LBL-27455
(Abstracts 1–16)

Lawrence Berkeley Laboratory

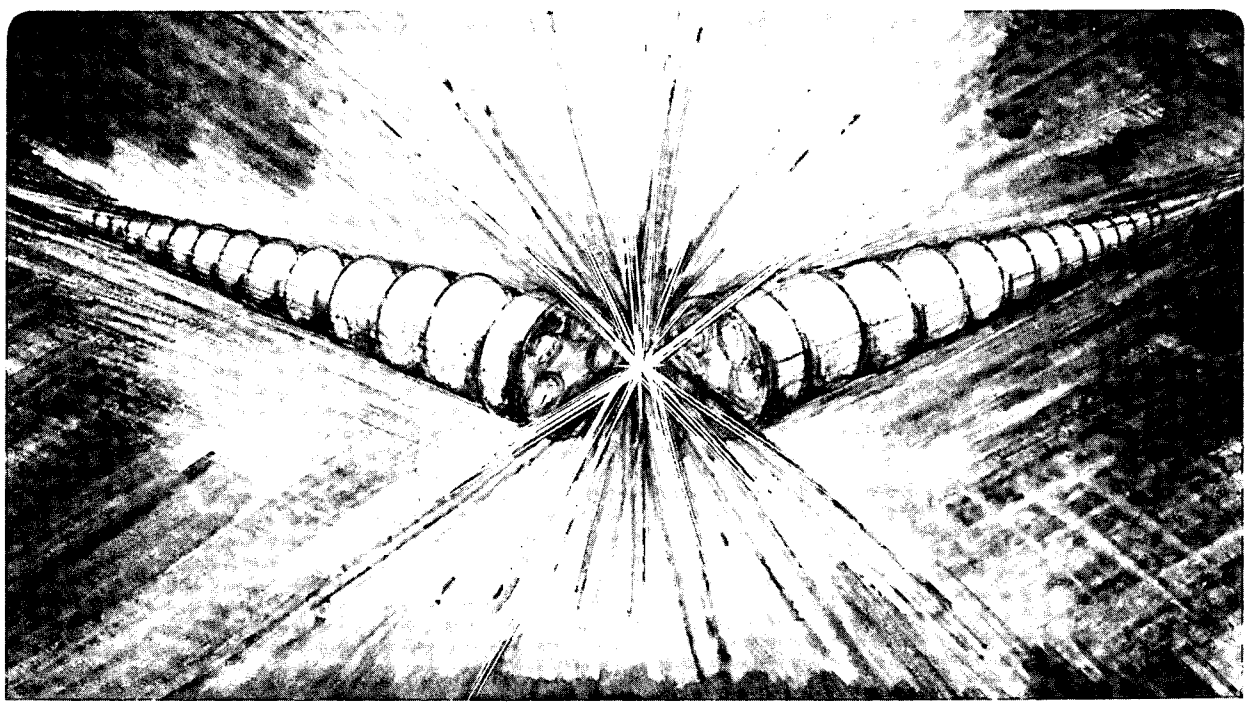
UNIVERSITY OF CALIFORNIA

Accelerator & Fusion Research Division

To be presented at the Thirty-First Annual Meeting of the Division of Plasma Physics, American Physical Society, Anaheim, CA, November 13–17, 1989

Abstracts Submitted for the Thirty-First Annual Meeting, Division of Plasma Physics

August 1989



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LBL-27455(1-16)

Abstracts Submitted
For the Thirty-First Annual Meeting
American Physical Society
Division of Plasma Physics
November 13-17, 1989

By Members of the
Accelerator and Fusion Research Division

Lawrence Berkeley Laboratory
One Cyclotron Road
Berkeley, CA 94720

August 1989

This work was supported by the Director, Office of Energy Research, Office of Fusion Energy of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

Theory

1. Huanchun Ye, "Gyroresonant Ballistic Waves and Analytic Solution for Gyroresonant Absorption"

2. Allan N. Kaufman, Huanchun Ye, and Daniel R. Cook, "Analytic Theory of Gyroresonant Absorption in Tokamaks"

3. E.R. Tracy, A.N. Kaufman, "Entropy Generation by Incoherent Linear Mode Conversion"

4. A.J. Neil, E.R. Tracy, and A.H. Boozer, "A Study of Filamentation Using a Self-consistent Wave-Kinetic Formulation of Wave-Plasma Interactions"

ION AND PLASMA SOURCES

5. G.C. Stutzin, A.T. Young, K.N. Leung, and W.B. Kunkel, "Experimental Study of H^o, $H_2(v'')$, and H^- in the LBL 20-cm diameter Source"

6. W.B. Kunkel, K.N. Leung, C.A. Hauck and S.R. Walther, "Electron Suppression Experiments in a Small Multicusp H^- Source"

7. K.N. Leung, C.A. Hauck, and W.B. Kunkel, "Some Optimization Experiments on a Small Multicusp H^-/D^- Source"

8. C.F. Chan and A.L Lietzke, "Optic Design of an Advanced Accelerator for High Current H^- Beam"

9. A.F. Lietzke, O.A. Anderson, W.S. Cooper, W.B. Kunkel, J.W. Kwan, K.N. Leung, and M.D. Williams, "Surface-production D^- Ion Source Development at LBL"

10. S.R. Walther, K.N. Leung and W.B. Kunkel, "Generation of B^+, N^+, Cu^+, and C^- ion beams using a filtered multicusp ion source,"

PHYSICS AND TECHNOLOGY OF ION AND NEUTRAL BEAMS

11. P. Purgalis, O.A. Anderson, W.S. Cooper, G.J. DeVries, W.B. Kunkel, J.W. Kwan, A.F. Lietzke, L. Soroka, and R.P. Wells; R.S. DeVoto, W.B. Lindquist, and L.L. Reginato; Y. Gohar; D. Sedgley and J. Brook, "A Neutral Beam System for Current Drive, Heating, and Burn Control on ITER"

12. O.A. Anderson and L. Soroka, "ITER Current Drive Accelerator using Surface-Produced D^- Beams"

13. J.W. Kwan, G.D. Ackerman, O.A. Anderson, W.S. Cooper, G.J. DeVries, R. Wells, L. Soroka, and W.F. Steele, "Testing of an ESQ Accelerator for Neutral Beam Injection"

14. W.S. Cooper and L. Soroka, "Secondary Electron Trajectories in an ESQ Accelerator"

15. S. Eylon, T. Fessenden, T. Garvey and H. Meuth, "Beam Dynamic Studies in the Multiple Beam Experiment MBE-4."

MISCELLANEOUS

16. J.W. Stearns and A.S. Schlachter, "Scaled cross sections for excitation of atomic hydrogen at neutral-beam injection energies for current drive"

LBL-27455(1)

Gyroresonant Ballistic Waves and Analytic Solution for Gyroresonant Absorption*

HUANCHUN YE, *Lawrence Berkeley Laboratory and University of California at Berkeley.*

Gyroresonant absorption is treated as mode-conversion to a continuum of gyroresonant ballistic waves (GBWs), which represent the propagation of linear perturbations of the Vlasov distribution, in the absence of an electromagnetic perturbation. The ℓth-harmonic GBWs have the following dispersion relation: $\omega = \mathbf{k} \cdot \mathbf{V}(\mathbf{x};\mathbf{I}) + \ell\Omega(\mathbf{x})$, where $\mathbf{V}$ is the guiding-center velocity, $\Omega(\mathbf{x}) = eB(\mathbf{x})/mc$ is the gyrofrequency, and $\mathbf{I}$ parameterizes the guiding-center orbits; this is the same as the ℓth-harmonic local gyroresonance condition. GBW packets have the same $\mathbf{x}$-orbits as guiding centers, but they carry with them phase information which cause them to travel in $\mathbf{k}$-space as well [1]. This point becomes clear from the Hamiltonian ray equations associated with the above dispersion relation: $d\mathbf{x}/dt = \partial\omega/\partial\mathbf{k} = \mathbf{V}$, $d\mathbf{k}/dt = -\partial\omega/\partial\mathbf{x} = -\nabla\mathbf{V}\cdot\mathbf{k} - \ell\nabla\Omega$. Thus phase-space ($\mathbf{x}$-$\mathbf{k}$ space) is the natural setting for gyroresonance problems. In this formalism the equations are manifestly Hermitian; dissipation appears only as phase-mixing of the GBWs. We apply this method, together with the theory of linear mode-conversion [2], to the minority fundamental and majority second-harmonic gyroresonant absorption of a magnetosonic wave [3], in a one-dimensional slab model, and obtain simple analytic expressions for the coefficients of transmission, reflection, conversion (to ion-Bernstein wave), and absorption, and for the local absorption profile.

* Work supported by US DOE under contract No. DE-AC03-76SF00098.

[1] H. Ye and A. N. Kaufman, *Phys. Rev. Lett.* **60**, 1642 (1988).

[2] A. N. Kaufman and L. Friedland, *Phys. Lett.* **123A**, 387 (1987); L. Friedland, G. Goldner and A. N. Kaufman, *Phys. Rev. Lett.* **58**, 1392 (1987); L. Friedland and A. N. Kaufman, *Phys. Fluids* **30**, 3050 (1987).

[3] H. Ye and A. N. Kaufman, *Phys. Rev. Lett.* **61**, 2762 (1988); H. Ye and A. N. Kaufman, *LBL-27337* (1989), submitted to *Phys. Rev. Lett.*

Abstract for invited paper at the Thirty-first Annual Meeting of the Division of Plasma Physics, American Physical Society, November 13-17, 1989, Anaheim, CA.

Abstract Submittedfor the Thirty-first Annual Meeting
Division of Plasma Physics
November 13-17 1989

LBL-27455(2)

Category Number and Subject 3.2 Plasma Heating with ICRF
_x_ Theory ____ Experiment

Analytic Theory of Gyroresonant Absorption in Tokamaks*.

ALLAN N. KAUFMAN, HUANCHUN YE and DANIEL R. COOK, *Physics Department and Lawrence Berkeley Laboratory, University of California at Berkeley* – A complete analysis of gyroresonant absorption in the 1-dimensional slab model has been performed, in terms of linear conversion to a continuum of gyroresonant ballistic waves and their phase propagation in k-space [1]. These concepts are now extended to tokamak geometry, where the resonant particles are parameterized by their 3-dimensional action [2] $\mathbf{I} = (\mu, J_b, p_\phi)$. The corresponding ballistic waves (for fundamental gyroresonance) have the dispersion relation

$$\omega(\mathbf{k}, \mathbf{x}; \mathbf{I}) = \Omega(\mathbf{x}) + \mathbf{k} \cdot \mathbf{V}(\mathbf{x}; \mathbf{I}),$$

where $\mathbf{V}$ is guiding-center velocity, and $\mathbf{x}$ is both guiding-center position and wave-packet position. These waves are excited by an incoming magnetosonic wave through linear conversion, propagate by $d\mathbf{k}/dt = -\partial\omega/\partial\mathbf{x}$, and then coherently emit a reflected magnetosonic wave, which is broadened in $\mathbf{k}$-space. The converted Bernstein wave is extracted from the ballistic waves, and the residiuum displays the absorption profile.

[1] Huanchun Ye and Allan N. Kaufman, "Phasing of Gyroresonant Ballistic Waves and Hermitian Solution of the Conversion-Absorption Problem," LBL-27337 (1989), submitted to *Phys. Rev. Lett.*

[2] Allan N. Kaufman, *Phys. Fluids* 15, 1063 (1972).

* This work is supported by US DOE under contract No. DE-AC0376SF00098.

Submitted by:

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LBL-27455(3)

Category Number and Subject 1.1 (General Waves)
x Theory ____ Experiment

Entropy Generation by Incoherent Linear Mode Conversion, E.R. TRACY,* *College of William and Mary, Williamsburg, VA*, and A.N. KAUFMAN,** *Lawrence Berkeley Laboratory, Berkeley, CA.* -- We consider a weakly inhomogeneous plasma which supports at least two distinct wave modes with dispersion functions $D_a(\mathbf{x},t,\mathbf{k},\omega)$ and $D_b(\mathbf{x},t,\mathbf{k},\omega)$. In certain localized regions of the wave phase space $(\mathbf{x},t,\mathbf{k},\omega)$, both dispersion functions can simultaneously vanish, leading to linear mode conversion (e.g., as occurs for Bernstein and magnetosonic waves in tokamaks). Matching conditions which relate the incoming and outgoing wave amplitudes (i.e., the S-matrix) can be derived by metaplectic techniques.[1] If the incoming waves are incoherent, then, although the mode conversion conserves energy, momentum, and action, it acts as a source of wave entropy. Thus the process is irreversible even when the original wave equations are non-dissipative. Incoherent mode conversion should occur if the waves are generated, for example, by instabilities or thermal emission. An H-theorem shows that linear conversion drives the system toward equal action densities of the two modes, i.e., equipartition.

1 A.N. Kaufman and L. Friedland, Phys. Lett. A123 (1987) 387.

* Supported by the Naval Research Lab, Laser Plasma Branch.
** Supported by the U.S. DOE under Contract No. DE-AC03-76SF00098

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LBL-27455(4)

Category Number and Subject 1.11 Laser/Plasma Interactions
x Theory ____ Experiment

A Study of Filamentation Using a Self-consistent Wave-Kinetic Formulation of Wave-Plasma Interactions,* A.J. NEIL, E.R. TRACY, and A.H. BOOZER, *Dept. Physics College of William and Mary, Williamsburg, VA.* -- A 1D simulation of the wave-kinetic model of laser/plasma interactions developed by Tracy and Boozer[1] has been implemented on a CRAY-2. By deriving the relevant equations of motion from an action principle, the model self-consistently couples the laser to the plasma. The advantages of this novel technique for studying wave-plasma interactions over conventional ray-tracing will be described. 2D simulations, and applications (including laser filamentation) will be discussed.

1 E.R. Tracy and A.H. Boozer, to appear Physics Letters A.

* Supported by the Naval Research Laboratory (Laser Plasma Branch).

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LBL-27455(5)

Category Number and Subject 4.12 Physics and Technology of Ion Sources

____ Theory _x_ Experiment

Experimental Study of H^o, $H_2(v'')$, and H^- in the LBL 20-cm diameter Source*, G.C. STUTZIN, A.T. YOUNG, K.N. LEUNG, and W.B. KUNKEL, *Lawrence Berkeley Laboratory, Berkeley, CA 94720* -- The density and temperature of H^o and $H_2(v'', J'')$ in the LBL 20-cm diameter H^- source are measured using VUV absorption spectroscopy. This is done both in the body of the plasma and in the magnetic filter region, as a function of discharge parameters. The extracted H^- current, the species mix of extracted positive ions, and the thermal electron characteristics are also measured. H^- densities are measured by the photodetachment method. The results will be compared with several theoretical models of the H^- formation mechanism. These data provide a better understanding of the kinetic processes related to H^- formation occurring in the discharge.

* Supported by the AFOSR and the Director, Office of Energy Research, Office of Fusion Energy, Development and Technology Division, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

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G.C. Stutzin

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LBL-27455(6)

Abstract Submitted for the Thirty-first Annual Meeting
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November 13-17 1989

Category Number and Subject 4.12 Ion and Plasma Sources
____ Theory _x_ Experiment

Electron Suppression Experiments in a Small Multicusp H^- Source,* W.B. KUNKEL, K.N. LEUNG, C.A. HAUCK, and S.R. WALTHER, *Lawrence Berkeley Laboratory, Berkeley, CA 94720* -- A small 7.5-cm-diam multicusp source has been developed to generate volume-produced H^- beams. At high discharge power, this source is capable of producing H^- current densities >250 mA/cm^2. However, the ratio of electrons to H^- ions in the extracted beam is large and is normally greater than 100. In order to reduce the power dissipated by the electrons on the accelerator electrodes, different schemes for suppressing the electrons before they reach the extraction region have been tested. It is found that some schemes can reduce both the electron and the H^- output currents. Other approaches, such as the installation of a collar at the extraction aperture, the addition of cesium to the hydrogen discharge, or the reduction of the source plasma potential, not only can reduce the electron current substantially, but bring about an enhancement in the extracted H^- current.

* Work is supported by Grumman Corp., USASDC, AFOSR and the U.S. DOE under Contract No. DE-AC03-76SF00098.

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November 13-17 1989

LBL-27455(7)

Category Number and Subject 4.12 Ion and Plasma Sources
____ Theory _x_ Experiment

Some Optimization Experiments on a Small Multicusp H^-/D^- Source,* K.N. LEUNG, C.A. HAUCK, and W.B. KUNKEL, *Lawrence Berkeley Laboratory, Berkeley, CA 94720* -- A small 7.5-cm-diam multicusp source has been developed to generate volume-produced H^- beams. Recently, it was found that the addition of cesium to the hydrogen discharge could greatly enhance the H^- yield. As a result, H^- current densities in excess of 1 A/cm^2 can now be easily obtained. In order to further improve the source efficiency and to reduce the ratio of electron to H^- current, the extraction aperture geometry and the magnetic filter are optimized for H_2 + Cs operation. A comparison between deuterium and hydrogen operation has been made. It is found that the D^- output current is typically 70% that of the H^- ions while the e/D^- ratio is about a factor of three to four higher than the ratio of e/H^-.

Beam current fluctuations can cause emittance growth. We have performed an extensive study of the noise levels of the arc and beam currents in the small multicusp source. It has been observed that position and shape of the tungsten filament and the extraction aperture geometry can greatly affect the level of fluctuations.

* Work is supported by Grumman Corp., USASDC, and the U.S. DOE under Contract No. DE-AC03-76SF00098.

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K.N. Leung

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LBL-27455(8)

Category Number and Subject 4.12 Ion and Plasma Source
____ Theory X Experiment

Optic Design of an Advanced Accelerator for High Current H^- Beam*, C. F. CHAN and A. L. LIETZKE, *Lawrence Berkeley Lab, Berkeley, CA 94720* -- We present an accelerator design which corrects some of the defects of previous accelerator designs for volume produced H^- ions. Particle trajectories from 2-D and 3-D calculations will be shown for an accelerator for 100 kv, 150 ma (delivered) H^- beam that illustrate the following features: 1) small emittance growth form the source aperture to accelerator exit, 2) a trap for extracted electrons that is located far enough from the source so that the magnetic field from the finite-length, movable e-trap magnets do not impede the exit motion of the H^- ions, 3) low heat load at the trap (less than 1 kw/cm^2), and 4) easy adjustment for variable energy and current.

* Supported by USASDC MIPR W31RPD-63-A087 and U.S. DOE Contract No. DE-AC03-76SF00098.

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LBL-27455(9)

Category Number and Subject 4.12 Ion and Plasma Sources
____ Theory _x_ Experiment

Surface-production D^- Ion Source Development at LBL* A.F. LIETZKE, O.A. ANDERSON, W.S. COOPER, W.B. KUNKEL, J.W. KWAN, K.N. LEUNG, and M.D. WILLIAMS, *Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720* -- Recent experiments on D^- produced from a barium surface reported that a conversion efficiency as high as 7.5% ($j_- \approx 60$ mA/cm^2) can be expected.[1] Such an intense D^- beam would be suitable for the ESQ accelerator in the MeV range being developed by LBL for ITER heating and current-drive needs. At LBL we have tested a vapor deposited barium converter with an existing hollow-cathode-generated thin sheet plasma. Additionally, a specially designed bucket with magnetic filter, using LaB_6 or tungsten cathodes, was constructed to produce an intense plasma ($j_+ \approx 250$ mA/cm^2). In the latter case, the 6 cm diameter movable converter is formed by melting barium onto a well-cooled molybdenum substrate. Assuming a 4% conversion efficiency, this source geometry should produce 140 mA of beam in a single channel. Experimental results will be reported.

* Supported by U.S. DOE Contract No. DE-AC03-76SF00098.

1. C.F.A. van Os., L.M. Lea, A.W. Kleyn and J. Los, Bull. Amer. Phy. Soc., 33, p2092, (1988).

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Category Number and Subject 4.12 Ion and Plasma Sources
_____ Theory _x_ Experiment

LBL-27455(10)

Generation of B^+,N^+,Cu^+,and C^- ion beams using a filtered multicusp ion source* - S.R. WALTHER†,K.N. LEUNG, and W.B. KUNKEL, *Lawrence Berkeley Laboratory, Berkeley, CA 94720.* ---A small filtered multicusp ion source has been used to generate positive ion beams of boron, nitrogen, and various metals for ion implantation applications. In the case of boron, BF_3 gas is used to generate boron beams with a $^{11}B^+$ ion fraction of 30% at a total current density of over 100 mA/cm^2 during DC operation. Using nitrogen gas, a N^+ ion fraction of over 98% has been achieved. This result eliminates the need for mass separation of the ion beam during implantation of steels. The source has also been modified to include a sputtering target for production of metal ion beams such as Cu^+. In this case, an argon plasma is used to generate the sputtering ions which strike a negatively biased target plate. C^- ion beams are needed for radioactive ^{14}C dating. A C^- ion beam was extracted from the ion source during operation with CO gas at a low arc voltage. This result was obtained without the use of cesium, which is commonly used for surface generation of negative ions.

† Present Address: Varian/Extrion, Gloucester, MA
* This work is supported by AFOSR and U.S. DOE under Contract #DE-AC03-76SF00098.

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LBL-27455(11)

Category Number and Subject 4.4 Neutral Beams (2nd choice: 3.1)
_____ Theory _x_ Experiment

A Neutral Beam System for Current Drive, Heating, and Burn Control on ITER,* P. PURGALIS, O.A. ANDERSON, W.S. COOPER, G.J. DEVRIES, W.B. KUNKEL, J.W. KWAN, A.F. LIETZKE, L. SOROKA, and R.P. WELLS, *Lawrence Berkeley Laboratory*; R.S. DEVOTO, W.B. LINDQUIST, and L. L. REGINATO, *Lawrence Livermore National Laboratory*; Y. GOHAR, *Argonne National Laboratory*; D. SEDGLEY and J. BROOK, *Grumman Space Systems Division* -- We propose a neutral beam system for ITER for current drive and heating as well as burn control. The system consists of 9 modules, each capable of delivering 10 MW of D^0 atoms at 1.3 MeV to the plasma; three ports are required. The beams can be steered for varying either the plasma current profile or, for burn control, the power deposited in the center of the plasma. The negative ion sources in the present design are surface-conversion sources; the accelerator is a multiple-aperture ESQ accelerator accelerating 0.14 A of D^- ions per channel. The beamlines use gas neutralizers, regenerable cryopumps, and a new design for a compact combination beam deflector and ion dump. The 1.3 MV high voltage supply, driven at ≥50 kHz, is small enough to be integrated with the accelerator, obviating the need for a separate high voltage transmission line and feed-through. The neutron shielding is adequate to permit the use of an epoxy high voltage insulator as well as the use of electronic power supply components in this location.

* Supported by the U. S. DOE, Contract DE-AC03-76SF00098.

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W.S. Cooper

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Category Number and Subject 4.4 Neutral Beams (2nd choice: 3.1)

☐ Theory ☒ Experiment

ITER Current Drive Accelerator using Surface-Produced D^- Beams,* O.A. ANDERSON and L. SOROKA, *Lawrence Berkeley Laboratory*—In order to obtain larger beamlet currents for the ITER neutral beam system than presently available from volume sources, the use of surface D^- production has been proposed. Surface sources produce a large transverse beam temperature which affects the overall design of the acceleration system. We compare computer simulations of 1.3 MeV CCVV accelerators[1] based on both types of sources. With the volume source, only space charge is significant in scaling the ESQ voltages with energy, but with the surface source, both space charge and temperature must be considered. We show that a simple analytic approach to alternating-gradient problems[2] gives excellent results in all situations. We also consider the ITER requirements for beam energy variation at constant current (namely 0.5, 0.75, and 1.0 times maximum energy) and show alternative ways of producing this variation with the CCVV system. Finally, we show how to reduce the transverse beam temperature at the accelerator exit by using a simple ESQ beam telescope.

*Supported by U.S. DOE Contract DE-AC03-76SF00098.
[1]O.A. Anderson, et al., *Nucl. Instrum. and Meth.* B40/41, 877 (1989).
[2]O.A. Anderson, submitted to *Particle Accelerators*.

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LBL-27455(13)

Category Number and Subject 4.4 Neutral Beams (2nd choice: 3.1)
_____ Theory _x_ Experiment

Testing of an ESQ Accelerator for Neutral Beam Injection* J. W. KWAN, G. D. ACKERMAN, O. A. ANDERSON, W. S. COOPER, and G. J. DEVRIES, R. WELLS, L. SOROKA, and W.F. STEELE, *Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720* -- The neutral beam system proposed for heating and current drive on ITER will require an accelerator which can deliver beams with tunable energies in the MeV range. At LBL an electrostatic-quadrupole (ESQ) accelerator is being developed for this purpose. The accelerator is modular (100 kV per module) and designed for dc acceleration of 140 mA of D^- per channel. Using two ESQ modules, we have obtained 45 mA of H^- at 200 keV in a single channel. The amount of beam current is presently limited by the ion source. In our conservative initial testing, we limited the pulse length to 0.5 seconds. Most of the beam loss is due to stripping by the background gas in the preaccelerator stage. Preliminary results on beam transmission through the ESQ modules and emittance growth are encouraging. Quantitative measurements on current accounting, heat load on electrodes, and emittance will be reported.

*Supported by U.S. DOE Contract No. DE-AC03-76SF00098.

Submitted by:

(signature of APS member)
J.W. Kwan

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_x_ This poster/oral should be placed in the following grouping: (specify order)
(1) P. Purgalis et al.;
(2) O.A. Anderson et al.;
(3) J.W. Kwan et al.
(4) W.S. Cooper et al.

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Abstract Submitted for the Thirty-first Annual Meeting
Division of Plasma Physics
November 13-17 1989

LBL-27455(14)

Category Number and Subject 4.4 Neutral Beams (2nd choice: 3.1)
____ Theory _x_ Experiment

Secondary Electron Trajectories in an ESQ Accelerator* W. S. COOPER and L. SOROKA; *Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720*
-- We have used a new computer code to study the trajectories of single particles in a 1 MeV- ESQ accelerator. The code models the accelerator as a series of "hard edged" segments, either accelerating gaps with purely longitudinal electric fields or electrostatic quadrupoles with purely transverse quadrupole fields. The beam space charge is approximated by a cylinder of uniform charge distribution; the radius of the cylinder in each segment is assumed to be known from other calculations, such as an envelope code. The trajectories of single particles are calculated relativistically correctly, but their space charge is neglected. Trajectories of single beam particles calculated by the new code give good agreement with envelope code calculations. An analysis of the trajectories of secondary electrons generated by the beam in a typical accelerator gap shows that 55% stop in the next downstream quadrupole element, 35% in the next gap, and 5% in the second quadrupole element. Less than 0.5% are accelerated to full energy. The mean final energy of the secondary electrons in this case was only 25 keV, so x-ray emission due to secondaries is not likely to be a problem in this type of accelerator.

*Supported by U. S. DOE Contract No. DE-AC03-76SF00098

Submitted by:
William S. Cooper
(signature of APS member)
W.S. Cooper

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HIFAN Note-433
LBL-27455(15)

Category Number and Subject 1. Particle Beam: accelerator or 40. Novel accelerator

☐ Theory ☒ Experiment

Beam Dynamic Studies in the Multiple Beam Experiment MBE-4. *

S. Eylon, T. Fessenden, T. Garvey, and H. Meuth, Lawrence Berkeley Laboratory, 1 Cyclotron Road, Berkeley, CA 94720--

MBE-4 is an experimental multiple beam heavy ion induction accelerator. The device accelerators four 10 mA Cs^+ beams from 200 kV to 900 kV, controlling and amplifying the current up to a factor of nine. In recent experiments we have been investigating the beam dynamics with a gentle acceleration schedule appropriate for a heavy ion driver for inertial confinement fusion. We shall report the results of the measurements of longitudinal and transverse beam dynamic properties using transverse double-slit emittance and position measuring devices, current-sensing Faraday cups and electrostatic energy analysers. Recent experiments have been studying the influence of various accelerator parameters on the quality of the accelerated beams. These include the effects of beam mismatch oscillations caused by focusing errors, source properties, and mechanical misalignments.

* This work was supported by the Director, Office of Energy Research, Office of Basic Energy Sciences, Advanced Energy Projects Division, U.S. Dept. of Energy, under Contract No. DE-AC03-76SF00098.

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Submitted by:

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(Address)

This form, or a reasonable facsimile, plus **TWO XEROX COPIES**, must be received by **NO LATER THAN NOON**, Monday, July 10, 1989 at the following address:

Saralyn Stewart
Institute for Fusion Studies
RLM 11.234
The University of Texas at Austin
Austin, TX 78712
Telephone: (512) 471-4378

Abstract Submitted for the Thirty-first Annual Meeting
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LBL-27455(16)

Category Number and Subject 3.1 Current Drive with Neutral Beams
_x_ Theory ____ Experiment

Scaled cross sections for excitation of atomic hydrogen at neutral-beam injection energies for current drive. J.W. STEARNS and A.S. SCHLACHTER, *Lawrence Berkeley Laboratory, Berkeley, CA 94720*;* R.E. OLSON, *University of Missouri/Rolla, Rolla, MO 65401* -- A single parameterized curve is presented to represent the cross sections $H(n) + X^{q+} \rightarrow H(n') + X^{q+}$ where n and n' are principal quantum numbers of the hydrogen atom and X^{q+} is a plasma ion of charge q^+. The range of parameters over which the curve is valid is: 20 q keV < E < 10 MeV, where E is the beam energy; $1 \leq n < 7$; $n < n' < 25$; $1 \leq q \leq 26$. The curve is:

$$\sigma_{n,n'} = \frac{1\times10^{14} n^3 q^2}{E(\delta^3+\delta^2)\ln(2.7n^{\delta/2})} \ln\left(\frac{\varepsilon n\sqrt{\delta}}{15}+1\right)\left(1-e^{-\left(\frac{\varepsilon-4}{130}\right)^2}\right) \text{ cm}^2/\text{ion}.$$

where $\delta = \Delta n = n'-n$, and $\varepsilon = \frac{E}{q} n^{(1.5\sqrt{\delta})}$. The reverse reaction may be calculated using the principle of detailed balance. The curve will be compared with a selection of theoretically calculated values and with experimental values.

This work was supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

Submitted by:

A. S. Schlachter
(signature of APS member)
A.S. Schlachter

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