini, C.K. Birdsall, E.C. Morse, "A Fully-Kinetic, Self-Consistent Particle Simulation Model of the Collisionless Plasma-Sheath Region," submitted to *Phys. Fluids B*, June 1989.

ERL Reports

J. Verboncoeur, "ES1 Reference Manual" (which is distributed with our PC disk, which is not included here - but free for the asking)

M.J. Gerver, S.E. Parker, and K. Theilhaber, "Analytic Solutions and Particle Simulations of Cross-Field Plasma Sheaths," Memo No. UCB/ERL M89/114, August 30, 1989.

I.J. Morey, and C.K. Birdsall, "Traveling-Wave-Tube Simulation: The IBC Code," Memo No. UCB/ERL M89/116, September 26, 1989.

S.E. Parker, and C.K. Birdsall, "Numerical Error in Electron Orbits with Large $\omega_{ce}\Delta t$," Memo No. UCB/ERL M89/136, December 20, 1989.

Talks, Conference Proceedings

At *Sherwood Theory Conference*, San Antonio, Texas, April 3-5, 1989:

W.S. Lawson and C.K. Birdsall, "Simulation of RF driven plasma edge."

S.E. Parker, C.K. Birdsall, A. Friedman, S.L. Ray, "Bounded multi-scale particle simulation: The sheath problem."

At *13th Conference on Numerical Simulation of Plasmas*, Santa Fe, NM, September 17-20, 1989

J.P. Verboncoeur, V. Vahedi, "WinGraphics: An Optimized Windowing Environment for Interactive Real-Time Simulations."

I.J. Morey, J.P. Verboncoeur, and V. Vahedi, "Bounded Plasma Device Simulation with PDW1, Including: External RLC Circuit, DC and RF Drive, and Collisional Processes."

I.J. Morey, and C.K. Birdsall, "The Traveling-Wave-Tube Code IBC."

M.V. Alves, V. Vahedi, and C.K. Birdsall, "PDC1: One-Dimensional Radial Code for a Cylindrical Plasma Device with an External RLC Circuit."

S.E. Parker, A. Friedman, S.L. Ray, and C.K. Birdsall, "Multi-Scale Particle Simulation of Bounded Plasmas."

S.E. Parker, "A Particle-In-Cell Method for Modeling Small Angle Coulomb Collisions in Plasmas."

R.J. Procassini, C.K. Birdsall, B.I. Cohen, and Y. Matsuda, "Comparison of Particle-In-Cell and Fokker-Planck Methods as Applied to the Modeling of Auxiliary-Heated Mirror Plasmas."

Talks, Poster Papers

At APS/Gaseous Electronics Conference Annual Meeting, Palo Alto, CA, October 17-20, 1989

I.J. Morey, V. Vahedi, J.P. Verboncoeur, and M.A. Lieberman, "Particle Simulation Code for Modeling Processing Plasmas."

M.V. Alves, V. Vahedi, and C.K. Birdsall, "Cylindrical Simulations for RF Discharges and Plasma Immersion Ion Implantation."

At APS/Division of Plasma Physics Annual Meeting, Anaheim, November 13-17, 1989.

R.J. Procassini, C.K. Birdsall, and B.I. Cohen, "Particle Simulations of a Low-Recycling Divertor Scrape-Off Layer."

C.K. Birdsall, R.J. Procassini, and B.I. Cohen, "Particle Simulations of a High-Recycling Divertor Scrape-Off Layer."

R.J. Procassini, B.I. Cohen, Y. Matsuda, and C.K. Birdsall, "Modeling of Auxiliary-Heated Mirror Plasmas: A Comparison of Particle-In-Cell and Fokker-Planck Methods."

S.E. Parker, and R.J. Procassini, "Large Space and Time Scale Particle Simulation of Bounded Plasmas with a 'Logical Sheath'."

M.V. Alves, V. Vahedi, and C.K. Birdsall, "RF Plasma Processes in Cylindrical Models and Plasma Immersion Ion Implantation."

I.J. Morey, V. Vahedi, and J. Verboncoeur, "Particle Simulation Code for Modeling Processing Plasmas."

1990

Journal Articles

Lou Ann Schwager and C.K. Birdsall, "Collector and Source Sheaths of a Finite Ion Temperature Plasma," *Phys. Fluids B*, pp 1057-1068, May 1990.

M.J. Gerver, S.E. Parker, and K. Theilhaber, "Analytic Solutions and Particle Simulations of Cross-Field Plasma Sheaths," *Phys. Fluids B*, pp 1069-1082, May 1990.

S.E. Parker, and C.K. Birdsall, "Numerical Error in Electron Orbits with Large $\omega_{ce} \Delta t$," accepted by *J. Comp. Physics*, April 1990.

I.J. Morey and C.K. Birdsall, "Traveling Wave-Tube Simulation: the IBC Code," *IEEE Trans. Plasma Sciences.*, pp. 482-489, June 1990.

ERL Reports

M.V. Alves, M.A. Lieberman, V. Vahedi, and C.K. Birdsall, "Sheath Voltage Ratio for Asymmetric RF Discharges," Memo. No. UCB/ERL M90/56, June 21, 1990.

V. Vahedi, M.A. Lieberman, M.A. Alves, J.P. Verboncoeur, and C.K. Birdsall, "A One Dimensional Collisional Model for Plasma Immersion Ion Implantation," Memo. No. UCB/ERL M90/60, July 9, 1990.

J.P. Verboncoeur and V. Vahedi, "PDP1: Plasma Device Planar 1 Dimensional Bounded Electrostatic Code. Reference Manual," August 1990.

Conference Proceedings, Poster Papers

Sherwood Fusion Theory Conference, Williamsburg, VA, April 23-25, 1990:

R.J. Procassini, and C.K. Birdsall, "Particle Simulations of Transport in a Diverted Tokamak Scrape-Off Layer: The High-Recycling Regime."

Live demonstration in Plasma Visualization evening session 7-11pm April 24 of our bounded plasma PC codes, applications. (by Birdsall, Vahedi)

Microwave Power Tube Conference, Monterey, CA, May 7-9, 1990:

I.J. Morey, and C.K. Birdsall, "Traveling-Wave Tube Simulation; the IBC Code."

Workshop on High-Density Plasma Techniques and Processes for Integrated Circuit Fabrication, Burlingame, CA, September 11-12, 1990.

V. Vahedi, M.A. Lieberman, M.A. Alves, J.P. Verboncoeur, and C.K. Birdsall, "A One Dimensional Collisional Model For Plasma Immersion Ion Implantation."

V. Vahedi, J.P. Verboncoeur, M.A. Alves, and C.K. Birdsall, "Plasma Processing Via Computer Simulation."

43rd Annual Gaseous Electronics Conference, Urbana-Champaign, IL, October 16-19, 1990.

C.K. Birdsall, "Particle-In-Cell Combined with Monte Carlo Collisions-In-Living Color." (Invited talk)

J.P. Verboncoeur, V. Vahedi, and C.K. Birdsall, "Power Deposition in Parallel Plate Discharges."

APS/Division of Plasma Physics, Cincinnati, OH, November 12-16, 1990.

S.E. Parker, and C.K. Birdsall, "Particle Transport due to Kelvin- Helmholtz Vortices and Small Scale Turbulence."

US-Japan Workshop on "Advanced Computer Simulation Techniques Applied to Plasmas and Fusion," UCLA, September 26-28, 1990.

V. Vahedi, J.P. Verboncoeur, M. Surendra, and C.K. Birdsall, "A Monte-Carlo Collision Model for the Particle-in-Cell Method."

Course

M.A. Lieberman and C.K. Birdsall, "Low Pressure Plasma Discharges Used in Semiconductor Processing", UC Extension, San Francisco, CA, May 23-25 1990, and Oxford, England, July 9-11, 1990.

Invited Talks

C.K. Birdsall, "Interactive Plasma Computer Experiments; Plasma Device Simulations on PC's and Workstations," January 16, 1990 at Naval Research Laboratory, Washington, D.C.

C.K. Birdsall, "Magnetized plasms sheath, with Kelvin-Helmholtz instability, vortices, Bohm-like diffusion", and "Computer experiments with bounded collisional plasmas on fast PC's, March 26-27, 1990, at University of Wisconsin, Madison, Wisconsin.

C.K. Birdsall, "Interactive Plasma Computer Experiments; Plasma Device Simulations on PC's and Workstations," June 1, 1990 Naval Post Graduate School, Monterey, CA.