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October 7-10, 1980, University of Oklahoma, Norman, Oklahoma

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Electron Collisions	Interhalogen Lasers	Photon Interactions
Breakdown, Corona	Excitation Transfer	Arcs
Glow Discharges	Distribution Functions	Ultraviolet Lasers
Heavy Ion Collisions	Metastable Reactions	Infrared Lasers
Rare Gas Halide Lasers	Attachment	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The program and abstracts of the 33rd Annual Gaseous Electronics Conference held in Norman, Oklahoma October 7-10, 1980 are included. Twenty-one sessions were held and a total of 140 papers were presented. Session titles correspond in part to the Key Words listed in Item 19.

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AFOSR 80-0236

THIRTY-THIRD ANNUAL

G A S E O U S E L E C T R O N I C S C O N F E R E N C E

OCTOBER 7-10, 1980

SPONSORED BY:
University of Oklahoma
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Program

and

Abstracts

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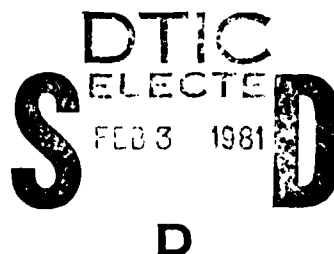C.A. BRAU
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A TOPICAL CONFERENCE OF THE AMERICAN PHYSICAL SOCIETY

ACKNOWLEDGMENTS

THE COVER:

"WOLF WARRIORS"

BY

DAVID WILLIAMS

COURTESY OF

THE GALLERIA

1630 WEST LINDSEY

NORMAN OK 73069

(405) 329-1225

David Williams

David Williams Kiowa-Apache-Tonkawa
has been exhibiting and winning
distinguished awards for his paintings
since 1960 including the Grand Award
at Philbrook Art Center in Tulsa in 1973
He has entered competitions and held
one-man shows all over the
United States

The artist who attended Bacone College
in Muskogee has had his work shown
in nationally distributed magazines
Williams work was also part of the
Vincent Price's Fine Art Exhibition

Gilcrease Museum and Philbrook Art
Center both in Tulsa are just two
of the many museums that have
included a David Williams in their
permanent collection

CONTENTS:

33RD ANNUAL GASEOUS ELECTRONICS CONFERENCE

PROGRAM

MONDAY EVENING   OCTOBER 6, 1980

HOUSING DESK   '   Open 24 hours/day
Sooner House	
REGISTRATION   7:30 - 10:00 P.M.
Forum Building Lobby	
MIXER (CASH BAR)   7:30 - 10:00 P.M.
Corridor A, Forum Building	

Oklahoma Center for Continuing Education
University of Oklahoma
Norman, Oklahoma

SESSION AA ELECTRON COLLISIONS I Chairperson: C.C. Lin, Univ. Wisconsin	9:00 A.M. Room A	SESSION AB BREAKDOWN AND CORONA Chairperson: W.P. Allis, JILA and MIT	9:00 A.M. Room B
AA-1 ELECTRON EXCITATION COEFFICIENTS FOR THE Ne($^3P_2$) AND Ne ($^3P_1$) STATES K. Tachibana and A.V. Phelps	(14 min)	AB-1 EFFECT OF HYDROGEN IMPURITY ON BREAKDOWN AND IONIZATION POTENTIALS FOR Ne-A MIXTURES A.K. Bhattacharya	(7 min)
AA-2 ELECTRON EXCITATION COEFFICIENTS FOR O_2 ($a^1\Delta_g$) METASTABLES IN O_2-Ar MIXTURES K. Tachibana and A.V. Phelps		AB-2 DEVELOPMENT OF OVERVOLTAGE BREAKDOWN AT HIGH GAS PRESSURE E.E. Kunhardt and W.W. Byszewski	(14 min)
AA-3 PRODUCTION OF EXCITED NITROGEN ATOMS BY ELECTRON-IMPACT DISSOCIATION OF N_2 A.R. Filippelli, F.A. Sharpton, C.C. Lin and E.T.P. Lee	(7 min)	AB-3 NANOSECOND-PULSE BREAKDOWN IN GASES AT HIGH OVERVOLTAGES E.E. Kunhardt, S. Levinson and M. Alley	
AA-4 CLOSE-COUPLING CALCULATION OF THE $X^1\Sigma_g^+ \rightarrow B^3\Pi_g$ EXCITATION CROSS SECTIONS OF N_2 BY ELECTRON IMPACT T.K. Holley, S. Chung, C.C. Lin, E.T.P. Lee	(7 min)	AB-4 GASDYNAMIC INTERACTIONS IN A NON-UNIFORM HIGH PRESSURE DISCHARGE J.L. Barto and O. Biblarz	(7 min)
AA-5 THE ELECTRONIC EXCITATION SPECTRUM OF SF_6 C.L. Chen, P.J. Chantry and D.K. Davies	(7 min)	AB-5 PRE-SPARK CHANNEL PHENOMENA IN LASER-TRIGGERED ELECTRICAL BREAKDOWN P.F. Williams, M.A. Gundersen and A. Watson	(7 min)
AA-6 ELECTRON IMPACT MULTIPLE IONIZATION CROSS SECTIONS OF Cs^+ IONS R.K. Feeney and D.R. Hertling	(7 min)	AB-6 ELECTRON DENSITIES IN LASER-TRIGGERED HYDROGEN SPARKS S.K. Dhali, R.J. Crumley, P.F. Williams, E.E. Kunhardt and M.A. Gundersen	(7 min)
AA-7 DISSOCIATIVE IONIZATION BY ELECTRON IMPACT OF VIBRATIONALLY EXCITED OXYGEN B. Evans, R.M. Hobson and Jen-Shih Chang	(7 min)	AB-7 MODEL STUDIES IN POSITIVE POINT-PLANE CORONA M.N. Hirsh and R.P. Abbott	(7 min)
AA-8 TOTAL INELASTIC CROSS SECTION FOR CH_4 PREDICTED FROM SWARM DATA L.E. Kline	(7 min)	AB-8 PULSE CHARACTERISTICS OF POSITIVE DC CORONA IN SF_6: EFFECTS OF TRACE DECOMPOSITION PRODUCTS D.A. Leep and R.J. Van Brunt	(7 min)
AA-9 ELECTRON DEPENDENCE OF THE DISSOCIATIVE RECOMBINATION COEFFICIENTS OF Ne_2^+ AND Ar_2^+ AT ELEVATED GAS TEMPERATURE R.M. Hobson, T. Maruyama, K. Keskinen, Y. Ichikawa, S. Teii, T. Kaneda and Jen-Shih Chang	(7 min)	AB-9 CORONAPHORESIS D.H. Douglas-Hamilton	(7 min)

COFFEE   10:30 - 10:50 A.M.

SESSION BA
ELECTRON COLLISIONS II
Chairperson: N. Steph. Univ. Oklahoma

10:50 A.M.
Room A

BA-1   AUTOIONIZING STATES IN THE IONIZATION
        CONTINUUM OF THE RARE GASES DETERMINED
        FROM NEAR-THRESHOLD ELECTRON IMPACT   (20 min)
        TECHNIQUES
        D. Spence

BA-2   TEMPORARY NEGATIVE ION FORMATION IN
        HALOGENATED ETHYLENES   (7 min)
        P.D. Burrow, A. Modelli, N.S. Chiu and
        K.D. Jordan

BA-3   ELASTIC SCATTERING OF ELECTRONS IN NEON   (7 min)
        M.G. Menendez, J.A. Rees and E.C. Beaty

BA-4   EXCITATION OF THE ASYMMETRIC STRETCH OF
        CO_2 BY ELECTRON IMPACT   (7 min)
        D. Thirumalai, K. Onda and D.G. Truhlar

BA-5   ELECTRON COLLISION QUENCHING OF $CO(v)$
        CHEMILUMINESCENCE IN CS_2/O_2 AND $CS_2/O_2/N_2O$ (7 min)
        FLAMES
        M.J. Kushner, W.M. Grossman and
        F.E.C. Culick

SESSION BB
GLOW DISCHARGES AND BOUNDARY-RELATED PHENOMENA
Chairperson: W.H. Long, Jr., Northrup R&T Ctr

10:50 A.M.
Room B

BB-1   THE DIFFUSION LENGTH FOR POSITIVE COLUMNS
        WITH NONLINEAR ELECTRON PRODUCTION AND   (7 min)
        LOSS RATES
        G. L. Rogoff

BB-2   SCHOTTKY THEORY OF THE POSITIVE COLUMN
        WITH ELECTRON ATTACHMENT   (7 min)
        J.H. Ingold

BB-3   THEORY OF A PLASMA COLUMN SUSTAINED BY
        A SURFACE WAVE   (7 min)
        C.M. Ferreira

BB-4   ELECTRODE SHEATH PREDICTIONS FOR
        ATTACHING GAS MIXTURES   (7 min)
        R.R. Mitchell, L.E. Kline and L.J. Denes

BB-5   I-V CHARACTERISTICS OF EXTERNALLY
        IONIZED PLASMAS IN PURE GASES   (7 min)
        P. Bletzinger

BB-6   FLUCTUATIONS IN GLOW DISCHARGE PARAMETERS
        IN NOBLE GASES   (7 min)
        W.G. McNaught and T.A. King

BB-7 O_2 DISSOCIATION MECHANISMS IN
        Ar + O_2 RF SPUTTERING DISCHARGE   (7 min)
        Y. Chouan, D. Collobert and A. Ricard

LUNCH   12:00 - 1:30 P.M.

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TUESDAY AFTERNOON/EVENING

SESSION C: GLOW DISCHARGES   Chairperson: D. Pigache, ONERA, France   1:30 P.M., Forum Room

C-1 EXPERIMENTAL AND THEORETICAL INVESTIGATION OF THE OPTOGALVANIC EFFECT IN THE HELIUM POSITIVE COLUMN   (20 min)
     J.E. Lawler

C-2 RESONANT SPECTROSCOPIC INVESTIGATIONS OF A GLOW DISCHARGE IN HELIUM   (7 min)
     H. Odenthal and J. Uhlenbusch

C-3 MEASUREMENT OF GLOW DISCHARGE PLASMA BY SELF-ABSORPTION METHOD UNDER A PLASMA NON-UNIFORMITY CONDITION   (7 min)
     Y. Ichikawa, R.M. Hobson, T. Maruyama and S. Teii

C-4 THE RADIAL DENSITY DISTRIBUTION AND ELECTRON TEMPERATURE IN A MEDIUM PRESSURE NEON POSITIVE COLUMN   (7 min)
     J.S. Chang, T. Maruyama, R.M. Hobson, Y. Ichikawa and S. Teii

C-5 METASTABLE ATOM DENSITY MEASUREMENT IN A Ne-Ar GAS MAXTURE POSITIVE COLUMN PLASMA   (7 min)
     T. Maruyama, Y. Ichikawa, R.M. Hobson and S. Teii

C-6 BASIC KINETIC PROCESSES IN NEON GAS DISCHARGE DISPLAYS   (7 min)
     W.L. Nighan and W.J. Wiegand

C-7 ULTRAVIOLET FLUORESCENCE FROM THE HgCl($D^2\Pi_{3/2}$) STATE IN A PULSED DISCHARGE OF $HgCl_2$ AND NEON   (7 min)
     S.G. Johnson and J.M. Proud

SESSION D   3:15 P.M.
WORKSHOP ON ELECTRON SCATTERING WITH EMPHASIS ON LASER APPLICATIONS
Chairperson: D. Spence, Argonne National Laboratory   Forum Room

This workshop will include theoretical and experimental discussions on electron scattering from atoms, molecules and
clusters. Both ground states and vibrationally and electronically excited state targets will be considered. Pro-
cesses discussed will include vibrational excitation, electronic excitation and de-excitation, dissociative attach-
ment, and absolute total scattering cross sections. Specific systems will include hydrogen halides and rare gas
halides.

D-1 INTRODUCTION -- D. Spence

D-2 SHAPE RESONANCES, VIBRATIONAL EXCITATION AND DIPOLE FIELDS IN ELECTRON-MOLECULE SCATTERING
     J.L. Dehmer

D-3 DISSOCIATIVE ATTACHMENT FROM EXCITED MOLECULES -- S.F. Wong

D-4 THEORETICAL STUDIES OF ELECTRON COLLISIONS IN ELECTRONIC TRANSITION LASERS -- A.U. Hazi

D-5 DETERMINATION OF ABSOLUTE ELECTRON-IMPACT CROSS SECTIONS -- S. Trajmar

D-6 COMPOUND STATES IN ATOMS, MOLECULES, AND CLUSTERS -- R.N. Compton

8:15 P.M.   Wind Ensemble Concert: Jacob Larson, Director.
             Holmberg Hall, Main Campus. No admission charge.

SESSION EA	9:00 A.M.
HEAVY PARTICLES I	Room A
Chairperson: R. Johnsen, Univ. Pittsburgh	

EA-1 DRIFT TUBE STUDIES OF ION-NEUTRAL REACTIONS
  W. Lindinger (20 min)

EA-2 SILICON ION CHEMISTRY IN THE IONOSPHERE
  D.W. Fahey, E.E. Ferguson, D.L. Albritton and F.C. Fehsenfeld (7 min)

EA-3 REACTIONS STUDIES OF MAGNESIUM IONS
  B.R. Rowe, D.W. Fahey, A.A. Viggiano, D.L. Albritton, E.E. Ferguson and F.C. Fehsenfeld (7 min)

EA-4 REACTIONS BETWEEN NEUTRALS CLUSTERED ON IONS
  B.R. Rowe, A.A. Viggiano and F.C. Fehsenfeld (7 min)

EA-5 COLLISIONAL DETACHMENT OF $He^-(^4P)$ BY VARIOUS GASES FROM 500 TO 4000 EV
  M.J. Coggiola and R.V. Hodges (7 min)

EA-6 COLLISIONAL DISSOCIATION OF NEGATIVE CLUSTER IONS FORMED IN N_2O/H_2O GASEOUS MIXTURES
  R.L.C. Wu and T.O. Tiernan (7 min)

EA-7 FEATURES OF O^- DETACHMENT IN GAS MIXTURES STUDIED BY A NON-STATIONARY METHOD
  C. Doussot, F. Bastien, E. Marode and J. Moruzzi (7 min)

SESSION EB	9:00 A.M.
RARE GAS HALIDE LASERS	Room B
Chairperson: K.Y. Tang, SRI International	

EB-1 ACCESSIBILITY OF THE $KrF^*(B)$ STATE TO LASER PHOTONS
  J.H. Jacob, D.W. Trainor, M. Rokni and J.C. Hsia (7 min)

EB-2 STUDY OF THE KrF LASER MEDIUM AT HIGH E-BEAM PUMP RATE
  C.B. Edwards, F. O'Neill and M.J. Shaw (7 min)

EB-3 LONG PULSE U.V. AND I.R. LASER EMISSION FROM A LOW TEMPERATURE HIGH DENSITY SUPERSONIC FLOW EXCITED BY AN ELECTRON BEAM STABILIZED DISCHARGE
  B. Forestier and B. Fontaine (7 min)

EB-4 THE USE OF COMPUTER MODELING TO OPTIMIZE DISCHARGE CONDITIONS IN EXCIMER LASERS
  W.L. Willis, A.E. Greene, C.R. Tallman and L.A. Holdridge (7 min)

EB-5 PULSE FORMING NETWORKS FOR HIGH PRESSURE DISCHARGES
  W.H. Long, Jr. (7 min)

EA-6 THE INFLUENCE OF DILUENT GAS ON THE ArF^* FLUORESCENCE YIELD
  R.S.F. Chang (7 min)

COFFEE   10:10 - 10:40 A.M.

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OCTOBER 8, 1980

SESSION FA
HEAVY PARTICLES II
Chairperson: G.A. Parker, Univ. Oklahoma

10:45 A.M.   Room A

FA-1 THE STABILITY OF DOUBLY CHARGED RARE GAS MOLECULAR IONS (7 min)
D.L. Huestis, H. Helm, K. Stephan and T.D. Mark

FA-2 REACTIONS OF CO_2^{++} AT THERMAL ENERGIES (7 min)
A.S.M. Raouf, J.D.C. Jones, K. Birkinshaw and N.D. Twiddy

FA-3 SELECTIVE FORMATION OF $He^+(n=3)$ IN $He^{++}-Li$ COLLISIONS (7 min)
J.L. Barrett and J.J. Leventhal

FA-4 ELECTRON TRANSFER IN COLLISIONS BETWEEN PROTONS AND PHOTOEXCITED Na(3p) (7 min)
C.E. Burkhardt, V.S. Kushawaha and J.J. Leventhal

FA-5 CHARGE TRANSFER PROCESSES DURING N^+ COLLISIONS (7 min)
C.R. Szmanda, R.S. Hozack and K.B. McAfee, Jr.

FA-6 CHARGE TRANSFER AND SPIN CHANGE IN $Ar^+ + Ar$ (7 min)
R.E. Johnson, E. Sieveka and K.B. McAfee

FA-7 FOUR-BODY CONVERSION OF ATOMIC HELIUM IONS (7 min)
C.P. deVries and H.J. Oskam

FA-8 ISOTOPE EFFECTS IN THE REACTIONS OF RARE GAS IONS WITH ISOTOPIC HYDROGEN (7 min)
A. Pizam, I. Dotan and F.S. Klein

SESSION FB
XENON-CHLORIDE LASERS
Chairperson: D. Klimek, AVCO Everett Res. Lab.

10:30 A.M.   Room B

FB-1 STUDY OF $XeCl/Xe_2Cl$ EXCITED STATE KINETICS USING SYNCHROTRON RADIATION EXCITATION (20 min)
K.Y. Tang, D.C. Lorents, R.L. Sharpless, D.L. Huestis, D. Helms, M. Durrett and G.K. Walters

FB-2 ELECTRON BEAM-PUMPING OF XeCl USING VARIABLE CURRENT DENSITY (7 min)
H.T. Powell and R.J. Poli

FB-3 KINETICS OF E-BEAM EXCITED XeCl (7 min)
W.L. Morgan and M.J. Pound

FB-4 XeCl LONG PULSE LASER KINETICS MODEL (7 min)
L.A. Levin, S.E. Moody, E.L. Klosterman, J.J. Ewing and R.E. Center

FB-5 LONG PULSE (200 NSEC) AVALANCHE DISCHARGE EXCIMER LASER OPERATION (7 min)
J. Levatter and Shao-Chi Lin

FB-6 THEORETICAL MODELLING OF DISCHARGE KINETICS IN TRANSMISSION LINE DRIVEN EXCIMER LASERS (7 min)
Yuh-Shuh Wang and Shao-Chi Lin

FB-7 EXPERIMENTAL AND THEORETICAL PERFORMANCE CHARACTERISTICS OF AN X-RAY PREIONIZED, 100 NS DISCHARGE XeCl LASER (7 min)
B.L. Wexler and L.J. Palumbo

LUNCH   12:00 - 1:30 P.M.

SESSION G: MERCURY BROMIDE AND INTERHALOGEN LASERS   1:30 P.M., Forum Room
Chairperson: R. Wexler, Naval Research Laboratory

G-1 SPECTROSCOPY, KINETICS AND LASER ACTION IN INTERHALOGEN MOLECULES   (20 min)
     M. Diegelmann, H.P. Grieneisen, F. Rebentrost and K.L. Kompa

G-2 ICl AND IF E STATE RADIATIVE LIFETIMES AND QUENCHING RATE CONSTANTS   (7 min)
     M.L. Dlabal, S.B. Hutchison and J.G. Eden

G-3 LASING CHARACTERISTICS OF IODINE-MONOFLUORIDE -- R.J. DeYoung   (7 min)

G-4 IF BLUE-GREEN LASER -- M.L. Dlabal, S.B. Hutchison, J.G. Eden and J.T. Verdeyen   (7 min)

G-5 OPTICAL AND ELECTRICAL CHARACTERISTICS OF E-BEAM IONIZED $HgBr_2$ DISSOCIATION LASERS   (7 min)
     R. Burnham and W.T. Whitney

G-6 INVESTIGATION OF HgBr* EXCITATION BY X-RAY SUSTAINED DISCHARGE IN $Xe/HgBr_2$ MIXTURES   (7 min)
     J. Degani, M. Rokni and S. Yatsiv

G-7 EFFICIENT HgBr(B→X) LASER OSCILLATION IN E-BEAM CONTROLLED DISCHARGE EXCITED $Xe/HgBr_2$ MIXTURES   (7 min)
     R.T. Brown and W.L. Nighan

G-8 SMALL SIGNAL GAIN, FLUORESCENCE AND ENERGY DEPOSITION IN AN $HgBr_2/HgBr$ DISSOCIATION LASER   (7 min)
     T.M. Shay, F. Hansen, M.C. Jordan, D. Gookin and E.J. Schimitschek

SESSION H: WORKSHOP ON KINETIC PROCESSES IN ELECTRONIC TRANSITION LASERS   3:00 - 5:30 P.M.
Chairperson: H.T. Powell, Lawrence Livermore Laboratory   Forum Room

This workshop will focus on recent experimental and analytical work in understanding important kinetic mechanisms
leading to the formation of upper states of rare gas halide and mercury halide lasers. Ionic and neutral formation
channels will be discussed in the context of electron beam and discharge-excited laser devices.

H-1 NEUTRAL REACTIONS INVOLVING RARE GAS HALIDE MOLECULES -- D. Setser   (15 min)

H-2 CHARGE TRANSFER PROCESSES IN RARE GASES -- C. Collins   (15 min)

H-3 ELECTRON IONIZATION RATES IN ELECTRICAL DISCHARGE LASERS -- K. Nygaard (15 min)

H-4 KINETIC PROCESSES IN SELF-SUSTAINED RARE GAS HALIDE AND MERCURY HALIDE LASERS -- R. Burnham   (15 min)

H-5 MODELING OF DISCHARGE-EXCITED RARE GAS HALIDE LASERS -- A. Greene   (15 min)

H-6 MODELING OF ELECTRON-BEAM-EXCITED, SHORT-PULSE KrF LASERS -- D. Klimek (15 min)

          A general discussion will follow the final presentation.

EVENING OUTING   5:30 - 5:45 Bus loading for trip to COWBOY HALL OF FAME AND WESTERN HERITAGE CENTER.

A barbeque dinner will be served at the Cowboy Hall at 6:45. Following dinner we will be given a private showing
of the collection. Return buses will load from 9:00 to 10:00 p.m.

SESSION I: EXCITATION TRANSFER   Chairperson: G. Salamo, Univ. Arkansas   9:00 A.M., Forum Room

I-1 LASER-INDUCED COLLISIONAL ENERGY TRANSFER -- G.A. Parker and J.C. Light   (12 min)

I-2 ENERGY POOLING IN Na(3p)-Na(3p) COLLISIONS -- V.S. Kushawaha and J.J. Leventhal (7 min)

I-3 MEASUREMENT OF THE COLLISIONAL DE-EXCITATION RATE COEFFICIENT OF $He_2(d^3\Sigma_u^+)$ WITH $He(1^1S)$ (7 min)
     J.W. Parker, L.W. Anderson, W.A. Fitzsimmons and C.C. Lin

I-4 TEMPERATURE DEPENDENCE OF THE RATE CONSTANTS FOR THE THREE BODY QUENCHING REACTIONS   (7 min)
     IN THE KrF* LASER SYSTEM
     D. Klimek and J. Hsia

I-5 VIBRATIONAL RELAXATION OF NO(v=1-8) CREATED IN ELECTRON IRRADIATED N_2/O_2 MIXTURES (7 min)
     B.D. Green, G.E. Caledonia and R.E. Murphy

COFFEE   9:50 - 10:10 A.M.

SESSION JA   10:10 A.M.
DISTRIBUTIONS AND TRANSPORT PROPERTIES   Room A
Chairperson: J. Ingold, General Electric

JA-1 EXTENDED BOLTZMANN ANALYSIS APPLIED   (20 min)
      TO ELECTRON SWARM EXPERIMENTS IN N_2
      L.C. Pitchford and A.V. Phelps

JA-2 ENHANCED ELECTRON CONDUCTIVITY IN RAMSAUER
      GASES - MOLECULAR GAS MIXTURES: ABSOLUTE   (7 min)
      INELASTIC CROSS-SECTION CALIBRATION
      A. Garscadden, G.A. Duke and W.F. Bailey

JA-3 COMPLEMENTARITY THEOREM FOR POSITION-   (7 min)
      DEPENDENT ELECTRON VELOCITY DISTRIBUTIONS
      P.J. Chantry

JA-4 BEHAVIOR OF TOWNSEND'S α/N AT HIGH E/N   (7 min)
      M. Hayashi

JA-5 NON-LTE PLASMA RECOVERY   (7 min)
      G. Ecker

JA-6 MICROWAVE INTERACTIONS OF ELECTRONS   (7 min)
      IN GLOW DISCHARGES
      F.T. Wu and C. Roberts

JA-7 MICROWAVE MEASUREMENTS ON A NEON PLASMA   (7 min)
      INDUCED BY A PROTON BEAM
      M. Fitaire, J. Margot, A.M. Pointu
      and M. Vialle

SESSION JB   10:20 A.M.
METASTABLE REACTIONS   Room B
Chairperson: D. Fahey, NOAA, ERG

JB-1 QUENCHING OF NEON METASTABLE ATOMS   (7 min)
      IN PURE NEON AFTERGLOWS
      J. Clark and A.J. Cunningham

JB-2 ENERGY TRANSFER PROCESSES IN   (7 min)
      HELIUM-COPPER AFTERGLOWS
      D.W. Ernie and H.J. Oskam

JB-3 PENNING IONIZATION OF Sr IN   (7 min)
      OPTOGALVANIC EFFECT
      R. Shuker, A. Ben-Amar, G. Erez, E. Miron

JB-4 THERMAL-ENERGY REACTIONS OF METASTABLE   (7 min)
      $O^+(^2D)$ IONS WITH O_2, N_2 AND H_2
      R. Johnsen and M.A. Biondi

JB-5 REACTIONS OF O^{2+} GROUND-STATE AND   (7 min)
      METASTABLE IONS WITH He, O_2 AND N_2
      R. Johnsen and M.A. Biondi

JB-6 EXCITATION OF THE HYDROGEN CONTINUUM   (7 min)
      IN COLLISIONS OF $Ar(^3P_0)$ WITH H_2
      C.R. Lishawa, W. Allison and
      E.E. Muschlitz, Jr.

JB-7 PRESSURE STUDIES OF $O_2(^1\Delta)$ PRODUCTION   (7 min)
      IN ELECTRICAL DISCHARGES
      T.R. Dooling, M. Zediker, J. Anderson,
      S. Nagalingam and G.H. Miley

BUSINESS MEETING   11:40 - 12:00, Room A

LUNCH   12:00 - 1:30 P.M.

SESSION KA: ATTACHMENT	1:30 P.M.	SESSION KB: PHOTON INTERACTIONS	1:30 P.M.
Chairperson: T. Miller, Univ. Oklahoma	Room A	Chairperson: H. Helm, SRI International	Room B

KA-1 BASIC PROCESSES IN CO2 LASER PLASMAS (7 min)
R.A. Sierra, S.R. Foltyn, H.L. Brooks,
M.C. Cornell and K.J. Nygaard

KA-2 ATTACHMENT AND IONIZATION IN HgBr2 (7 min)
W.J. Wiegand and L.R. Boedeker

KA-3 ELECTRON TRANSPORT COEFFICIENTS IN
GAS MIXTURES CONTAINING HgBr2 (7 min)
H.L. Brooks, R.A. Sierra, E. Weigold
and K.J. Nygaard

KA-4 MEASUREMENTS OF THE RATE COEFFICIENT FOR
ATTACHMENT OF THERMAL ELECTRONS TO SF6 (7 min)
R.W. Crompton, A.G. Robertson,
K. Nygaard and R. Hegerberg

KA-5 ABSTRACT WITHDRAWN

KA-6 MEASUREMENTS OF ELECTRON TRANSPORT, ATTACH-
MENT, AND IONIZATION IN HC1 (7 min)
D.K. Davies

KA-7 GROUND STATE ELECTRONIC ATTACHMENT RATES
IN HC1 (7 min)
R.C. Sze and A.E. Greene

KA-8 ELECTRON ATTACHMENT TO HALOCARBONS
I. Szamrej, D.L. McCorkle, L.G. (7 min)
Christophorou and S.M. Spyros

KB-1 STATE-SELECTIVE PHOTOLYSIS OF Cs2 AND CsKr
C.B. Collins, F.W. Lee, H. Golnabi, (12 min)
P. Vicharelli, D. Popescu and I. Popescu

KB-2 ABSORPTION PROFILES FOR TRANSITIONS TO
SODIUM RYDBERG LEVELS PERTURBED BY HIGH
CONCENTRATIONS OF ARGON (7 min)
D. Krebs and L.D. Schearer

KB-3 UV MULTIPHOTON IONIZATION OF Xe AND
SEVERAL SMALL MOLECULES AT 193 AND 248 NM (7 min)
R.V. Hodges, L.C. Lee and J.T. Moseley

KB-4 OII AND NII BRANCHING RATIOS IN THE EUV (7 min)
M.D. Morrison and A.J. Cunningham

KB-5 RADIATIVE LIFETIME MEASUREMENTS OF THE
4p5P, 4p3P AND 4d5D° MULTIPLETS OF OXYGEN (7 min)
R.-L. Day, R.J. Anderson and G.J. Salamo

KB-6 WIDE RANGE ABSOLUTE MAGNITUDE PHOTO-
DETACHMENT SPECTRUM OF O3̄
S.B. Woo, E.M. Helmy, P. Mauk (14 min)
and A. Paszek

KB-7 GAS PHASE STRUCTURE CONSTANTS OF NO2̄ (7 min)
S.B. Woo, D. Koon, W. Clodius,
E.M. Helmy and N.K. Kang

KB-8 ZERO CORE-CONTRIBUTION CALCULATION OF
THE PHOTO-DETACHMENT OF HETERONUCLEAR
DIATOMIC MOLECULES (7 min)
W.B. Clodius, R.M. Stehman and S.B. Woo

OPEN HOUSE: 3:30 P.M.
DEPARTMENT OF PHYSICS AND ASTRONOMY, Main Campus
SEVERE STORMS LABORATORY (NOAA), North Campus
DEGOLYER HISTORY OF SCIENCE COLLECTION, University Library, Main Campus
FRED JONES ART CENTER, Main Campus
STOVALL MUSEUM OF SCIENCE AND HISTORY, Main Campus

SOCIAL HOUR: 6:30 P.M.   Commons Restaurant, Oklahoma Center for Continuing Education

BANQUET: 7:30 P.M.   Commons Restaurant, Oklahoma Center for Continuing Education
GUEST SPEAKER: Professor Duane H. Roller, McCasland Professor of History,
Curator of DeGolyer History of Science Collection
Topic: "Classical' Classical Physics"

SESSION LA
ARCS I   9:00 A.M.
                                          Room A
Chairperson: A.K. Bhattacharya, General Electric

LA-1 OPTO-GALVANIC SPECTROSCOPY AND THERMAL
      RELAXATION IN HIGH-PRESSURE MERCURY
      AND SODIUM ARC DISCHARGES   (7 min)
      W.J. van den Hoek and J.A. Visser

LA-2 PROPERTIES OF HIGH-PRESSURE SODIUM ARCS
      AT FREQUENCIES ABOVE 50 HZ   (7 min)
      J.W.F. Dorleijn and
      R.L.A. van der Heijden

LA-3 CALCULATIONS OF RADIATION TRANSPORT AND
      TEMPERATURE PROFILE IN A METAL HALIDE
      LAMP CONTAINING SODIUM   (7 min)
      B.F. Jones and D.A.J. Mottram

LA-4 ON MODELING VERTICAL HIGH PRESSURE ARCS
      WITH AXIAL SEGREGATION OF ADDITIVES   (7 min)
      R.J. Zollweg and D.K. McLain

LA-5 ACOUSTIC RESONANCES IN HIGH PRESSURE
      MERCURY DISCHARGES   (7 min)
      R. Schafer and H.-P. Stormberg

LA-6 PHASE DEPENDENT PLASMA TEMPERATURE AND
      ELECTRICAL CONDUCTIVITY FOR INTERMEDIATE
      PRESSURE SODIUM ARCS   (7 min)
      E.F. Wyner and W.M. Keeffe

LA-7 VOLTAGE-CURRENT RELATIONSHIP FOR
      PULSED ARC DISCHARGES   (7 min)
      P. Walsh, W. Lama and T. Hammond

SESSION LB
ULTRAVIOLET LASERS   9:00 A.M.
                                           Room B
Chairperson: S.G. Leslie, Westinghouse R&D

LB-1 DETERMINATION OF THE EXCITATION KINETICS
      OF ArH*   ⎫
      J. Shmulovich and S. Yatsiv   ⎬ (20 min)

LB-2 RECOMBINATION SPECTRUM IN X-RAY   ⎭
      PHOTOIONIZED XENON AND Hg-VAPOUR
      J. Degani and S. Yatsiv

LB-3 A GAIN PREDICTION FOR A HELIUM, NITROGEN
      SYSTEM BASED ON RADIATIVE COLLISIONS   (7 min)
      L.W. Downes, J.D. Kinne, S.D. Marcum,
      R.A. Tilton and W.E. Wells

LB-4 TRANSIENT ABSORPTION IN ARGON AND
      NEON FROM 2500 Å to 3700 Å   (7 min)
      L.F. Champagne, L.J. Palumbo
      and R.S.F. Chang

LB-5 LONG-PULSE N2 UV LASERS AT 357.7, 380.5
      AND 405.9 NM IN N2/Ar/Ne/He MIXTURE   (7 min)
      M.S. Chou and G.A. Zawadzkas

LB-6 PLASMA SHIELDING EFFECTS ON IONIC
      RECOMBINATION   (12 min)
      W.L. Morgan, B.L. Whitten
      and J.N. Bardsley

COFFEE 10:10 - 10:30 A.M.

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SESSION MA ARCS II Chairperson: H. Mercure, IREQ, Quebec	10:30 A.M. Room A	SESSION MB INFRARED LASERS Chairperson: A. Garscadden, Aero Propulsion Lab	10:30 A.M. Room B
MA-1 POTENTIAL PROBE MEASUREMENTS IN A BUTT-ELECTRODE VACUUM ARC WITH A TRANSFERSE MAGNETIC FIELD C.P. Scheffler, R. Dollinger, J. Sullivan and C. King	(7 min)	MB-1 FISSION FRAGMENT LASING OF Ar-Xe R.J. DeYoung and M.D. Williams	(7 min)
MA-2 CLUSTERING OF VACUUM ARC CATHODE SPOTS L.P. Harris	(7 min)	MB-2 STEADY-STATE NUMERiCAL SOLUTIONS OF COMPLEX PLASMA CHEMISTRY MODELS G.L. Jones, M.A. Prelas and S.K. Loyalka	(7 min)
MA-3 EFFECT OF MAGNETIC FIELD ON TRANSPORT COEFFICIENTS OF PLASMA MAINTAINED BY CW CO_2 LASER J. Kurzyna	(7 min)	MB-3 THEORETICAL ANALYSIS OF A POTENTIAL ELECTRICALLY PUMPED OXYGEN-IODINE LASER D. Pigache, J. Bonnet, D. David and G. Fournier	(7 min)
MA-4 ARCS IN HIGH SPEED FLOWS T.F. Bernecki, Y.C. Lau and D.M. Benenson	(7 min)	MB-4 KINETIC MODELING OF FAST-AXIAL-FLOW CO_2 EDL'S R.E. Beverly III	(7 min)
MA-5 POWER LOSSES FROM A DC SF_6 ARC IN GAS FLOW Y. Chien and A. Lee	(7 min)	MB-5 PLASMA KINETIC EFFECTS OF THE ADDITION OF OXYGEN TO CO LASER DISCHARGES G.A. Murray and A.L.S. Smith	(7 min)
MA-6 EXPERIMENTAL DETERMINATION OF THE POPULATION DENSITIES OF THE Ar 3p54p-3p54s STATES IN THE NON-EQUILIBRIUM REGION OF A FLUID TRANSPIRATION ARC H.J. Daams, C.G. Stojanoff	(7 min)	MB-6 HIGH FREQUENCY OPTO-GALVANIC LASER STABILISATION A.L.S. Smith and S. Moffatt	(7 min)
MA-7 PLASMA JET MOMENTUM IN A TIP-PLANE ARC CONFIGURATION J. Converti, W.C. Unkel	(7 min)	MB-7 VIBRATIONAL TEMPERATURE OF $N2X^1\Sigma_g^+$ STATE IN A WEAKLY IONIZED NITROGEN PLASMA S. Ono and S. Teii	(7 min)
MA-8 ELECTRIC ARC RADIUS AND CHARACTERISTICS Ta-Ming Fang	(7 min)		

ADJOURN   12:00 NOON

SESSION AA
9:00 A.M., TUESDAY, OCTOBER 7, 1980
ROOM A

ELECTRON COLLISIONS I

CHAIRPERSON: C. C. LIN
                UNIVERSITY OF WISCONSIN

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AA-1 Electron Excitation Coefficients for the Ne($^3P_2$) and Ne($^3P_1$) States.* - K. TACHIBANA** and A. V. PHELPS+, JILA, U. of Colorado and NBS. -- Excitation coefficients for the $^3P_2$ and $^3P_1$ states of Ne have been measured by combining electron drift tube and laser absorption techniques. The drift tube[1] is fitted with mirrors to obtain a $\sim$2 m absorption path. The dye laser ($\sim$200 MHz width) could be scanned or locked to the peak of the absorption profile. Steady-state absorption of the 588.2 and 614.3 nm lines varied from 0.05 to 4% and the $^3P_2$ density from 10^{12} to 10^{14} m^{-3}. $^3P_2$ excitation coefficients per unit distance and per atom varied from 7×10^{-24} m^2 at $E/N = 2\times10^{-21}$ V m^2 to 7×10^{-22} m^2 at $E/N = 2.5\times10^{-19}$ V m^2, i.e., from 30 to 15% of our calculated total excitation coefficients. Excitation coefficients for the Ne($^3P_1$) resonance state measured using the 609.6 nm line are about 15% of calculated excitation coefficients.

AA-2 Electron Excitation Coefficients for $O_2(a^1\Delta_g)$ Metastables in O_2-Ar Mixtures,* - K. TACHIBANA** and A. V. PHELPS+, JILA, U. of Colorado and NBS. -- Excitation coefficients for $O_2(a^1\Delta_g)$ metastables have been determined from the 1.27 µm emission from an electron drift tube.[1] The mixtures contained 1 to 5% O_2 in Ar at total densities from 10^{24} to 2×10^{25} m^{-3}. Maximum 1.27 µm signals at the intrinsic-Ge detector were 10^{-10} to 10^{-8} W/m^2. 1.27 µm transients yield a diffusion coefficient-gas density product of 2.8×10^{20} m^{-1} sec^{-1} and collisional destruction coefficients of 1.6×10^{-24} m^3/sec for O_2 and 2.8×10^{-26} m^3/sec for Ar. Experimental excitation coefficients for 1% O_2 and 3×10^{-22} < E/N < 10^{-20} V m^2 are about 130% of calculations using our O_2 cross sections[1] and recent Ar momentum transfer cross sections.[2] Cascading from higher O_2 states was assumed to be 100% efficient. For 5% O_2 and 6×10^{-22} < E/N < 10^{-20} V m^2 the experimental coefficients are 60-80% of calculations.

AA-3   Production of Excited Nitrogen Atoms by Electron-Impact Dissociation of N_2.[*]   A. R. FILIPPELLI, F. A. SHARPTON,[†] CHUN C. LIN, U. of Wisconsin-Madison, and EDWARD T. P. LEE, Air Force Geophysics Laboratory-- Production of excited nitrogen atoms in the ^4S, ^4P, ^4D, ^4F, ^2P, ^2D terms of the $2p^23p$, $2p^23d$, $2p^24d$, and $2p^23p'$ configurations by electron-impact dissociation of N_2 is studied by measuring the optical excitation functions of emission lines of the types $3p{\to}3s$, $3d{\to}3p$, $4d{\to}3p$, $3p'{\to}3s'$. The peak values of the optical cross sections (term-to-term) are generally within the range of 3×10^{-18} to $7\times10^{-20}cm^2$.   The excitation functions exhibit a broad maximum at 90 eV with a structure at about 35 eV suggestive of two distinct mechanisms for producing the excited atoms. We have characterized the nature of the excited electronic states of N_2 that are mainly responsible for the dissociation process, and used them to explain the key features of the excitation functions at low energies.

AA-4   Close-coupling Calculation of the $X^1\Sigma_g^+ \to B^3\Pi_g$ Excitation Cross Sections of N_2 by Electron Impact.[*] THOMAS K. HOLLEY, SUNGGI CHUNG, CHUN C. LIN, U. of Wisconsin-Madison, and EDWARD T. P. LEE, Air Force Geophysics Lab.--Theoretical calculations for the $X^1\Sigma_g^+ \to B^3\Pi_g$ excitation cross sections of the nitrogen molecule by electron impact have been performed by using the close-coupling method and R-matrix method. All the direct- and exchange-potential terms are computed in an ab initio manner by means of the Gaussian technique. The scattered-wave functions are constrained to be orthogonal to all orbitals of the target N_2 states, and allowance has been made for terms corresponding to the negative ion $N_2^-(^2\Pi_g)$. The computed cross sections are substantially enhanced by inclusion of the $N_2^-(^2\Pi_g)$ terms.

AA-5 The Electronic Excitation Spectrum of SF_6. C.L. CHEN, P.J. CHANTRY and D.K. DAVIES, Westinghouse R&D Center.--The large attachment cross section for very low energy electrons in SF_6 provides the basis of the electron scavenger technique[1] for studying threshold electron impact excitation spectra. By measuring the SF_5^- signal as a function of electron energy and pressure the technique is applied here to SF_6 itself, the relevant spectrum being identified by its p^2 dependence. Peaks are observed at 11.4, 13.3, and 14.7 eV, corresponding to previously reported electron impact energy loss spectra.[2,3] In addition, a weaker band at $\sim$6 eV is detected, corresponding to an excitation cross section approximately a factor of five smaller than the higher energy processes. Weak optical absorption has been reported[4] in this region, but from a separate optical absorption experiment we place an upper limit of 4×10^{-24} cm^2 on the absorption cross section at 2175 Å.

[1] R.K. Curran, J. Chem. Phys. 38, 780 (1963).
[2] J.A. Simpson et al., J. Chem. Phys. 44, 4403 (1966).
[3] S. Trajmar and A. Chutjian, J. Phys. B: Atom, Molec. Phys. 10, 2943 (1977).
[4] T.K. Lin et al., J. Chem. Phys. 19, 71 (1951).

AA-6 Electron Impact Multiple Ionization Cross Sections of Cs^+ Ions.* R.K. FEENEY and D.R. HERTLING, Georgia Institute of Technology.--Absolute cross sections for the electron impact double, triple and quadruple ionization of Cs^+ ions have been experimentally determined as a function of incident electron energy from below threshold to approximately 5000 eV. The measurements were accomplished with a crossed beam facility operating in the pulsed beam mode. The electron source was a modified 6L6GC vacuum tube operated to yield approximately 1 mA. of electron current. A thermionic-type ion source typically produced a collimated ion beam of 30 nA. The two beam current distributions were determined immediately prior to collision by means of a movable slit scanner. After interacting with the electron beam the ion beam charge state components were separated in a two-stage, parallel plate electrostatic analyzer. Numerous consistency checks were performed to evaluate possible sources of experimental error.

AA-7 Dissociative Ionization by Electron Impact of Vibrationally Excited Oxygen - B. EVANS and R.M. HOBSON, York University, Canada and JEN-SHIH CHANG, McMaster University, Canada -- The dissociative ionization of O_2 by electron impact was studied for vibrational temperature from 1500°K to 6100°K and electron energies from 50-500eV. The vibrationally excited O_2 was obtained by the use of a shock heated molecular beam[1]. The vibrational temperature was determined by the theory of Evans et al.[2] The "reflection method" has been extended to estimate the variation of the dissociative ionization cross section with vibrational temperature. Theoretical prediction shows that the cross section for dissociative ionization for O_2 increases with vibrational temperature. The experimental results are consistent with theory to 20% from the room temperature value in the range considered.

1. B. Evans, R.M. Hobson, J.S. Chang, and K. Teshima, Shock Tubes and Waves ed. Lifshitz and Rom,1980 p.571

2. B. Evans, R.M. Hobson, A. Yau, J.S. Chang, Bull. Am. Phys. Soc. (1980) 25 p. 112

3. G. Herzberg, "Molecular Spectra and Molecular Structure."Vol. II Van Nostrand Inc., N.Y. (1950)p391

AA-8 Total Inelastic Cross Section for CH_4 Predicted From Swarm Data,* L. E. KLINE, Westinghouse R&D -- Coefficients for electron transport and electron impact excitation, dissociation, attachment and ionization in CH_4 have been predicted by numerically solving the Boltzmann equation to find the electron energy distribution. The required input cross sections were taken from the literature for all collision processes except dissociation and electronic excitation. A combined cross section for the last two processes was inferred by taking the dissociation cross section of Ref. 1 and adjusting its magnitude until the predicted net ionization coefficient (ionization minus attachment) agreed with measured values[2]. The resulting peak cross section is $9.5 \times 10^{-16} cm^2$. This value is twice the value measured for dissociation alone in Ref. 1 by observing the decrease in CH_4 pressure as dissociation products are removed by a getter. The results of the present calcualtions are inconsistent with the much smaller cross sections (10^{-19} to $10^{-18} cm^2$) measured by observing optical radiation or excited particle production.

1. H. F. Winters, J. Chem. Phys. 63, 3462 (1975).
2. A. H. Cookson et. al, Brit.J. Appl Phys,17,891(1966).

AA-9 Electron Dependence of the Dissociative Recombination Coefficients of Ne_2^+ and Ar_2^+ at elevated gas temperature - R.M. HOBSON, T. MARUYAMA, K. KESKINEN, Y. ICHIKAWA, York University, Canada, S. Teii, Musashi Institute of Technology, Japan, T. Kaneda and Jen-Shih Chang, McMaster University, Canada -- The dissociative recombination coefficient of Ne_2^+ and Ar_2^+ was measured for gas temperatures between 1500 and 3000 and electron temperatures between 2000°K and 10,000°K. The r.f. produced plasma was shock heated in a 4 cm i.d. low pressure shock tube. The electrons were heated independently of the gas and ions by using a focussed microwave beam. The charge density decay and electron temperature were measured by using double and triple probes, respectively. The dissociative recombination coefficients are determined by fitting the experimental results to computer generated solutions. The experimental result shows that if we express the dependence of the recombination coefficient on electron temperature Te as a power law, i.e. $Te^{-\gamma}$, no single power law dependence holds over the range of measurement for both Ne_2^+ and Ar_2^+, γ ranges between 0.1 and 0.5 for Ne_2^+. γ increases with increasing electron temperature. Ar_2^+ was found to have a similar dependence on Te at this elevated gas temperature.

SESSION AB

9:00 A.M., TUESDAY, OCTOBER 7, 1980

ROOM B

BREAKDOWN AND CORONA

CHAIRPERSON: W. P. ALLIS

JOINT INSTITUTE FOR LABORATORY ASTROPHYSICS

AND MASSACHUSETTS INSTITUTE OF TECHNOLOGY

AB-1 Effect of Hydrogen Impurity on Breakdown and Ionization Potentials for Ne-A Mixtures.

A.K. BHATTACHARYA, GE, Lighting Business Group, Nela Park, Cleveland, OH 44112 --The effect of H_2 on the breakdown potentials and Townsend ionization coefficients for Ne-A mixtures were measured by the luminous-flux method. Both argon and hydrogen form Penning mixtures with neon. The breakdown potentials for Ne-A gas mixtures are determined by the Penning reaction, $Ne^m + A \rightarrow Ne + e + A^+$, between metastable neon (Ne^m) and ground state A atoms. At low H_2 concentrations ($<0.1\%$) the BD potentials and Townsend ionization coefficients are unaffected. At higher H_2 levels ($>0.1\%$), increase in BD potential caused by the lowering of the Townsend ionization coefficients depends upon the value of the product, $p\,d$, of the fill pressure (p) and the electrode separation (d). This is due to (1) lowering of electron average energy which determines Ne^m density, and (2) non-ionizing reaction, $Ne^m + H_2 \rightarrow H*(n=3) + H + Ne$, competing with the Penning reaction between Ne^m and A atoms.

AB-2 Development of Overvoltage Breakdown at High Gas Pressure, E. E. KUNHARDT and W. W. BYSZEWSKI, Texas Tech University*-- A model for the development of electrical breakdown in high pressure gases is presented. It describes the initial phases of breakdown in the regime where the Townsend avalanche mechanism does not apply. In the model, the energy distribution function for electrons in the advancing avalanche is assumed to have two components: the fast and the slow electrons. The fast electrons "run away" from the avalanche, but are "trapped" at various distances ahead of the avalanche, depending on the energy of the electrons and the properties of the avalanche and the background gas. This mechanism plays the fundamental role in increasing the speed of propagation of the avalanche when the applied voltage is $\lesssim$ 20 percent over the self breakdown voltage. In light of this model a brief discussion of experimental results is given.

AB-3 <u>Nanosecond-Pulse Breakdown in Gases at High Over-</u>
<u>voltages</u> -- E.E. KUNHARDT, S. LEVINSON, and M. ALLEY,
<u>Texas Tech University</u>* -- Physical insight into the
breakdown initiation processes and the formation time of
nanosecond-pulse discharges in a homogeneous-field gap
may be inferred from the study of the observational de-
lay time. In this paper, we report the results of ex-
periments carried out to measure the observational delay
time as a function of gas pressure (up to 1600 Torr) and
percent overvoltage (up to 1200%). The experiments were
carried out in an evacuable spark gap chamber that forms
part of a coaxial line system. Trapezoidal voltage
pulses in the range of 50 to 160 kV and 50 ns duration,
with 4 ns risetime were applied to the gap. The elec-
trode separation can be varied up to 3 cm. Briefly, the
results indicate that there is a minimum in the mean de-
lay time as a function of percent overvoltage. This im-
plies that there are conditions of overvoltage for which
avalanche development is optimum. The implication of
these results as to the nature of the pre-breakdown pro-
cesses will be discussed.

AB-4 <u>Gasdynamic Interactions in a Non-Uniform High</u>
<u>Pressure Discharge. J. L. Barto and O. Biblarz,* U.S.</u>
<u>Naval Academy.</u>--A study of current (Ib) and voltage (Vb)
at breakdown for a high pressure corona discharge with a
subsonic stabilizing flow is reported. Gasdynamic in-
teractions change breakdown properties in a highly
stressed anode with a grounded plate cathode. The cur-
rent direction is parallel or anti-parallel to the flow.
Both Ib and Vb have been found to increase and decrease,
not necessarily in phase, nor by the same amounts, as a
function of flow speed and turbulence intensity in a
complicated fashion. An "anode extension" model has
been developed which describes most of the characteris-
tic variations in the breakdown properties. This model
is more sophisticated than previous ones[1] in that it
reflects dominant processes through a wide range of
velocities and turbulence intensities for both flow
orientations.

*Naval Postgraduate School, Monterey, CA.

[1]
  O. Biblarz, J. L. Barto, and H. A. Post, "Gas Dynamic
Effects on a Diffuse Electrical Discharge in Air," Isr.
J. Tech. 15,59 (1977).

AB-5 Pre-Spark Channel Phenomena in Laser-Triggered
Electrical Breakdown - P.F. WILLIAMS, and M.A. GUNDERSEN,
TEXAS TECH U., and A. WATSON, U. of WINDSOR* -- The
behavior of a number of simple gases undergoing laser-
triggered electrical breakdown has been investigated.
In hydrogen, pre-spark gap current oscillograms are
qualitatively similar to corresponding results in con-
ventional over-volted gaps. Also in hydrogen the delay
between arrival of the triggering laser pulse and the
closure of the gap by a spark was accurately given by
an exponential function of E/P. In other gases, devia-
tions from a simple dependence on E/P were observed.

AB-6 Electron Densities in Laser-Triggered Hydrogen
Sparks - S.K. DHALI, R.J. CRUMLEY, P.F. WILLIAMS,
E.E. KUNHARDT, and M.A. GUNDERSEN, Texas Tech U.* --
Stark broadening measurements of the H_β emission line
were used to determine the temporally and spatially
resolved electron density in laser-triggered hydrogen
sparks. Our computer-controlled data acquisition
allowed us to Abel transform entire spectra on a point
by point basis. Subsequent line shape comparison with
theoretical profiles provided an independent check on
system linearity and on transform accuracy. The data
are consistent with a simple hydrodynamic model of spark
channel evolution.

AB-7   Model Studies in Positive Point-Plane Corona,
M. N. HIRSH* and R. P. ABBOTT**, U. Minnesota, Morris--
An analytical expression has been derived for the axial
electric field in the space charge zone of the positive
point-plane corona in air as a function of continuous
current and positive ion mobility. At high currents,
this yields a discharge characteristic $I=k(V-V_0)^2$, which
agrees with experiments and yields a positive ion
mobility on the order of 2.5 cm^2/Vsec. Numerical
integration of the exact field over the space charge
region yields values for the voltage drop across the
ionization zone, and ion mobility values consistent
with the asymptotic result. A model of positive ion-
electron kinetics and transport has been developed
which appears to explain the ionization zone voltage
drop, and to yield a criterion for spark breakdown in
terms of the electric field gradient at the point.
An expanded model which also includes negative ions
is currently being developed, which promises to yield
a field-dependent criterion for streamer onset.

Present addresses:

*Laboratory for Laser Energetics, University of Rochester.

**E.E. Department. University of Minnesota

AB-8   Pulse Characteristics of Positive DC Corona in
SF_6: Effects of Trace Decomposition Products - D.A. LEEP
and R.J. VAN BRUNT, National Bureau of Standards* --
Point-plane positive dc corona in pure SF_6 at pressures
of (50-500)kPa occurs predominantly as pulse bursts,
the characteristics of which depend on gas pressure and
applied voltage. Measured corona pulse height
distributions and rates of occurrence were found to be
sensitive to gas composition, which was monitored by a
gas chromatograph-mass spectrometer. Corona-induced
decomposition of SF_6 in the presence of trace amounts of
moisture was found to produce SOF_2, SO_2F_2 and other polar
molecules. As decomposition progresses and relative
concentrations of polar molecules increase, the corona
pulses become smaller and more isolated, i.e., the burst
activity disappears. It is speculated that these changes
in corona characteristics are related to the effect of
trace concentrations of polar molecules on development
of positive ion space charge in the gap.

AB-9 Coronaphoresis - D. H. DOUGLAS-HAMILTON, Avco Everett Research Lab. Inc. -- An effect analogous to electrophoresis occurs in corona discharges. Ionization of gas in a corona is followed by rapid charge transfer to the lowest ionization-potential material present. This material, carrying the charge, can then be swept out of the gas electrostatically. In this way host gases can be purified of contaminants to extremely high purity levels, since contaminants frequently have lower ionization potentials than the host gas. A theoretical model of this effect has been derived, and an experiment was designed to detect the phenomenon; experimental results confirming the existence of the coronaphoresis effect in mixtures of He, N_2 and O_2 will be described, in which the results obtained were close to the theoretical predictions.

SESSION BA
10:50 A.M., TUESDAY, OCTOBER 7, 1980
ROOM A

ELECTRON COLLISIONS II

CHAIRPERSON: N. C. STEPH
              UNIVERSITY OF OKLAHOMA

BA-1 Autoionizing States in the Ionization Continuum of the Rare Gases Determined from Near-Threshold Electron Impact Techniques.* D. SPENCE, Argonne National Laboratory.--Identification and energy locations of neutral autoionizing states obtained from a variety of near-threshold electron impact techniques are examined. We find: 1) Structures observed in electroionization spectra[1] are shifted in energy by "post-collision interactions" (PCI), but are not subject to misinterpretation by Feshbach resonances; 2) structures in broadband photon[2] spectra, conversely, appear not to be subject to PCI, but the spectra are dominated by resonance structures leading to misidentification of the observed structures.

*Work performed under the auspices of the U.D. Dept. of Energy.

[1] E. Bolduc, J. J. Quemener and P. Marmet, J. Chem. Phys. 57, 1957 (1971).

[2] P. Veillette and P. Marchand, Can. J. Phys. 54, 1208 (1976).

BA-2 Temporary Negative Ion Formation in Halogenated Ethylenes - P.D. BURROW, A. MODELLI, N.S. CHIU, U. of Nebraska and K.D. JORDAN, U. of Pittsburgh*--The electron affinities for addition of an electron into the lowest unfilled π^* orbitals of the chloroethylenes have been measured by electron transmission spectroscopy.[1] As expected from simple arguments, the negative ions are stabilized upon chlorine substitution. A new resonance in the electron scattering cross section of each of the compounds is observed which we attribute to temporary occupation of the C-C σ^* orbital. This assignment is supported by the opposite behavior of the π^* and σ^* resonances under fluorine substitution.[2]

*Supported by NSF and PRF.

[1] L. Sanche and G.J. Schulz, Phys. Rev. A5, 1672 (1972).
[2] N.S. Chiu, P.D. Burrow and K.D. Jordan, Chem. Phys. Letters 68, 121 (1979).

BA-3 Elastic Scattering of Electrons in Neon - M. G. MENENDEZ,* J. A. REES† and E. C. BEATY,‡ JILA, Univ. of Colo. & NBS--The differential cross section (DCS) for elastic scattering in neon shows a pronounced minimum at angles near 100°, for electron energies in the range 50 to 100 eV. The energy at which this minimum is deepest is the critical energy, E_c, and its prediction is a sensitive test of theory. For energies close to E_c the electrons scattered at angles close to the critical angle will be highly polarized. A previous measurement[1] of E_c for neon differed significantly from calculated values. The present work reports DCS measurements for angles between 20° and 135° at energies of 50 to 100 eV. The critical energy is deduced to be (64.0±1.0) eV, the corresponding critical angle being (102.0°±0.5°). These values are in excellent agreement with values predicted[1] from theoretical data.[2,3]

*JILA Visiting Fellow, 1979-80. Permanent address: Univ. of Georgia
†Permanent address: Univ. of Liverpool, U.K.
‡Staff Member, Quantum Physics Division, NBS.

[1]K.J.Kollath and C.B. Lucas, Z. Physik A292, 215 (1979).
[2]D.W. Walker, Adv. Phys. 20, 257 (1971).
[3]K. Blum and P.G. Burke, J. Phys. B 8, L410 (1975).

BA-4 Excitation of the Asymmetric Stretch of CO_2 by Electron Impact - DEVARAJAN THIRUMALAI, KUNIZO ONDA, and DONALD G. TRUHLAR, Univ. of Minnesota.*--Differential, integral, and momentum-transfer cross sections have been calculated for elastic scattering, rotational excitation, and excitation of the 001 asymmetric stretch mode of CO_2 by electron impact at 10 eV. We carried out rotational close coupling calculations involving up to 36 channels for the equilibrium geometry and up to 50 channels for an asymmetric geometry. Then we calculated vibrational excitation cross sections by the vibrational sudden approximation. The electron-CO_2 potential included a static-plus-polarization potential calculated by the INDOX/1s/AAP method and a local exchange potential calculated from the semiclassical exchange approximation and the polarized electron density. The differential cross section for vibrational excitation agrees well with experiment. The integral cross sections (in a_0^2) for transitions to various final states (v',j') from the ground state are: 25.1 (0,0), 25.7 (0,2), 9.2 (0,4), 3.0 (0,6), 1.3 (0,8), 0.76 (1,1), 0.16 (1,3), 0.013 (1,5), and 0.005 (1,7).

BA-5 <u>Electron Collision Quenching of CO(v)</u> <u>Chemiluminescence in</u> CS_2/O_2 <u>and</u> $CS_2/O_2/N_2O$ <u>Flames</u>* - M. J. KUSHNER, <u>Sandia National Labs</u>; W. M. GROSSMAN and F. E. C. CULICK, <u>Calif.</u> <u>Inst. of Technology</u>--The reactions $O+CS_2 \rightarrow$ $CS+SO$ and $O+CS \rightarrow CO(v)+S$ create vibrationally excited carbon monoxide and form the basis of the CO flame laser. We applied a transverse glow discharge to CS_2/O_2 and $CS_2/O_2/N_2O$ flames and observed changes in the $CO(v)$ distribution for evidence of electron collision transfer between excited vibrational states. We found that the CO(v) distributions were thermalized by the discharge, the effect being particularly severe in $CS_2/O_2/N_2O$ flames. An analysis was performed in which the change in the rate of population due to the applied discharge was calculated. From this analysis we suggest that superelastic electron collisions by which molecules cascade to lower vibrational levels by successive electron collisions is the cause of the quenching.

SESSION BB
10:50 A.M., TUESDAY, OCTOBER 7, 1980
ROOM B

GLOW DISCHARGES AND BOUNDARY-RELATED PHENOMENA

CHAIRPERSON: W.H. LONG, JR.
NORTHRUP RESEARCH AND TECHNOLOGY CENTER

BB-1 **The Diffusion Length for Positive Columns with Nonlinear Electron Production and Loss Rates.** GERALD L. ROGOFF, Westinghouse R&D Center--The characteristic diffusion length is of limited use for steady-state positive columns with electron production and loss rates linear and quadratic in electron density. For this case, however, the average density $\overline{n_e}$ is accurately characterized by a diffusion length Λ_r defined such that Λ_r^{-2} is the spatial average of $-\nabla^2 n_e/n_e$. Thus for an axially-uniform column, $\Lambda_r^{-2} = S/A$, where S is the integral of $-\nabla^2 n_e/n_e$ over the arbitrarily-shaped column cross section, and A is the cross-sectional area. The length Λ_r accounts for the average diffusion loss rate for all possible signs and relative magnitudes of the coefficients of the linear rate (ν) and the quadratic rate (k). S is unlimited in magnitude; and for $\nu < 0$, S can be negative.[1] Thus Λ_r cannot always be viewed as a simple measure of the effective size of the container. Moreover, for $\nu=0$, Λ_r cannot be used to determine the electron temperature or operating electric field, since k is independent of Λ_r. Note that the above expression separates the influences of column shape[1] (in S) and column size (A). Values of S are available for circular and rectangular column cross sections.[1]

[1]G. L. Rogoff, J. Appl. Phys. **51**, 3144 (1980).

BB-2 **Schottky Theory of the Positive Column with Electron Attachment.** J.H. INGOLD, General Electric Co. Cleveland, OH 44112. -- The Schottky theory of the low pressure positive column is extended to include negative ions formed by electron attachment to electronegative particles. Analytic solutions for the spatial distributions of charged particles in slab geometry are given. For example, when the density of negative ions is ten or more times the electron density, then the spatial distribution of electron density is calculated to be flat over most of the discharge cross-section, as observed by Thompson. In no case is the ratio of negative ion density to electron density constant over the discharge cross-section, as is frequently assumed. However, another assumption that is frequently made — namely, that electrons and negative ions are in Boltzmann equilibrium with the space charge field — is shown to be valid in most cases. Other peculiarities of the positive column with negative ions are discussed.

[1]J. B. Thompson, Proc. Phys., Soc. (London) 73,818 (1959).

BB-3 Theory of a Plasma Column Sustained by a Surface Wave - C.M. FERREIRA, Lab. Physique des Gaz et des Plasmas, Univ. Paris-Sud, Orsay, France--A self-consistent theory of a cylindrical plasma column sustained by a surface wave has been derived which gives absolute values and radial profiles of electron density, electron temperature, HF electric field intensity and atomic excited states densities as a function of gas pressure, wave frequency and HF absorbed power. The basic equations are the continuity and the momentum transfer equations, for both electrons and ions, the equations for the wave electric field and the electron energy equation. The theory is shown to agree well with measurements in argon discharges previously reported[1]. A close agreement is obtained when the theoretical values of the electron temperature are used to determine the axial attenuation of the wave due to electron collisions. The theoretical electron density and field profiles are significantly different from, respectively, the classical Bessel type and the field profiles of surface waves in homogeneous media . The radial distribution of excited atoms is either flat or increases to reach a maximum near the wall, as experimentally observed.

[1]M. Moisan et al., Revue Phys. Appl. 15 (1980).

BB-4 Electrode Sheath Predictions for Attaching Gas Mixtures,* R. R. MITCHELL, L. E. KLINE, and L. J. DENES, Westinghouse R&D Center -- We observe that arc formation begins in the cathode sheath region of high pressure glow discharges when the gas mixture contains small amounts of an attaching gas and in both sheath regions at high attacher concentrations. To interpret these results we have used a steady state one dimensional continuity equation model to calculate the electric field, particle fluxes, and particle densities vs. position in the anode and cathode sheath regions. We studied the parameter ranges $300 \leq$ pressure $\leq 10,000$ Torr and $1 \leq$ current density ≤ 1000 A/cm^2 for both helium and XeF laser mixtures containing helium buffer, 0.08% Xe and 0.02-2.0% NF$_3$. We find that the cathode sheath characteristics are insensitive to both attacher concentration and the presence or absence of electron diffusion. The anode sheath field increases as the attacher concentration increases. The thickness of the high field region at the anode is insensitive to attacher concentration and decreases as current density increases. The anode sheath region is strongly affected by the presence of electron diffusion.

BB-5 I-V Characteristics of Externally Ionized Plasmas in Pure Gases. PETER BLETZINGER, WPAFB, Aero Propulsion Laboratory.-When operating E-beam preionized discharges in a pure environment with no attaching gases, the discharge (sustainer) voltage was much lower than would be expected if the electron density were determined solely by E-beam ionization and recombination losses. In an atmospheric pressure Argon discharge for example, the sustainer voltage was less than 200V at a current density of 13mA/cm^2 (discharge) and less than 50μA/cm^2 (E-beam). The I-V characteristic had a differential impedance of only a few ohms. Still, this discharge was under complete control of the E-beam preionization. A reason for this very large conductivity can be additional ionization in a cathode sheath[1]; our discharge voltages were even lower than in (1) which may be due to observed Argon metastables causing even more efficient ionization. An attempt to increase the drift velocity by adding N$_2$ considerably increased both the voltage drop and the differential impedance. If the sustainer discharge is to be used as the control element of a switch, the low voltage drop is very attractive; for operation at high E/N, an attaching species has to be added.

[1] J.L. Lowke & D.K. Davies, J. Appl Phys. 48, 4991, 1977.

BB-6 Fluctuations in Glow Discharge Parameters in Noble Gases - W.G.McNAUGHT and T.A.KING,Manchester U.*-- The fluctuation frequency spectra for whole tube voltage and side light emission from He-Ne glow discharges have been investigated with variation of cathode material, shape and degree of oxidation. Determination of the discharge V-i characteristics for flat plate Al-alloy cathodes provides the normal glow gas discharge current density and the cathode area required to maintain a normal glow discharge with minimal sputtering. The fluctuation spectra of cathodes of this area but covering a wide range of shapes have been compared with emphasis on the 0-1 MHz range. For total gas pressures in the torr region, pure and mixed He-Ne discharges have been studied over a range of relative gas pressures and for cathode surfaces made from Al and Al-alloys. Cathodes with oxidised surfaces have a much lower fluctuation amplitude than non-oxidised surfaces, cathode shape is found to significantly influence the fluctuation amplitude. A certain conical cathode has been found to be significantly quiet. Correlations have been observed in the fluctuations of whole tube voltage and side light emission from different regions of the positive column.

*Supported by R.A.E., Farnborough.

BB-7 O_2 Dissociation Mechanisms in Ar + O_2 RF Sputtering Discharge, Y. CHOUAN,* D. COLLOBERT,* and A. RICARD** --Emissivity of OI lines is studied in a RF sputtering experiment where a Si target is sputtered in a mixture of O_2 and Ar at a total pressure of 10^{-2} Torr. Rutherford Backscattering analysis of the thin films obtained is performed. The results are the following depending on Oxygen concentration in the discharge. When there is less than 2% of O_2 in the sputtering gas, pure Si is obtained; when there is more than 2% of O_2, stoechiometric SiO_2 is obtained. Spectroscopic results suggest reactions take place between sputtered atoms and plasma species. The study of OI lines gives results upon reactions occurring between molecular Oxygen and electrons or Argon metastable atoms. A description and a discussion of kinetics processes is given.

*CNET, Dept. TIC/ROC, B.P 40 22301, Lannion, France.

**Lab. Phys. Plasmas, Univ. Paris-Sud, 91405 Orsay, France.

SESSION C
1:30 P.M., TUESDAY, OCTOBER 7, 1980
FORUM ROOM

GLOW DISCHARGES

CHAIRPERSON: D. PIGACHE
               OFFICE NATIONAL D'ÉTUDES ET DE RECHERCHES
               AÉROSPATIALES, FRANCE

C-1 Experimental and Theoretical Investigation of the Optogalvanic Effect in the Helium Positive Column - James E. LAWLER, Stanford U.* --A linear, steady state, analytical rate equation model of the optogalvanic effect in a positive column on the 587.6 nm He transition is presented. Absolute measurements of the optogalvanic effect in a positive column on the 587.6 nm He transition are reported. The model and the experiment are found to agree over a substantial range of direct currents and over a factor of 10 in column radius-pressure product. This model relates the absolute magnitude of the optogalvanic effect to a known ionization rate.[1] The structure of this model should be useful in determining ionization rates of electronically excited levels from optogalvanic measurements.

[1]H. F. Wellenstein and W. W. Robertson, J. Chem. Phys. 56, 1077 (1972).

C-2 Resonant Spectroscopic Investigations of a Glow Discharge in Helium, H. ODENTHAL and J. UHLENBUSCH, Universitat Dusseldorf, F.R.G.--Temperature, velocity distribution and population density of neutral Helium in the 2^3P level are measured by absorption, dispersion and resonant scattering experiments in the positive column of a glow discharge (R=1cm, l=1cm, R=0.5cm, l=0.5m) as a function of discharge current (I=1-120mA) and pressure (p=1-10 Torr) with a tunable dye-laser of 2 MHz. The Helium temperature in such a discharge varies between 300 K and 700 K and the population density of the 2^3P level changes between 10^8 and $10^{11}/cm^3$. The frequency resolved measurements mentioned above have shown that Doppler-broadening is predominant and that the results are in agreement with the linear dispersion theroy. By a simultaneous solution of the energy balance and the rate equation for the electrons, their temperature profile can be derived (typically 50000 K) where their density varies from 10^{10} to 10^{12} cm^{-3}. Experiment and theoretical results are compared.

C-3   The Measurement of a Glow Discharge Plasma by a
Self-absorption Method Under a Condition of Plasma Non-
uniformity - Y. ICHIKAWA and R.M. HOBSON,York University,
Canada, T. MARUYAMA and S. TEII, Musashi Institute of
Technology, Japan -- In the optical absorption method[1,2],
used to determine metastable atom densities in a glow dis-
charge plasma, a spatially uniform plasma has usually been
assumed. However, in the case of spatially non-uniform plas-
mas such as in striated positive columns, modulated positive
columns etc, the method applied to the analysis of absorption
data is not well established. In this paper, the radiative
transfer equation is solved when the densities of excited
species are varied with time and space (n=f(kx±wt), where k
is the wave number and w is the angular frequency). The theo-
retical result shows that the ordinary data analysis method
(assuming uniform plasma) leads to a large error when inter-
preting the results of the non-uniform plasma with $A/kL \gtrsim 1$,
where A is the density amplitude of the excited species nor-
malized by the mean value and L is the plasma length. Experi-
mental confirmation has been obtained in He and Ar discharges

[1]T. Goto, M. Mori and S. Hattori, Appl. Phys. Letters,
29, 358 (1976)
[2]Y. Ichikawa and S. Teii, J. Phys.D: Appl. Phys. 13,
(1980) (in press)

C-4 The Radial Density Distribution and Electron Tem-
perature in a Medium Pressure Neon Positive Column - JEN
SHIH CHANG and T. MARUYAMA, McMaster University, Canada,
R.M. HOBSON, York University, Canada, Y. ICHIKAWA and S.
TEII, Musashi Institute of Technology, Japan -- An exact
numerical analysis has been carried out for the plasma
radial density distribution and electron temperature in
a chemically reacting medium pressure positive column plas-
ma. The chemical reactions considered in the present model
are (a)dissociative recombination of molecular ions, (b)
three body ion conversion, (c)ionization by metastable, (d)
metastable-metastable collisional ionization (e)direct
ionization. Hence, five coupled equations have been solved.
Plasma parameters were measured simultaneously by an elec-
trostatic probe, mass spectrometer and self-absorption
technique. The results show that: (1)the radial density dis-
tribution of metastable particles, atomic and molecular ions
are observed to differ significantly from each other and also
from the Schottky theory of the positive column; (2)the elec-
tron temperature obtained from the present model agrees re-
latively well with that predicted by the simplified theory of
Ichikawa et al[1]; (3) three-body conversion rate coefficient
obtained by employing the present model is $1.7 \times 10^{-31} cm^{6}/sec$.

[1]Y. Ichikawa and S. Teii, J. Phys.D: Appl. Phys., 13 (1980)

C-5   Metastable Atom Density Measurement in a Ne-Ar Gas mixture Positive Column Plasma - T. MARUYAMA, Y. ICHIKAWA, and R.M. HOBSON, York University, Canada, S. TEII, Musashi Institute of Technology, Japan -- The measurement of metastable atom number densities in Ne-Ar gas-mixture positive column plasmas has been carried out by the self-absorption method[1] in a 21mm I.D. discharge tube. A wide range of the gas mixture ratio was changed under a constant total pressure and discharge current. The experimental results show that: (1) mixing a small amount of Ar gas in the Ne discharge leads to a rapid decrease of the densities of neon $1s_3$ and $1s_5$ metastables due to the Penning ionization effect; (2) the radial density profiles of neon metastables become narrower, depending on increasing the mixing ratio of Ar; (3) the argon metastable increases gradually with increasing the mixing ratio of Ar; (4) present experimental results agree well with the theory of Dote and Ichikawa[2]

[1] Y. Ichikawa and S. Teii, J. Phys. D: Appl. Phys., 13, 1980 (in press)

[2] T. Dote and Y. Ichikawa, Trans. Trans. IEEE of Jpn. 99-A, 369, 1980

C-6   Basic Kinetic Processes in Neon Gas Discharge Displays--W. L. NIGHAN and W. J. WIEGAND, United Technologies Research Center*--An analysis of basic kinetic processes in electrically excited Ne-Xe Penning mixtures has resulted in identification of the production and loss processes controlling the populations of the light emitting $Ne(2p_j)$ states in gas discharge displays. Excited state production efficiencies and luminous efficiencies have been computed for conditions typical of plasma panel displays. Comparison of the computed intensities of the thirty $Ne(2p_j)$ - $Ne(1s_j)$ transitions in the 5400-8080 Å range with measured values resulted in very good agreement, lending support to the validity of the analysis and modeling of the Ne-excited states responsible for the observed visible emission in Neon discharge displays.

C-7 Ultraviolet Fluorescence From The $HgCl(D^2\Pi_{3/2})$ State in a Pulsed Discharge of $HgCl_2$ and Neon, S. G. JOHNSON, GTE Products Corp.* and J. M. PROUD, GTE Labs**--The fluorescence of the $HgCl(D^2\Pi_{3/2})$ state between 240 and 265nm has been studied in a series of $HgCl_2$/Ne mixtures. The mixtures were excited by a 6 nsec. high voltage pulse which was capacitively coupled to the electrodeless discharge. (Typical operating conditions were : Neon 0 to $1.6x10^{18}cm^{-3}$, $HgCl_2 \sim 1.6x10^{17}cm^{-3}$, Gas Temperature$\sim 165^{\circ}C$, $E/N \sim 2x10^{-13}$ to $2x10^{-14}vcm^2$). The vibrational temperature of the D state was determined analytically as a function of the neon gas pressure. Radiation from the $HgCl(B^2\Sigma^+)$ state was also observed for these discharges. The vibrational temperature of the B state was determined by a comparative analysis of experimental data to a computer simulated spectra. A comparison of the vibrational temperatures for the two states will be discussed.

*   Sylvania Lighting Center, Danvers, MA 01923
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NOTES

SESSION D
3:15 P.M., TUESDAY, OCTOBER 7, 1980
FORUM ROOM

WORKSHOP ON ELECTRON SCATTERING WITH EMPHASIS ON
  LASER APPLICATIONS

THIS WORKSHOP WILL INCLUDE THEORETICAL AND EXPERIMENTAL
DISCUSSIONS ON ELECTRON SCATTERING FROM ATOMS, MOLECULES
AND CLUSTERS. BOTH GROUND STATES AND VIBRATIONALLY AND
ELECTRONICALLY EXCITED STATE TARGETS WILL BE CONSIDERED.
PROCESSES DISCUSSED WILL INCLUDE VIBRATIONAL EXCITATION,
ELECTRONIC EXCITATION AND DE-EXCITATION, DISSOCIATIVE
ATTACHMENT, AND ABSOLUTE TOTAL SCATTERING CROSS SECTIONS.
SPECIFIC SYSTEMS WILL INCLUDE HYDROGEN HALIDES AND RARE
GAS HALIDES.

CHAIRPERSON: D. SPENCE
              ARGONNE NATIONAL LABORATORY

INTRODUCTION

D. Spence

SHAPE RESONANCES, VIBRATIONAL EXCITATION AND
DIPOLE FIELDS IN ELECTRON-MOLECULE SCATTERING

J. L. Dehmer

DISSOCIATIVE ATTACHMENT FROM EXCITED MOLECULES

S. F. Wong

THEORETICAL STUDIES OF ELECTRON COLLISIONS
IN ELECTRONIC TRANSITION LASERS

A. U. Hazi

DETERMINATION OF ABSOLUTE ELECTRON-IMPACT CROSS SECTIONS

S. Trajmar

COMPOUND STATES IN ATOMS, MOLECULES, AND CLUSTERS

R. N. Compton

SESSION EA

9:00 A.M., WEDNESDAY, OCTOBER 8, 1980

ROOM A

HEAVY PARTICLES I

CHAIRPERSON: R. JOHNSEN

UNIVERSITY OF PITTSBURGH

EA-1 <u>Drift Tube Studies of Ion-Neutral Reactions</u>[+] W. LINDINGER, <u>U.Innsbruck,Austria</u>.-- Various ion-neutral reactions have been studied in the range from thermal to a few eV kinetic energy, KE_{cm}, between the reactants. For some reactions, such as Ne^+ with N_2 and CO and Ar^+ with O_2 strong energy dependences of the rate coefficients k are observed, which can be partly understood in terms of the product state distributions. Reactions of molecular ions, such as N_2^+, O_2^+ and CO_2^+ show in many cases besides a considerable dependence on KE_{cm} also strong influences from the ionic vibrational excitation. A study of the energetics of the forward and the reverse reaction $Ar^+ + N_2 \text{ -- } N_2^+ + Ar$ shows the forward reaction to proceed mainly via a slightly endothermic reaction channel, populating the $N_2^+(X,v=1)$ state.

EA-2 <u>Silicon Ion Chemistry in the Ionosphere</u>, D. W. FAHEY, E. E. FERGUSON, D. L. ALBRITTON, and F. C. FEHSENFELD, <u>Aeronomy Laboratory</u>, <u>NOAA/ERL</u>, Boulder Colorado, 80303.
Loss processes which remove Si^+ ions selectively relative to other meteor derived atomic ions in the E-region and D-region of the ionosphere have been identified and measured in the laboratory, The major Si^+ loss in the E-region is the reaction

$$Si^+ + H_2O \rightarrow SiOH^+ + H$$
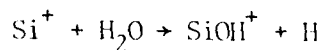
with a rate constant of $2.3 \pm 0.9 \times 10^{-10}$ cm^3 s^{-1} at 300 K. At lower altitudes Si^+ ions associate in a three-body reaction with O_2

$$Si^+ + O_2 + M \rightarrow SiO_2^+ + M$$
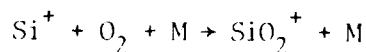
with a rate constant of 1.0×10^{-29} cm^6 s^{-1} at 300 K with M being helium. The measuring technique will be outlined, the measured Si^+ rate constants reported and the atmospheric implications of the measurements discussed.

EA-3 Reactions Studies of Magnesium Ions, B. R. ROWE, D. W. FAHEY, A. A. VIGGIANO, D. L. ALBRITTON, E. E. FERGUSON, and F. C. FEHSENFELD, NOAA/ERL, Aeronomy Laboratory, Boulder CO 80303

There have been numerous observations of meteoric ions in the earth's atmosphere. One of the most abundant metallic neutrals deposited by meteorite ablation in the atmosphere is magnesium. Mg^+ has been observed in the atmosphere and plays an important role in the ionospheric ion chemistry. Reaction rate constants have been measured for the reaction of Mg^+ with O_3, HNO_3, H_2O_2; MgO^+ with CO, H_2, and H_2O; and $MgOH^+$ with H_2O, NH_3, and HNO_3. The rate constant will be reported and the implication to atmospheric ion chemistry will be discussed.

EA-4 Reactions Between Neutrals Clustered on Ions, B. R. ROWE, A. A. VIGGIANO and F. C. FEHSENFELD, Aeronomy Laboratory, NOAA/ERL, Boulder CO 80303

Alkali metals have relatively low ionization potentials and the alkali metal ions are isoelectronic with the noble gases. For these reasons these ions are relatively non-reactive. However, these ions will associate with neutrals to form weakly bound cluster ions. We have observed cases in which a molecule clustered to an alkali metal ion reacts with a reactant neutral with a rate constant much larger than the corresponding rate constant for the reaction between these same neutrals in the absence of the catalytic ion. For example, in the reaction

$$O_3 + NO \rightarrow NO_2 + O_2, \tag{1}$$
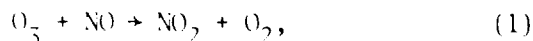
$k_1 = 2.5 \times 10^{-12} \exp - \dfrac{1450}{T} \; cm^3 \, s^{-1}$ between 205 K and 361 K while for the reaction

$$Na^+ \cdot O_3 + NO \rightarrow Na^+ + NO_2 + O_2 \tag{2}$$
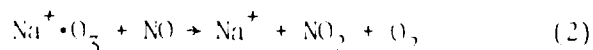
$k_2 = 6.5 \times 10^{-11} \; cm^3 \, s^{-1}$ independent of temperature between 163 K and 243 K. The rate constants measured for several of these reactions will be reported and implication of these results discussed.

EA-5   Collisional Detachment of He$^-$(^{4}P) by Various Gases from 500 to 4000 eV.* M. J. COGGIOLA and R. V. HODGES, Molecular Physics Laboratory, SRI International.--Cross sections for the attenuation of a beam of He$^-$(1s2s2p ^{4}P) in He, Ne, Ar, H$_2$, O$_2$ and NO have been measured for projectile energies between 500 eV and 4 keV. The He$^-$ beam was formed by two step charge exchange of He$^+$ in Na vapor, and electrostatically separated from the residual He$^+$ and He^0 before entering a small collision cell. The measured cross sections for all target species were large at these energies, ranging from 12.5 A^2 for Ar at 1 keV to 33.5 A^2 for NO at 1 keV. Our values for He and Ar at 4 keV are within 10% of those determined by Simpson and Gilbody [J. Phys. B5, 1959 (1972)]. The detachment cross sections for the rare gases and H$_2$ remained essentially constant over the energy range studied, however, the O$_2$ and NO cross sections exhibited a very sharp rise with decreasing energy below 1 keV.

EA-6   Collisional Dissociation of Negative Cluster Ions Formed in N$_2$O/H$_2$O Gaseous Mixtures*- RICHARD L. C. WU and THOMAS O. TIERNAN, Wright State U.--An in-line tandem mass spectrometer has been employed to determine accurate translational energy thresholds for collision-induced dissociation of the cluster ions, OH$^-$(H$_2$O)n, n=1-4, and NO$_3^-$(H$_2$O) formed by electron impact in a mixture of N$_2$O and H$_2$O. Two products, OH$^-$ and NO$_3^-$, were observed from CID of the projectile ion NO$_3^-$(H$_2$O). The cluster products, OH$^-$(H$_2$O)n, n=0-3 were observed from CID of OH$^-$(H$_2$O)n, n=1-4. The bond dissociation energies measured for the NO$_3^-$(H$_2$O) ion by this method are D$_0^0$(NO$_3^-$-H$_2$O)= 0.4 + 0.1 eV, and D$_0^0$(OH$^-$-HNO$_3$)= 3.1 + 0.1 eV respectively. These and other data obtained in this study will be compared with that derived from high pressure equilibrium experiments.

EA-7 Features of O^- detachment in gas mixtures studied by a non stationary method - C.DOUSSOT, F.BASTIEN, E.MARODE, C.N.R.S.-E.S.E.-91190 GIF-FRANCE,and J.MORUZZI, University of Liverpool-U.K. --A drift method is used to gather informations on negative ion detachment in a gas. If a steady electron source is operated (here a U.V. lamp emiting through a coated window, with an extracting grid in front of the cathode) the produced negative ion concentration depends upon the processes of production and destruction of negative ion.The mass analysed ion signal is due to negative ion drifting through a hole in the anode. When the electron source is cut off, the ion signal depends mainly on the destruction processes, so that its shape gives informations on destruction processes. The equation of the various possible processes has been written, and the systeme has been tested comparing the signal of O^- in pure O_2 and O_2/SO_2. Experiment and theory are in good agreement . If mixtures of O_2/N_2 , including air, is tested the O^- signal exhibits some features which suggest only a production near the electron source. This could be explained by a two steps production process of O^- disturbed by N_2 but not by Ar in O_2/Ar mixtures.

SESSION EB

9:00 A.M., WEDNESDAY, OCTOBER 8, 1980

ROOM B

RARE GAS HALIDE LASERS

CHAIRPERSON: K.Y. TANG

SRI INTERNATIONAL

EB-1 <u>Accessibility of the KrF*(B) State to Laser Photons</u>* - J.H. JACOB, D.W. TRAINOR, M. ROKNI[1], and J.C. HSIA, Avco Everett Research Laboratory, Inc. -- Using electron beam excitation of $Ar/Kr/F_2$ mixtures in a 1-meter laser, we monitored KrF*(B) sidelight fluorescence of the 249 nm B→X transition. By comparing signals observed in the presence and absence of cavity flux, we evaluated the ability of the photon field to depopulate the upper laser level by stimulated emission. From these experiments, we concluded that some of the KrF* population was in higher vibrational levels and could not be effectively extracted by stimulated emission at the normal laser operating wavelength.

[1]Permanent address: The Hebrew University, Jerusalem, Israel.

EB-2 <u>Study of the KrF Laser Medium at High E-Beam Pump Rate</u> - C.B. EDWARDS, F. O'NEILL and M.J. SHAW, <u>Rutherford Lab., U.K.</u> -- A large value of the ratio of gain to non-saturable loss is required for the KrF laser to operate efficiently. We have carried out a study to measure these parameters directly at high excitation rate in a 60 ns e-beam-pumped KrF laser as a function of pump power (0.7 - 3.7 MW/cm^3) and pressure (1000 - 3000 torr). Gain has been measured using a CW 248.2 nm probe laser (frequency doubled 496.5 nm Ar-ion line). Transient loss, both with and without lasing, has been measured by probing the pumped medium with a CW 257.2 nm laser (frequency doubled 514.5 nm Ar-ion line). Gains $\sim 13\% \text{ cm}^{-1}$, saturable losses $\sim 3\% \text{ cm}^{-1}$ and non-saturable losses $\sim 2\% \text{ cm}^{-1}$ have been recorded. A favourable gain to non-saturable loss ratio (i.e. ~ 10) is obtained for a laser pressure ~ 1500 torr and an e-beam pump rate $\sim 2 MW/cm^3$. Laser extraction efficiency measurements have also been performed in the same cell for comparison with the gain and loss measurements. A kinetic model has been developed to explain the experimental results.

EB-3   Long Pulse U.V. and I.R. Laser Emission from a
Low Temperature High Density Supersonic Flow Excited by
an Electron Beam Stabilized Discharge--B. FORESTIER, B.
FONTAINE, Institut of Fluid Mechanics, U. Aix-Marseille.
--The results related to U.V. emissions are an extension
of those given at 32nd GEC. It has not been possible to
achieve on XeCl transition laser emission from a super-
sonic flow ($T \simeq 100K$, $\rho < 2$ amagats) excited by an e-beam
stabilized discharge. The energy is increased by lowering
the temperature and by the discharge.

With a discharge excitation it has been possible to a-
chieve in a classical way, laser emission at 10.6μ on
CO_2, power is increased at low temperature and time de-
pendence is strongly modified. Due to supersonic flow of
active medium it has been possible with a short excita-
tion time (500ns) to achieve, 3 cm downstream the excita-
tion zone, a long pulse laser emission (tens of μs). The
conditions of these last experiments may be convenient to
achieve laser at longer λ in I.R. (14 and $16\mu m$) following
cascade transitions.

At last, some results related to Xe_2Cl, whose fluores-
cence emission is strongly increased at low temperature,
will be given. Gain on this trimer transition has been
recently achieved elsewhere.

EB-4   The Use of Computer Modeling to Optimize
Discharge Conditions in Excimer Lasers.*   W. L. WILLIS,
A. E. GREENE, C. R. TALLMAN, and L. A. HOLDRIDGE, Los
Alamos Scientific Laboratory--The KrF laser model of
Greene and Brau[1] has been reduced to a laser cavity gas
code and combined with a circuit analysis code, SUPER-
SCEPTRE. In this combination the gas code becomes inter-
active with the discharge circuit analysis as a time
varying load parameter. The result is a potentially
powerful tool for optimizing the laser system. The
effects of discharge duration, source impedance, current
density, rates of rise of current and voltage, and energy
deposition have been studied in several PFN configura-
tions. One circuit which the code predicted would be
particularly efficient, a non-symmetric Blumlein, has
now been constructed. The result is a doubling of the
efficiency of the laser from a "wall plug" efficiency of
0.7% to 1.6%. When XeCl is lased in the same cavity a
similar improvement in efficiency is achieved. Progress
on development of an XeCl gas code will also be discussed.

[1]A. E. Greene and C. A. Brau, IEEE JQE. 14, 951, 1978.

EB-5   Pulse Forming Networks for High Pressure Dis-
charges - W. H. LONG, JR., Northrop Research & Techno-
logy Center--The transfer efficiency for coupling energy
into a high-pressure gas discharge is investigated.
Single- and multi-stage pulse forming networks are con-
sidered in both parallel and series configurations.
Switching is achieved through a multichannel arc dis-
charge with empirically determined resistive time phase.
The load is modelled as a self-sustained glow discharge
with single- and multi-step ionization processes and
with attachment and recombination losses. A series
inductance is included in both the switch and the load
to simulate physical connection to the PFN. The dis-
charge voltage waveform reveals a transient regime and
a quasi-steady-state regime. The breakdown time is
controlled by the switch closing time, the load induc-
tance, and the single-step ionization rate. Impedance
matching in the steady-state regime is achieved with a
charging voltage determined by the PFN impedance and
the discharge current-voltage characteristic. Scaling
laws are derived for minimizing the switch and PFN
losses and maximizing the energy deposited into the
desired excited states of the gas.

EB-6   The Influence of Diluent Gas on the ArF*
Fluorescence Yield - R.S.F. CHANG, Naval Research Lab.--
ArF* (193 nm) emission intensity variation has been
studied as a function of pressure in Ar/F_2, $Ne/Ar/F_2$,
Ar/NF_3 and $Ne/Ar/NF_3$ mixtures under long pulse electron
beam excitation. Quenching rate constants of ArF* by
Ne, Ar, F_2 and NF_3 have been determined. We have
measured the ArF* fluorescence yield from each mixture
and with comparable energy deposition in the gas, the
$Ne/Ar/F_2$ mix gives the highest yield. The effect of
substituting neon for argon as the diluent gas will be
discussed in terms of the collisional quenching
kinetics.

SESSION FA

10:45 A.M., WEDNESDAY, OCTOBER 8, 1980

ROOM A

HEAVY PARTICLES II

CHAIRPERSON: G. A. PARKER

UNIVERSITY OF OKLAHOMA

FA-1 The Stability of Doubly Charged Rare Gas Molecular Ions--D. L. HUESTIS and H. HELM, Molecular Physics Laboratory, SRI International, K. STEPHAN and T. D. MÄRK, Institute für Experimentalphysik, Leopold Franzens Universität, Innsbruck, Austria.--Simple consideration of atomic first and second ionization potentials shows that for certain atomic combinations stable diatomic ions carrying two positive charges should exist below the lowest dissociation limit. One such ion, $NeXe^{++}$, has been observed experimentally by double ionization of the van der Waals dimer NeXe. Similar experiments also resulted in production of a long-lived $ArXe^{++}$ ion. The stability of these doubly charged molecular ions is rationalized using semiquantitative potential curves derived from the isoelectronic neutral molecules XeO and ICl. These potential energy curves lead to reinterpretation of the observations of other investigators on the kinetics of the low lying states of Xe^{++} in Ar and Ne.

FA-2 Reactions of CO_2^{++} at Thermal Energies

A.S.M. RAOUF, J.D.C. JONES, K. BIRKINSHAW & N.D.TWIDDY University College of Wales, Aberystwyth, U.K.

The reactions of CO_2^{++} with He, Ne, Ar, Kr, Xe, O_2, N_2, H_2, CO, NO, CO_2, COS, CH_4 and C_2H_4 have been studied using a selected ion flow tube (SIFT) technique at thermal energies (300K). Reaction rate coefficients have been determined, and in general these are found to be close to the appropriate (Langevin or ADO) gas kinetic values.

   Those reactions for which ionic product identification has been possible are found to proceed by a charge transfer mechanism:

$$CO_2^{++} + (X) \rightarrow \begin{cases} CO_2^{+} + (X)^{+} & \text{(a)} \\ O^{+} + CO + (X)^{+} & \text{(b)} \end{cases}$$
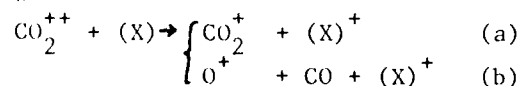
For neutral reactants having exoergicities for simple charge transfer less than 7-8eV, channel (a) was found to dominate. For other cases, (b) appeared to be the major channel. Although

$$CO_2^{++} + Ne \rightarrow CO_2^{+} + Ne$$

is exoergic by about 1eV, no reaction was observed.

FA-3 Selective Formation of He^+ (n=3) in He^{++}-Li Collisions* J.L. BARRETT and J.J. LEVENTHAL, Univ. of Mo.-St. Louis. --Excited state formation in inelastic He^{++}-Li collisions has been diagnosed by dispersal and detection of both visible and soft x-ray radiation emanating from the intersection of He^{++} and Li beams. The theoretical predictions of Shipsey et. al.[1], that He^+ (n=3) is preferentially formed, are found to be valid. The cross section for this selective process is sufficently high to support the suggested application for production of super-radiance at the HeII Lyman α and Lyman β wavelengths, $304\mathring{A}$ and $256\mathring{A}$ respectively.

[1]E.J. Shipsey, L.T. Redman, J.C. Browne and R.E. Olson, Phys. Rev A, 18, 1961(1978).

FA-4 Electron Transfer in Collisions between Protons and Photoexcited Na(3p).*C.E. BURKHARDT, V.S. KUSHAWAHA AND J. J. LEVENTHAL,Univ. of Mo. St. Louis -- The enhancement in production of H(n=2) from H^+-Na(3p) collisions over that produced in H^+-Na(3s) collisions has been studied in an ion beam apparatus using a dye laser tuned to the Na(3s $\rightarrow$ 3p) transition to produce Na(3p) target atoms. Detection of Lα radiation synchronized with the mechanically chopped cw laser beam indicates that enhancement occurs only for relative kinetic energies below 25 eV. The highest enhancement observed in the kinetic energy range 1-25 eV is less than a factor of two.

FA-5   Charge Transfer Processes during N+ Collisions.-
C. R. SZMANDA, R. S. HOZACK and K. B. MCAFEE, JR., Bell
Telephone Laboratories, Murray Hill, New Jersey. --
Studies of N+ collisions at intermediate energies with
beams of various diatomic and atomic particles have ex-
hibited a wide variety of energy and charge transfer
processes, interference effects, and spin fine-struc-
tures. By measuring accurately, the differentially
scattered slow target particle deflection, transfer re-
actions involving the ^{3}P, ^{1}D, ^{1}S states as well as pos-
sibly the ^{5}S are clearly resolved. The relative charge
exchange cross-sections for processes involving polar
molecules like CO are radically different from those ob-
tained in N_2. For the N+ on N_2 system we find that the
^{3}P and ^{1}D states have very low cross-sections while the
^{1}S and ^{5}S states interact strongly. For N+ on CO all
excited N+ states interact. In the case of N+ colli-
sions with atomic neutrals the effects of spin fine-
structure are evident.

FA-6   Charge Transfer and Spin Change in Ar$^+$ + Ar,
R. E. JOHNSON and E. STEVEKA, University of Virginia,
and K. B. MCAFEE, Bell Laboratories.--Calculations of
differential scattering cross sections for charge ex-
change in Ar$^+$ + Ar have been carried out in the energy
range 100 eV to 300 eV for CM angles less than 10°.
These calculations allow for transitions between the
fine structure multiplet of the Ar$^+$(^{2}P$_j$) state. In the
partial wave expansion we use transition amplitudes ob-
tained in the impact parameter approximation. Compari-
son is made with the crossed-beam experiment of McAfee
et al.[1] The effect of the fine structure splitting and
rotational coupling will be discussed.

[1] K. B. McAfee, R. Hozack, and R. E. Johnson, Phys. Rev.
Lett., to be published (1980).

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FA-7 <u>Four-Body Conversion of Atomic Helium Ions.</u>[*]
C.P. de VRIES and H.J. OSKAM, <u>University of Minnesota</u>.
The conversion of atomic helium ions into molecular
ions was studied in pure helium and in helium-neon
mixtures containing between 0.1% and 50% neon. The
addition of neon to the gas allowed measurements of
the conversion rate over a wider range than ordinarily
possible in pure helium afterglows. The measurements
showed that the termolecular conversion reaction,
$He^+ + 2He \rightarrow He_2^+ + He$, is augmented by the four-body
conversion reaction $He^+ + 3He \rightarrow products$. Conversion
rate coefficients of $(5.7 \pm 0.8) \times 10^{-32} cm^6 sec^{-1}$ and
$(2.6 \pm 0.4) \times 10^{-49} cm^9 sec^{-1}$ were found for the termolecu-
lar and four-body conversion reactions, respectively.
Conversion of Ne^+ ions was also measured in the ex-
periments, but it did not exhibit any four-body re-
action component in the pressure ranges studied.

FA-8   <u>Isotope Effects in the Reactions of Rare Gas</u>
<u>Ions with Isotopic HYdrogen</u>. A. PIZAM, I. DOTAN, and
F.S. KLEIN, <u>Isotope Dept., Weizmann Institute of Sci.,</u>
<u>Rehovot, Israel</u>--Inter- and intra-molecular isotope
effects were studied in the reactions of Ar^+ and Kr^+
ions with H_2, HD and D_2. The study has been carried out
in an ion source of a Varian MAT CH4 mass spectrometer
operated in a pulsed mode. The energy could be varied
between thermal to 1 eV ion kinetic energy. The intra-
molecular isotope effect for both reactions showed an
increase with increasing kinetic energy. The increase
was much faster for the reaction of Kr^+ ions than for
the reaction Ar^+ ions. The intermolecular isotope effect
for the reaction of Kr^+ ions showed an unusual behavior
$k_{HD} > k_{H_2} > k_{D_2}$. The rate constants for all three reactions
show only a small energy dependence. The rate constants
for both channels of the reaction of Ar^+ ions with
hydrogen - charge transfer and atom abstraction -
increase with increasing kinetic energy. The intra-
molecular isotope effect for the charge transfer channel
shows the usual behavior $k_{H_2} > k_{HD} > k_{D_2}$, whereas the atom
abstraction gives: $k_{H_2} > k_{HD} > k_{D_2}$.

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SESSION FB

10:30 A.M., WEDNESDAY, OCTOBER 8, 1980

ROOM B

XENON-CHLORIDE LASERS

,

CHAIRPERSON: D. KLIMEK

AVCO EVERETT RESEARCH LABORATORY

FB-1 Study of XeCl/Xe$_2$Cl Excited State Kinetics Using Synchrotron Radiation Excitation - K. Y. TANG, D. C. LORENTS, R. L. SHARPLESS and D. L. HUESTIS, Molecular Physics Laboratory, SRI International, Menlo Park, CA 94025 and D. HELMS, M. DURRETT and G. K. WALTERS, Physics Department, Rice University, Houston, Tx 77001 -- Formation and decay processes of XeCl/Xe$_2$Cl excited states have been studied by following the time decay behavior of the chemiluminescence from XeCl* and Xe$_2$Cl*. The experiments wer carried out using synchrotron radiation to excite Xe and Cl$_2$ in various gas mixtures in the wavelength region between 1100 and 1500 Å. Fluorescence excitation spectra of Cl$_2^*$, XeCl(B), XeCl(C) and Xe$_2$Cl* were scanned in order to characterize the origin of reacting species. Emissions from XeCl*/Xe$_2$Cl* were observed with Xe/Cl$_2$ mixtures when either Xe or Cl$_2$ was excited. The time-resolved fluorescence from the individual excited species was monitored using a time-correlated single-photon-counting device. Reactions were identified through the excitation of Xe and Cl$_2$ and their rate constants were determined from Stern-Volmer plots. Results will be discussed.

FB-2 Electron Beam-Pumping of XeCl Using Variable Current Density - H. T. POWELL and R. J. POLI, Lawrence Livermore National Laboratory*-- We have studied the XeCl fluorescence and laser performance as a function of e-beam current density, gas mixture, and laser cavity reflectors. A well-defined gas volume was homogeneously excited by an e-beam current density in the range 5-500 A/cm^2 for a period of 50 ns. We have used either Cl$_2$, HCl, CCl$_4$, or CCl$_3$F as chlorine donors and have observed qualitative effects caused by vibrational excitation of the donor and subsequently increased electron attachment, burn-out of the chlorine donor, and electron deactivation of XeCl. We found only minor differences in both fluorescence and laser performance between Ne, Ar, and Kr as majority diluents. We also studied the saturation of XeCl caused by intracavity laser fluences up to 10 MW/cm^2 and the deleterious effect on the laser performance of transient medium absorption.

FB-3   Kinetics of E-Beam Excited XeCl -
W. L. MORGAN and M. J. POUND, Lawrence Livermore
National Laboratory*--A detailed kinetic model has
been used in the interpretation of the XeCl fluo-
rescence measurements of Powell and Poli (previous
paper). We have performed calculations for
Ne/Xe/HCl and Ne/Xe/Cl$_2$ mixtures for e-beam
pumping powers of 40-4000 kW/cm^3 corresponding to
the 5-500 A/cm^2 of the experiment. We find that
the peak fluorescent intensities using HCl are much
greater than obtained with Cl$_2$ and exhibit a dif-
ferent current dependence. We attribute this to
the much larger HCl attachment rate, which is
enhanced by vibrational excitation. The effects of
electron quenching of XeCl and burnout of the halo-
gen donor also appear in the current dependence of
peak fluorescence and in the temporal fluorescence
profiles. We estimate the rate coefficient for
electron quenching of XeCl to be 2 x 10^{-8} cm^3/s.

FB-4   XeCl Long Pulse Laser Kinetics Model.
L.A. LEVIN, S.E. MOODY, E.L. KLOSTERMAN, J.J. EWING,
R.E.CENTER, Mathematical Sciences N.W. --A kinetics
model which is used to predict absorption, gain, and
long pulse XeCl laser performance in multiatmospheric
neon/xenon/HCl mixtures is described. The results
obtained using the model are compared to measured trans-
ient absorption in pure Ne/Xe mixtures as well as to
measured laser performance at several laboratories. A
key distinguishing feature of the model is the inclusion
of a fast 3-body charge exchange process between Ne$_2^+$
and Xe$^+$. This process provides an effective direct
channel for XeCl* formation thru ion-ion recombination
of Xe$^+$ and Xe$_2^+$ with Cl$^-$. The results show that Xe$_2^+$ is
the major absorber in pure Ne/Xe mixtures where the Xe
concentration exceeds roughly .75%. For lower Xe con-
centrations, Ne$_2^+$ is the dominant absorber. In optimum
laser mixtures, the majority absorber is Cl$^-$ with
roughly equal contributions from Xe$_2^+$ and Xe$_2^*$ and less
with Ne$_2^+$.

FB-5 Long Pulse (200 nsec) Avalanche Discharge Excimer Laser Operation - JEFF LEVATTER and SHAO-CHI LIN, University of California, San Diego.[*] -- High energy loadings (100 to 500 J/ℓ-atm) with a 200 nsec discharge duration have been obtained in an above atmospheric pressure XeCl laser system. These discharges appear to be spatially uniform and show only a relatively small temporal impedance collapse. The experimental apparatus used consists of an x-ray pre-ionized, 1-liter volume, low impedance H_2O transmission line driven, avalanche discharge device. Under appropriate conditions, high energy ultraviolet 200 nsec laser pulses have also been produced.

FB-6 Theoretical Modelling of Discharge Kinetics in Transmission Line Driven Excimer Lasers - YUH-SHUH WANG and SHAO-CHI LIN, University of California, San Diego.[*] --Theoretical modelling of the discharge kinetics in rare gas halide excimer lasers driven by a transmission line type pulse forming network (PFN) is described. Appropriate gas kinetic equations are solved simultaneously with the time evolution of the electron mole fraction during the transient discharge. The time-dependent electron energy distribution function is obtained from numerical solution of the Boltzmann equation with all relevant elastic (including electron-electron), inelastic, attachment, recombination, and ionization collisions through a self-consistent iteration technique. This theoretical model has been used in a parametric study of XeCl laser performance in relatively long pulse operations. These numerical results are also compared with some recent experiments.

FB-7   Experimental and Theoretical Performance
Characteristics of an X-ray Preionized, 100 ns Discharge
XeCl Laser - B. L. WEXLER and L. J. PALUMBO, Naval
Research Laboratory--Measurements have been made of the
voltage and current in a transmission-line driven, x-ray
preionized XeCl laser as a function of gas mixture,
pressure and charging voltage. When compared with
laser output, preliminary results indicate wallplug
efficiencies over 1% and instantaneous power effici-
encies over 2%. The experimental data compare well
with the predictions of a model which includes the
discharge circuitry.

SESSION G
1:30 P.M., WEDNESDAY, OCTOBER 8, 1980
FORUM ROOM

MERCURY BROMIDE AND INTERHALOGEN LASERS

CHAIRPERSON: R. WEXLER
               NAVAL RESEARCH LABORATORY

G-1   Spectroscopy, Kinetics and Laser
Action in Interhalogen Molecules
M. DIEGELMANN, H.P. GRIENEISEN, F. REBEN-
TROST, K.L. KOMPA, Max-Planck-Gesellschaft,
Projektgruppe f. Laserforschung, Garching,
W. Germany - Fluorescence emission originat-
ing from the $D'(^3\pi_2) \leftarrow A'(^3\pi_2)$ transitions
of all diatomic interhalogen compounds has
been studied with e-beam excitation. Wave-
lengths between 284 nm (ClF) and 491 nm (IF)
were found. The experimental results are
interpreted on the basis of a molecular
model allowing for the prediction of the ob-
served spectra. The kinetics of the produc-
tion of the upper level is discussed in de-
tail. Kinetic parameters were determined
from time-resolved measurements of the
fluorescence signals for F_2^*, Cl_2^* and I_2^*.
Experiments to excite these molecules in a
fast transverse discharge configuration led
to three new laser systems (ClF, BrF and IF).
Energies in the mJ range were obtained.

G-2   IC and IF E State Radiative Lifetimes and
Quenching Rate Constants[*] - M.L. DLABAL, S.B. HUTCHISON[⊥]
and J.G. EDEN, Univ. of Illinois, Urbana, IL 61801 --
The radiative lifetime of the violet IC (E → A) band
and the ICℓ (E) state quenching rate constants have
been obtained by electronically exciting IC with an
ArF (193 nm) laser or a 600 keV electron beam. By
examining the exponential decay of the IC spontaneous
emission for various IC pressures, the E → A radiative
lifetime was found to be 14 ± 1 ns. Similar experiments
involving the IF (E → A) band have been performed by
photodissociating IF_5 using an excimer laser.

[⊥] Present address: GTE-Sylvania, P.O. Box 188,
Mountain View, CA   94042.

G-3 Lasing Characteristics of Iodine-Monofluoride - R. J. DE YOUNG, Miami U.*--Recently, lasing has been observed in IF* at 491 and 484 nm in mixtures of He/CF_3I/ NF_3. Optimum lasing in a UV preionized TEA discharge, was observed at an E/N of 1.8 x 10^{-16} with 1277/.65/2 Torr of He/CF_3I/NF_3 using a 32% transmission output cavity mirror and Rmax back mirror. The media gain, under optimum conditions, was found to be ~2% per cm. Lasing occurred in both F* and IF*, but F* lasing (~700 nm) always preceeded IF* lasing in time indicating that a precursor to IF* lasing is excited fluorine. With a 32% transmission output mirror, and optimum gas conditions, the IF* lasing output was 4 μ Joules. Passivation of the laser cell with CF_3I was necessary for longer term static operation.

G-4 IF Blue-Green Laser* - M.L. DLABAL, S.B.HUTCHISON[+], J.G. EDEN and J.T. VERDEYEN, Univ. of Illinois, Urbana, IL 61801 -- Lasing on five transitions (472.7, 478.7, 484.7, 490.7 and 496.5 nm) of the IF(E → A) band has been observed in discharge pumped He, NF_3 and CF_3I gas mixtures. Single pulse energies greater than 2 mJ in a ~30 ns FWHM pulse (~70 kW peak power) have been obtained. Gain measurements have also been performed (using a tunable dye laser) and reveal that gain in excess of 0.8% - cm^{-1} exists over the entire 470-500 nm wavelength region. The small signal gain coefficient at the 491 nm band peak is (2.4 ± 0.2)% - cm^{-1}. Similar experiments have been conducted for the ICℓ(E → A) band and the results will be discussed.

+ Present address: GTE-Sylvania, P.O. Box 188, Mountain View, CA 94042.

G-5   Optical and Electrical Characteristics of E-Beam Ionized $HgBr_2$ Dissociation Lasers - R. BURNHAM and W. T. WHITNEY, Naval Research Laboratory--Measurements have been made of the voltage-current characteristic, laser output, and optical extraction efficiency from $HgBr(B \rightarrow X)$ lasers. The lasers were pumped by dissociative excitation of $HgBr_2$ in a self-sustained discharge preionized by a small e-beam. Laser energies of 50 mJ were obtained with efficiencies of 0.1% overall and 0.4° instantaneous. Sidelight fluorescence experiments give extraction efficiencies between 15% and 30%. The extraction efficiency may be limited either by intracavity absorption or by bottlenecking in the lower laser level. These efficiency-limiting processes are presently under investigation and results from these studies will also be presented.

G-6   Investigation of HgBr* Excitation by X-Ray Sustained Discharge in $Xe/HgBr_2$ Mixtures.   J. DEGANI, M. ROKNI and S. YATSIV, Hebrew University.--The excitation kinetics and luminescence of HgBr* are investigated in $Xe/HgBr_2$ mixtures, under X-ray irradiation as well as under X-ray sustained low current discharge. The discharge characteristics are studied for mixtures containing variable amounts of $HgBr_2$. A value of $8.4 \times 10^{-11} cm^3$ sec^{-1} is measured for the attachment rate of slow electrons to $HgBr_2$, by observing the decay of the electron current following a 30 nsec. X-ray radiation pulse. From the dependence of the intensity of the HgBr $B \rightarrow X$ transition on themercuric bromide density, the quenching rate of HgBr* by $HgBr_2$ is determined. The dependence of the emitted radiation intensity on the applied electric field is investigated and its spatial distribution is studied. Experimental evidence for generation of HgBr* by dissociative excitation of $HgBr_2$ by electrons at energies below 10 eV is presented. The formation kinetic processes conforming with the experimental results are discussed.

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G-7   Efficient HgBr(B→X) Laser Oscillation in E-Beam Controlled Discharge Excited Xe/HgBr$_2$ Mixtures--R. T. BROWN and W. L. NIGHAN, United Technologies Research Center*--This presentation reports results of an investigation of e-beam controlled discharge-excited HgBr(B)/HgBr$_2$ dissociation lasers using Xe as the primary energy receptor-transfer species. Experimental discharge and laser characteristics are reported which show that when Xe is used in place of N$_2$ in the HgBr$_2$ dissociation laser, a substantial improvement in efficiency is obtained. In addition, calculations show that the discharge excited Xe/HgBr$_2$ dissociation laser has considerable potential as a blue-green laser source, with potential electrical-optical energy conversion efficiency in the 5-10% range.

G-8   Small Signal Gain, Fluorescence and Energy Deposition in an HgBr$_2$/HgBr Dissociation Laser —

T. M. SHAY, F. HANSEN, M. C. JORDAN, D. GOOKIN, and E.J. SCHIMITSCHEK, Naval Ocean Systems Center, San Diego CA, 92152
—The small signal gain (g_o), fluorescence and energy deposition of an HgBr laser has been measured as a function of both N$_2$ partial pressure and wavelength. The experimental set-up was similar to the one described previously (1). The gas fill consisted of Ne or Ne/N$_2$ mixtures with a total gas pressure of 1000 torr (measured at 20°C). The HgBr$_2$ vapor pressure was 2.3 torr (155°C). A dye laser was used to probe g_o, while the relative population of HgBr(B) was monitored by sidelight fluorescence. The spectral dependence of g_o for the HgBr laser follows the spontaneous emission profile of the HgBr B —→ X transition. g_o at the spectral peak of the B —→ X emission (502nm) has been measured to be up to 9.5%/cm with 100 torr of N$_2$ and a maximum of 7.2%/cm without N$_2$. An intrinsic laser energy efficiency of 2.2% has been measured when operating under optimum conditions.

[1] E.J. Schimitschek and J.E. Celto, Appl. Phys. Lett. 36, 176 (1980).

SESSION H
3:00 P.M., WEDNESDAY, OCTOBER 8, 1980
FORUM ROOM

WORKSHOP ON KINETIC PROCESSES IN ELECTRONIC TRANSITION
LASERS

THIS WORKSHOP WILL FOCUS ON RECENT EXPERIMENTAL AND
ANALYTICAL WORK IN UNDERSTANDING IMPORTANT KINETIC
MECHANISMS LEADING TO THE FORMATION OF UPPER STATES OF
RARE GAS HALIDE AND MERCURY HALIDE LASERS. IONIC AND
NEUTRAL FORMATION CHANNELS WILL BE DISCUSSED IN THE
CONTEXT OF ELECTRON BEAM AND DISCHARGE-EXCITED LASER
DEVICES.

CHAIRPERSON: H. T. POWELL
            LAWRENCE LIVERMORE LABORATORY

NEUTRAL REACTIONS INVOLVING RARE GAS HALIDE MOLECULES

D. Setser

CHARGE TRANSFER PROCESSES IN RARE GASES

C. Collins

ELECTRON IONIZATION RATES IN ELECTRICAL DISCHARGE LASERS

K. Nygaard

KINETIC PROCESSES IN SELF-SUSTAINED RARE GAS HALIDE
AND MERCURY HALIDE LASERS

R. Burnham

MODELING OF DISCHARGE-EXCITED RARE GAS HALIDE LASERS

A. Greene

MODELING OF ELECTRON-BEAM-EXCITED, SHORT-PULSE KrF LASERS

D. Klimek

SESSION I

9:00 A.M., THURSDAY, OCTOBER 9, 1980

FORUM ROOM

EXCITATION TRANSFER

CHAIRPERSON: G. SALAMO

UNIVERSITY OF ARKANSAS

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I-1   Laser-induced Collisional Energy Transfer*, GREG-ORY A. PARKER and JOHN C. LIGHT, University of Oklahoma. --A rotational decoupling approximation is developed for the interaction of an s-state atom with a Σ-state diatomic molecule in the presence of an intense laser field. Coupled channel calculations are presented for the field dependent collisions of He with HF and TF. The results indicate that an intense field strength ($\sim 10^8$ watts/cm^2) is necessary to induce a significant amount of translational-to-vibrational energy transfer. However with an intense laser field significant translational-to-vibrational transition probabilities are obtained for frequencies which are nearly 200 cm^{-1} off resonance from the nearest dipole allowed transition of the isolated diatom.

I-2   Energy Pooling in Na(3p) - Na(3p) Collisions* V.S. KUSHAWAHA and J.J. LEVENTHAL, Univ. of Mo.-St. Louis. --The formation of Na(nℓ) and Na$_2^+$ in sodium vapor ($\sim 10^{13}$ cm^{-3}) irradiated by a single frequency (20MHz bandwidth) cw dye laser tuned to one of the D lines has been studied. The dependence of product signal on laser power density suggests that Na(3p) - Na(3p) energy pooling collisions are responsible for these species. Rate constants for specific reaction channels and temperature dependences of rate constants will also be reported.

I-3   Measurement of the Collisional De-excitation Rate Coefficient of $He_2(d^3\Sigma_u^+)$ with $He(1^1S)$.* J. W. PARKER, L. W. ANDERSON, W. A. FITZSIMMONS, and CHUN C. LIN, U. of Wisconsin-Madison.--We report a bimolecular rate coefficient of $(2.5\pm0.17)\times10^{-12}cm^3sec^{-1}$ at 293°K for the quenching of $He_2(d^3\Sigma_u^+)$ molecules by collision with $He(1^1S)$ atoms; this reaction is measured in the afterglow of a pulsed helium discharge. A pulsed dye laser is used to excite molecules from the metastable $a^3\Sigma_u^+$ level to the $e^3\Pi g$ level. Rapid collisional relaxation transfers some of the $e^3\Pi g$ molecules to the $d^3\Sigma_u^+$ level. The quenching rate of the $d^3\Sigma^+$ population is measured by monitoring the $d^3\Sigma_u^+ \rightarrow b^3\Pi g$ laser-induced fluorescence for various discharge pressures between 50 and 800 Torr. This result will be compared to previous work.

I-4   Temperature Dependence of the Rate Constants for the Three Body Quenching Reactions in the KrF* Laser System*, D. KLIMEK AND J. HSIA, Avco Everett Res. Lab., Inc.-- The KrF* and Kr_2F^* fluorescence emissions from e-beam excited $F_2/Kr/Ar$ mixtures were measured over the temperature range of 315°K to 420°K, at total densities of 1,2, and 3 amagats. These data were used in conjunction with kinetic model calculations to evaluate the temperature dependence of three body quenching reactions of the type:

$$KrF^* + R + M \rightarrow RKrF^* + M$$
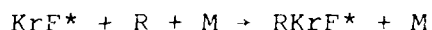
where: R = Ar, Kr and M = Ar, Kr
The temperature dependences of the corresponding rate constants were calculated by Shui[1]. The decrease in three body KrF* quenching with increasing temperature deduced from the experimental data agrees with that calculated to within 15%. Details of the experiment, and comparison with model calculations, will be presented.

1. V.H. Shui, Appl. Phys. Lett. 34, 203 (1979).

I-5   Vibrational Relaxation of NO(v=1-8) Created in Electron Irradiated N_2/O_2 Mixtures - B. D. GREEN and G. E. CALEDONIA, Physical Sciences Inc. and R. E. MURPHY, Air Force Geophysics Laboratory*--The technique of time resolved spectroscopy has been applied to the measure-ment of the room temperature relaxation of highly excited vibrational levels of molecules created in electron irradiated mixtures. Fluorescence from up to 10 excited vibrational levels of NO was observed, supporting the $N(^2D)+O_2$ reaction channel for NO formation. The decays from eight levels could be followed to obtain preliminary estimates of the reaction rate constants for the processes $NO(v)+O_2 \longrightarrow NO(v-1)+O_2$. The role of other quenchers such as N_2 and the beam created species O and N in the relaxation of NO(v) has also been estimated in light of the kinetic data and computer modeling calculations.

SESSION JA
10:10 A.M., THURSDAY, OCTOBER 9, 1980
ROOM A

DISTRIBUTIONS AND TRANSPORT PROPERTIES

CHAIRPERSON: J. INGOLD
              GENERAL ELECTRIC, CLEVELAND

JA-1 Extended Boltzmann Analysis Applied to Electron Swarm Experiments in N_2.* L.C. PITCHFORD and A.V. PHELPS[†] -- JILA, Univ. of Colo. & NBS. - The recently developed technique[1] for the solution of the electron Boltzmann equation using a multi-term spherical harmonic expansion has been applied to the analysis of electron swarm experiments in N_2. Using this method, transport coefficients and rate coefficients for vibrational excitation, electronic excitation and ionization have been calculated for electrons in N_2 over a range of E/N from 10^{-17} to 2×10^{-15} V-cm^2. Significant differences are found between the results of the two-term and the converged (six-term) calculations for some parameters. For example, there is almost a 30% difference in calculated excitation rate coefficients for the N_2 A state at an E/N of 7×10^{-16} V-cm^2, while very little change is found for other parameters. In addition, the effects of anisotropies in the electron scattering cross sections on the calculated transport and rate coefficients have been investigated.

1. L. C. Pitchford, S.V. ONeil and J. R. Rumble, Jr., Phys. Rev. A (submitted).

JA-2 Enhanced Electron Conductivity in Ramsauer Gases-Molecular Gas Mixtures: Absolute Inelastic Cross-Section Calibration. A. GARSCADDEN, G.A. DUKE, and W.F. BAILEY, Aero Propulsion Lab., Air Force Wright Aeronautical Labs., and A.F. Institute of Technology. Wright-Patterson AFB Ohio 45433.--Calculations of the electron conductivity using a numerical solution of the collisional Boltzmann transport equation for CO-Xe, CO-Kr, CO-Ar, N_2-Ar and similar molecular gas-rare gas mixtures have revealed that the electron drift velocity is significantly enhanced for certain proportions of the mixed gases. For example, in CO-Kr, for 10% CO, 90% Kr, at an E/N = 15 Td, the electron drift velocity is 7.6×10^6 cm sec^{-1}, as compared to 1.4×10^6 cm sec^{-1} in pure krypton and to 2.2×10^6 cm sec^{-1} in pure carbon monoxide. The enhancement effect, which requires a total momentum transfer collision frequency increasing with energy and a low energy inelastic loss process, is non-linear in the fractional concentration of the molecular gas. This non linearity combined with the sensitivity of the drift velocity to the ratio of the elastic collision frequency compared to the inelastic collision frequency, permits calibration of the inelastic cross-section magnitude.

JA-3 Complementarity Theorem for Position-Dependent Electron Velocity Distributions. P.J. CHANTRY, Westinghouse R&D Center.--When a stream of electrons drifting in a uniform field approaches an absorbing anode, their density and velocity distribution become functions of position. As pointed out by Lowke et al.,[1] the position dependence in this situation (I) is complementary to that existing in a second situation (II), where electrons diffuse upstream and drift downstream from a steady transparent planar source. The theorem can be proved via a simple "gedanken" experiment which reveals some minor errors in the earlier work,[1] and explains unexpected features of a previous Monte-Carlo simulation of II. The ideal source for such simulations of II is shown to be the electrons impinging on the anode in I. This ideal source will produce the velocity distribution appropriate to E/N for all downstream positions, allowing the computational space to be minimized. It cannot be prescribed a priori in detail, but clearly it should occupy only the forward hemisphere, and based on available data,[1,2] have a mean energy approximately twice the equilibrium value.

[1] J.J. Lowke, J.H. Parker, Jr., and C.A. Hall, Phys. Rev. A15 1237, (1977).

[2] G.L. Braglia and J.J. Lowke, J. Phys. D12 1831 (1979).

JA-4   Behavior of Townsend's α/N at High E/N- M. HAYASHI, Nagoya Inst.Tech.-- The authorities suggested that α/N should decrease with increasing E/N at sufficiently high values of E/N. This is based on the fact that the ionization cross section has a maximum at electron energy of about 100eV. L.H.Fisher concluded in his unpublished paper that there was no credible experimental evidence that any gas displayed a maximum in its α/N versus E/N curve.

Recent experiments of Haydon's and our groups and our Monte Carlo calculations show the fact that the energy distribution functions of electron avalanches are unequilibrium at high E/N, so the α of $I = I_0 \exp[\alpha (d-d_0)]$ can not be defined. In the gases which have the small cross sections, these breaks occur easily. The value α is defined when E/p_0 is smaller than about 300 V/cm·Torr in He and H_2. The exact experiments of α in He at E/p_0 of about 300 or so are needed. The value I_0 is not the initial photoelectric current and it is a function of E/N. And the value d_0 is not the energy equilibrium distance even at low E/N.

JA-5 Non-LTE Plasma Recovery, GUNTER ECKER, Ruhr-
Universitat, Bochum, FRG -- Numerous investigations
studying the recovery of a residual plasma under the
influence of an electric field are based on the assump-
tion of local thermodynamic equilibrium (LTE). However,
the strong energy flux within the velocity space of the
electrons due to inelastic phenomena and from the elec-
tron component to other particle components of the gas
may cause deviations from LTE strong enough to affect
substantially the recovery process. Our analysis consi-
ders a uniform nitrogen plasma of given initial ioniza-
tion in its time development under the influence of an
instantaneously applied homogeneous electric field.
Inelastic collisions of the first and second kind in the
vibrational and electronic range are taken into account.
We find that LTE-deviations cause order of magnitude
differences in the recovery-rise-time.

JA-6 Microwave Interactions of Electrons in Glow Dis-
charges, FRANK T. WU and CHARLES ROBERTS, Naval Weapons
Center, China Lake CA.--The plasma-microwave interactions
in a gas-filled discharge tube were investigated from the
kinetic theory point of view. To do this the Boltzmann
equation is formulated for the problem with the assump-
tion that the discharge is operated in a normal glow,
and, therefore, a spatially homogeneous plasma. The
electron energy distribution is numerically integrated
for some typical plasma density and discharge conditions,
under the influence of microwave radiation. Some derived
transport coefficients, such as the electron conductivity,
electron kinetic temperature, and electron collision
ionization coefficient, are obtained from the calculated
electron energy distribution function. These coeffi-
cients are treated as a function of microwave frequencies,
typically in the range of 2-20 GHz. The results of D.C.
and Microwave discharges are compared. Further insight
into the possible usage of a gas-filled discharge tube as
a detector for microwaves will be discussed.

JA-7   Microwave Measurements on a Neon Plasma Induced
by a Proton Beam - M. FITAIRE, J. MARGOT, A.M. POINTU
and M. VIALLE, Université Paris-Sud, France[*]--Calcula-
tion of low and medium energy part of the electron dis-
tribution function of a Neon plasma, induced by a stead
-state low intensity proton beam, have been performed
using a simplified formalism[1]. In order to improve its
validity, a microwave cavity method involving a P.L.L.
technique, has been applied to our experiment, allowing
an automatic recording of mean electronic density and
effective electron-neutral collision frequency, versus
variable gas pressure (10 to 500 Torrs) and beam curre
density (0.1 to 2 $\mu A/cm^2$). Comparison with correspondi
calculated moments using previous distribution functio
is found to be satisfactory.

[1]A.M. Pointu, D. Auphelle, F. Euvé, M. Fitaire and
M. Vialle, to be published in Journal de Physique.

SESSION JB
10:20 A.M., Thursday, October 9, 1980
Room B

METASTABLE REACTIONS

Chairperson: D. Fahey

Environmental Research Laboratorie

JB-1 Quenching of Neon Metastable Atoms in Pure Neon Afterglows - J. CLARK* & A. J. CUNNINGHAM, Univ. Texas at Dallas.--We report the results of a study of the quenching of neon metastables in a pure neon afterglow. Two and three body rate coefficients for the destruction of $^3P_0$, $^3P_1$, $^3P_2$, and $^1P_1$ states of neon were measured. The experiments were conducted over a temperature range of -100 to +200 degrees celcius, and a pressure range of 10 - 500 Torr. A single frequency dye laser was used to monitor the temporal evolution of the absolute population density of the lowest lying states of neon using absorption spectroscopy. Measurements of the absorption line profiles versus pressure and temperature in a pulsed D.C. discharge will also be presented.

JB-2 Energy Transfer Processes in Helium-Copper Afterglows.* D.W. ERNIE and H.J. OSKAM, University of Minnesota.--The time dependencies of 35 CuI energy levels between 15.96 eV and 24.62 eV were studied using light emission and absorption spectroscopy during the afterglow of a sputtered He-Cu hollow cathode discharge. By measuring the decay of the $He^m(2^3S)$ and $Cu(4s^2s^1)$ densities, it was possible to determine the helium species He^+, He_2^+, $He^m(2^3S)$, and $He_2^m(a^3\Sigma_u^+)$ responsible for production of the CuII states. The CuII levels between 22.7 eV and 24.62 eV are produced, either directly or by cascading, by charge exchange between He^+ and Cu. The CuII levels between 15.96 eV and 21.41 eV are produced by charge exchange between He_2^+ and Cu. The dependence on the energy defect of the reaction rate coefficients for this process indicates that the reaction occurs via a dissociative charge transfer mechanism. No evidence was found for the production of CuII states by the Penning ionization of Cu by $He^m(2^3S)$ or $He_2^m(a^3\Sigma_u^+)$.

JB-3 Penning Ionization of Sr in Optogalvanic Effect.
R. SHUKER, A. BEN-AMAR and G. EREZ, Ben-Gurion Univ.
and E. MIRON, Nuc. Res. Center-Negev.-- The optogalvanic
technique is used to study the Penning Ionization of Sr
in a discharge plasma of Sr and Ne mixture.[1] The meta-
stable level of Ne, $^3P_0$, at 134821 cm^{-1} is within kT
from the second ionization level of Sr (at 134890 cm^{-1}
from the ground of neutral Sr) and the second metastable
of Ne, $^3P_2$, at 134044 cm^{-1} is within kT from many SrII
levels, where T is the translational temperature of the
gas discharge. Thus a Penning ionization of Sr by Ne
metastables can be achieved. A pulsed nitrogen pumped
dye laser tuned to transitions from these matastable
levels of Ne is used. The resulting optogalvanic signal
has a characteristic positive part, a few tens of μsec.,
after the laser excitation exhibiting the effect of the
energy transfer by the Penning effect.

[1] R. Shuker, A. Ben-Amar, G. Erez and E. Miron, Post
deadline paper, International Quantum Electronics
Conference, Boston (1980).

JB-4   Thermal-energy Reactions of Metastable $O^+(^2D)$
Ions with O_2, N_2, and H_2.* - R. JOHNSEN and M. A. BIONDI
- U. Pittsburgh.--Reactions of O^{+m} metastable ions with
O_2, N_2, and H_2 have been investigated using drift-tube
mass-spectrometer techniques. The reaction $He^+ + O_2 \rightarrow$
$He + O^+ + O$ is used as the source of metastable ions,
and differences in ionic mobilities between ground-
state and excited ions in helium carrier gas are
exploited to distinguish the two types of ions. For
the metastable ions, ordinary charge transfer at a rate
approaching the Langevin limit is found to be the
dominant reaction branch in all three reactions; $k(N_2) =$
(8 ± 2) x 10^{-10}, $k(O_2) = (7 \pm 2)$ x 10^{-10} and $k(H_2) \sim$
2 x 10^{-9} cm/sec. The inference that vibrationally
excited H_2^+ ions are formed in the reaction $O^{+m} + H_2$,
together with other observations, strongly suggests that
the metastable state of the O^+ ions is ^2D rather than
^2P, a possible alternative.

JB-5 Reactions of O^{2+} Ground-State and Metastable Ions with He, O_2 and N_2.[*] - R. JOHNSEN and M. A. BIONDI - U. Pittsburgh.--In an attempt to resolve a 3 order-of-magnitude discrepancy between the ab-initio calculation of the charge transfer rate for $O^{2+} + He \rightarrow O^+ + He^+$ and the experimental result we have employed a drift-tube mass-spectrometer apparatus for a detailed study of this reaction. The reaction $Ne^{2+} + O_2 \rightarrow O^{2+} + \ldots$ was used to produce O^{2+} ions in specific states determined by the state of the Ne^{2+} ions. Mobility differences among these states were exploited to provide distinguishable reaction rates for the different O^{2+} states. The results *indicate that* previous experimental data referred to metastable O^{2+} ions and that the rate for ground-state O^{2+} ions reacting with helium [$k = (3.5 \pm 1.5) \times 10^{-11}$ cm^3/sec] is remarkably close to the theoretical value. Previous conclusions regarding the ionospherically important reactions of O^{2+} with O_2 and N_2, however, remain valid, since their rates were found to be insensitive to the particular O^{2+} state.

JB-6 Excitation of the Hydrogen Continuum in Collisions of $Ar(^3P_0)$ with H_2 - C.R. LISHAWA, W. ALLISON, and E.E. MUSCHLITZ, JR., University of Florida[*]--The hydrogen continuum emission ($a^{3}\Sigma_g^+ \rightarrow b^{3}\Sigma_u^+$) has been observed arising from the collision process: $Ar(^3P_0) + H_2(X^1\Sigma_g^+) \rightarrow Ar(^1S_0) + H_2(a^3\Sigma_g^+, v'=0)$ in a crossed supersonic molecular beam apparatus previously described.[1] The process is endoergic by 0.08 eV. The total intensity of the continuum was found to rise sharply from an onset at 0.080 ± 0.005 eV and reach a nearly constant value from 0.1 to 0.15 eV, the highest relative energy attained in these measurements. The spectral distribution of the continuum compares very well with the calculations of James and Coolidge,[2] however, the experimentally determined maximum lies at 3000Å, 350Å higher than the calculated value.

[1] E.R. Cutshall and E.E. Muschlitz, Jr., J. Chem. Phys. 40, 3171(1979).

[2] H.M. James and A.S. Coolidge, Phys. Rev. 55, 184(1939).

JB-7   Pressure Studies of $O_2(^1\Delta)$ Production in Electrical Discharges.* T.R. Dooling, M. Zediker, J. Anderson, S. Nagalingam, and G.H. Miley, Univ. of IL, Urbana, 61801--Experimental studies using a coaxial discharge in a flowing system to produce $O_2(^1\Delta)$ have been performed. The goal of this work is to produce kinetic data on $O_2(^1\Delta)$ metastable densities and life-times at pressures suitable for nuclear-pumped laser work (10 to 600 torr). Measurements used the 1.27-μm and 634-nm emission to monitor metastable density and dimol formation several points downstream from the dis-charge region.

Data for pure oxygen pressures in excess of 10 torr, effects due to 380 torr total pressure, and ef-fects due to flow rate variations above 0.3 g/min will be presented.

Implications of these results relative to de-velopment of a hybrid nuclear-electrical pumped cell will be presented.

SESSION KA
1:30 P.M., THURSDAY, OCTOBER 9, 1980
ROOM A

ATTACHMENT

CHAIRPERSON: T. M. MILLER
             UNIVERSITY OF OKLAHOMA

KA-1   Basic Processes in CO_2 Laser Plasmas* - R. A.
SIERRA[+], S. R. FOLTYN[+], H. L. BROOKS, M. C. CORNELL, and
K. J. NYGAARD, Department of Physics, University of
Missouri-Rolla -- Employing a pulsed electron swarm tech-
nique, we have determined electron drift velocities and
attachment and ionization rates in $[He]:[N_2]:[CO_2]$ mix-
tures with density ratios of 12:1:4 and 0:1:4. Further-
more, by using a 160 kvolt electron beam as a primary
source of ionization, we have measured electron-ion re-
combination in the same gas mixtures.

[+]Present address: Los Alamos Scientific Laboratory,
Los Alamos NM.

KA-2   Attachment and Ionization in $HgBr_2$*--W. J.
WIEGAND and L. R. BOEDEKER, United Technologies Research
Center--Cross sections for ionization and dissociative
attachment in mercuric bromide have been measured in an
electron beam apparatus. Product ions were identified
by mass analysis. The total ionization cross section
exhibits a threshold near 10.6 eV, a magnitude of ap-
proximately 2×10^{-15} cm^2 at 70 eV, and a predominance of
$HgBr_2^+$ formation. A survey of negative ions between 0
and 70 eV revealed only Br^- formation in a several volt
range near 4 eV with a peak attachment cross section of
1×10^{-17} cm^2. This magnitude was independently verified
by swarm measurements of the electron attachment rate in
$HgBr_2$/buffer gas mixtures. Details of the experimental
findings will be described and implications of these
results to mercuric bromide laser discharges will be
discussed.

KA-3   Electron Transport Coefficients in Gas Mixtures
Containing HgBr$_2$* - H. L. BROOKS, R. A. SIERRA**, E.
WEIGOLD+, and K. J. NYGAARD, Physics Department, University of Missouri-Rolla--We have measured the electron drift velocities and effective cross sections for attachment and ionization in mixtures of HgBr$_2$ with nitrogen, helium and neon. The method used studied the evolution of an electron swarm drifting in an electric field and measured the number of ions formed in the gas. Results will be presented for E/N (electric field/gas number density) values of 1 to 300 Td, at temperatures from 130°C to 150°C. Observation of fluorescent side light was used to try to identify the state of HgBr formed in the attachment process.

KA-4   Measurements of the rate coefficient for attachment of thermal electrons to SF$_6$. R.W. CROMPTON, A.G. ROBERTSON, K. NYGAARD+ and R. HEGERBERG, Australian National University --Measurements of electron population decay rates in SF$_6$-N$_2$ mixtures containing 1 to 5 ppm of SF$_6$ and at pressures between 5 and 25 Torr have been analysed to determine the attachment rate coefficient with an uncertainty of less than 5%. In contrast with similar measurements[1] in O$_2$-N$_2$ mixtures showing comparable electron loss rates there is little or no evidence of attachment cooling when either the total pressure or mixture composition, or both, are varied. The implication of this result with respect to the energy dependence of the cross section for the initial reaction to form SF$_6^{-*}$ will be discussed.

[1] R.W. Crompton, R. Hegerberg, and H.R. Skullerud, J. Phys. B (in press, 1980).

KA-5 Abstract Withdrawn

KA-6 Measurements of Electron Transport, Attachment,
and Ionization in HCl - D.K. DAVIES, Westinghouse R&D
Center*--A pulsed drift tube has been used to measure the
arrival time spectra of electrons, negative ions, and
positive ions in HCl and thereby determine values of the
electron drift velocity, and attachment and ionization
coefficients over the range $3 \leqslant E/N \leqslant 300$ Td. The attach-
ment rate coefficient increases rapidly with increasing
E/N above 25 Td to a maximum $\sim 9 \times 10^{-11}$ cm^3/sec (a factor
of two lower than previous measurements[1]) at E/N ~ 85 Td
and decreases relatively slowly at higher values of E/N.
The negative ion spectra show only one dominant ion spe-
cies having a reduced mobility of 0.70 cm^2/sec V, whereas
the positive ion spectra show two distinct ion species.
The ionization coefficient α/N is given to within ±4% by
$\alpha/N(cm^2) = 4.43 \times 10^{-16} exp [-757/[(E/N)(Td)]]$ over the
range $125 \leqslant E/N \leqslant 300$ Td, and is about 25% lower than pre-
vious measurements.[2] The limiting value of E/N (at which
the ionization and attachment rates are equal) is 163 ±
1 Td.

[1]V.A. Bailey and W.E. Duncanson, Phil. Mag. 10, 145 (1930).
[2]J.S. Townsend, Phil. Mag. 5, 389 (1903).

KA-7 Ground State Electronic Attachment Rates in HCl
R. C. SZE and A. E. GREENE, Los Alamos Scientific
Laboratory*--The dissociative attachment rates for HCl are
measured with a very low current density, short pulse,
electron beam machine. Under these conditions essen-
tially no HCl is believed to be vibrationally excited.
Data are obtained using partial pressures of HCl of ~ 200
parts per million in nitrogen and argon. Dissociative
attachment rates for mean electron energies in the range
of 0.7-1.2 ev and 2.5 to 5 ev are obtained. The rate
constants measured give $\sim 4.5 \times 10^{-10}$ cm^3/s and $\sim 1.7 \times 10^{-10}$
cm^3/s in the low and high mean electron energy ranges.
The results are compared with the theoretical values
obtained by Boltzmann code calculations of the electron
energy distributions including the cross-section data of
R. Azria, et.al. and L. G. Christophorou, et.al. The
present data agrees to within 50% of the calculated
curves.

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KA-8 Electron Attachment to Halocarbons*--I. SZAMREJ, D.L. McCORKLE, L.G. CHRISTOPHOROU, and S.M. SPYROS, U. of Tenn.--The electron attachment rate constants for the halocarbons C_2Cl_4, $1,1-C_2H_2Cl_2$, trans-$1,2-C_2H_2Cl_2$ and C_2H_3Cl have been measured in mixtures with nitrogen and argon. The respective total electron attachment cross sections, $\sigma_a(\varepsilon)$, for these compounds were determined using the swarm unfolding method. Maxima in $\sigma_a(\varepsilon)$ were found at 0.05 and 0.57 eV (C_2Cl_4); < 0.05, 0.35, and 0.94 eV ($1,1-C_2H_2Cl_2$); 0.11 and 1.04 eV (trans-$1,2-C_2H_2Cl_2$); and 1.5 eV (C_2H_3Cl). Also the temperature dependence of electron attachment to $1,1-C_2H_4Cl_2$ was investigated in mixtures with nitrogen and argon from 323 to 473K. The electron attachment rate constants in mixtures with both nitrogen and argon increase with increasing temperature. At all temperatures the rate constants for this halocarbon are larger when measured in nitrogen than in argon. The energy integrated cross sections from 0.04 to 2.5 eV were determined for these and other halocarbons studied earlier. The relation of the integrated cross section to the corresponding DC breakdown strength for these gases will be discussed.

SESSION KB
1:30 P.M., THURSDAY, OCTOBER 9, 1980
ROOM B

PHOTON INTERACTIONS

CHAIRPERSON: H. HELM
               SRI INTERNATIONAL

KB-1 <u>State-Selective Photolysis of Cs₂ and CsKr*</u>. C.B.
COLLINS, F. W. LEE, H. GOLNABI and P. VICHARELLI, <u>Univ.
of Texas at Dallas</u>; D. POPESCU and I. POPESCU, <u>Central
Inst. of Physics of Romania</u>--A two photon technique for
the measurement of relative cross sections for the photo-
lysis of simple molecules into particular product chan-
nels has been recently reported.[1] It has been used to
examine the dissociation of Cs_2 into each energetically
possible product state.[2,3] Reported here is a study of
the dependence of the photolysis yield from both Cs_2 and
CsKr upon the time of delay between excitation of the
parent molecule and the detection of the products. It
has provided data needed for the estimation of several
of the repulsive potential curves describing unstable
states of Cs_2 and CsKr.

1. C. B. Collins, J. A. Anderson, F. W. Lee, P. A.
Vicharelli, D. Popescu and Iovitzu Popescu, Phys Rev.
Lett. 44, 139 (1980).
2. C. B. Collins and J. A. Anderson, J.Chem.Phys. Pend.
3. C. B. Collins, F. W. Lee, J. A. Anderson, D. Popescu
and Iovitzu Popescu, J. Chem. Phys. Pend.

KB-2 <u>Absorption Profiles for Transitions to Sodium
Rydberg Levels Perturbed by High Concentrations of Ar-
gon,*</u> - D. KREBS, and L. D. SCHEARER, <u>University of
Missouri - Rolla</u> -- A nitrogen-pumped dye laser system
has been used to investigate the $3^2P_{1/2,3/2} \cdot n^2D_{3/2,5/2}$
and $3^2P_{1/2,3/2} \cdot n^2S_{1/2}$ (6 $\le$ n $<$ 22) line profiles for
sodium perturbed by .2 to 2 Amagats of argon. Sodium
was ionized in a stepwise process which incorporated
one of the above resonant transitions as an intermediate
step. The relative ion yield was determined as a func-
tion of laser wavelength and the resulting data analyzed
by a micro-computer to obtain absorption profiles for
the resonant transitions.

KB-3   UV Multiphoton Ionization of Xe and Several
Small Molecules at 193 and 248 nm.* R. V. HODGES, L. C.
LEE, and J. T. MOSELEY, SRI International.--Relative
multiphoton ionization rates for Xe, NO, NO_2, N_2O, O_2,
N_2, CO, CO_2, H_2O, SO_2, CF_3Cl, CF_3I, and C_2F_5I were
measured as a function of laser power at 193 and 248 nm.
A weakly focused rare gas-halogen excimer laser beam
passed in front of the exit aperture of an ion drift
tube. Ions formed in the laser beam were extracted by
the drift field into a quadrupole mass spectrometer.
Relative ionization rates varied among these molecules
over six orders of magnitude. In several cases the
ionization mechanism could be inferred from the ion
fragmentation pattern, a knowledge of the single photon
spectroscopy of the molecule, and the power dependence
of the ionization rate.

KB-4   OII and NII Branching Ratios in the EUV--M.D.
MORRISON and A.H. CUNNINGHAM, Physics Program, University
of Texas at Dallas, Richardson TX - Branching ratios for
several sets of extreme ultraviolet transitions in
ionized oxygen and ionized nitrogen have been measured.
The transitions terminate on the $^3D^o$ and $^3P^o$ metastable
levels of OII and the ^1S and ^1D metastable levels of NII.
The emissions were excited in both windowless hollow ca-
thode and capillary discharge lamps and viewed by a $\frac{1}{2}$ m
differentially pumped Seya-Manioka VUV monochromator.
Branching ratios were derived from the observed intensity
ratio of the multiplet pairs. The present results give
line ratios in agreement with measured FUV dayglow values
and help clarify the contribution of OII (538A) and OII
(581A) to the dayglow spectrum.

KB-5   Radiative Lifetime Measurements of the $4p^5P$, $4p^3P$ and $4d^5D°$ Multiplets of Oxygen.   R.-L. DAY, R. J. ANDERSON, and G. J. SALAMO, University of Arkansas*-- Time-resolved spectroscopy is used to observe the $4p^5P \rightarrow 3s^5S°$, $4p^3P \rightarrow 3s^3S°$ and $4d^5D° \rightarrow 3p^5P$ multiplet transitions of the OI spectrum occurring at $\lambda = 3974$ Å, $\lambda = 4368$ Å and $\lambda = 6157$ Å, respectively. The excited atomic multiplets result from dissociative-excitation of an O_2 target gas by a pulsed electron beam of 100 eV incident energy, 0.5--$1\mu s$ pulse duration and ≤ 5ns cut-off time. They are observed at a spectral resolution $\Delta\lambda \leq 3$ Å and for O_2 gas pressures in the range 20-100 mtorr. Computer and graphical analyses of the radiative decay curves at 20 mtorr yields lifetime values of $198 + 20$, $145 + 15$ and $92 + 9$ nanoseconds for the $4p^5P$, $4p^3P$ and $4d^5D°$ multiplets, respectively. Comparisons with currently accepted theoretical values and other available experimental measurements will be discussed.

KB-6   Wide Range Absolute Magnitude Photodetachment Spectrum of O_3^- - S. B. WOO, E. M. HELMY,* P. MAUK and A. PASZEK, University of Delaware.--Photodetachment of O_3^- is done in a drift tube using a pulsed dye laser. Ions are mass identified and are thermalized to room temperature. Photodetached electrons are detected. Relative cross sections are put on an absolute scale by calibration to O^-. Laser multi-pass configuration is used to increase the effective number of photons while keeping laser flux per pulse small. This makes extraneous electrons arising from the photodetachment of photodissociated fragments small and yet yields reasonable signal to noise ratio. As a result, an absolute photodetachment spectrum of O_3^-, extending from the visible to just below the vacuum U.V. is determined. The threshold energy is $2.1 \pm_{0.02}^{0.1}$ eV. The cross section is of the order of 2×10^{-19} cm^2 near the threshold and rises to about 6×10^{-19} cm^2 at 4.6 eV. The absolute calibration of the preliminary data is estimated to be 50%. Franck-Condon analysis will be applied on a more refined set of data to find the structure constants of O_3^-.

*Delaware State College, Dept. of Physics.

KB-7 Gas Phase Structure Constants of NO_2^-. - S.B. W
D.KOON, W. CLODIUS, E.M. HELMY,* and N.K. KANG, Univ. o
Del.--An absolute magnitude photodetachment spectrum o
NO_2^- extending from visible to just below vacuum U.V. i
obtained. A dye laser served as the photon source. A
drift tube is used to provide NO_2^- in ground electronic
and vibrational state to simplify the interpretation o
the data. Least squares fitting to:

$$\sigma_T(E) = \sum_{i=0}^{n} F_i \sigma_i(E)$$

where $\sigma_T(E)$, the total photodetachment cross section a
function of photon energy, is used to determine the in
tensity of various vibrational transitions. F_i and σ_i
are respectively the Franck-Condon (F-C) factors and t
partial cross sections corresponding to a vibrational
transition from the (0,0,0) state of NO_2^- to the ith st
of its neutral. The resulting F-C factors are compare
with calculated ones to yield a bond angle $\theta = 115.5 \pm$
and a bond length $r = 1.25 \pm 0.01$ Å for NO_2^-. Another
possible choice of r and θ will be discussed. Previou
structural constants (115.4°,1.236 Å) were determined
only for an interactive environment.

*Department of Physics, Delaware State College.

KB-8 Zero Core-Contribution Calculation of the Phot
detachment of Heteronuclear Diatomic Molecules - W. B.
CLODIUS, R.M. STEHMAN and S. B. WOO, Univ. of Del.*--T
zero core-contribution model has previously been appli
to atomic[1] and homonuclear diatomic[2] negative ions. W
have extended the method to heteronuclear molecules in
two ways. First, Schmidt orthogonalization,[3] which wa
not necessary in the homonuclear case, was used to
prevent undesired coupling between the bound state and
the detached state. Second, the bound state was repre
sented by a linear combination of two atomic orbitals.
We determined the proper mixing ratios of the orbitals
by attributing the difference between the dipole momen
of the anion and neutral as solely due to the additior
electron. OH⁻ is given as an example. The absolute
cross section we calculate agrees with the measured da
to within a factor of two, while Reed et al.'s[3] calcul
tion agrees within a factor of five.

[1]R.M. Stehman and S. B. Woo, Phys. Rev. A 20, 281 (1
[2]R.M. Stehman, B. Am. Phys. Soc. 23, 155 (1978).
[3]K.J. Reed, A.H. Zimmerman, H.C. Anderson, and J.I.
Brauman, J. Chem. Phys. 64, 1368 (1976).

SESSION LA
9:00 A.M., FRIDAY, OCTOBER 10, 1980
ROOM A

ARCS I

CHAIRPERSON: A. K. BHATTACHARYA
GENERAL ELECTRIC, CLEVELAND

LA-1 Opto-galvanic Spectroscopy and Thermal Relaxation in High-pressure Mercury and Sodium Arc Discharges.--W.J. VAN DEN HOEK and J. A. VISSER, Philips Lighting Division, Eindhoven, Netherlands -- Photon-induced impedance changes (opto-galvanic effect) have been detected in a mercury arc (3.2 A, 125V, d.c.) and a sodium arc (6.5 A, 28V, d.c.). The arcs were irradiated by chopped tunable laser radiation from a Rhodamine 6G dye laser. The voltage changes were measured via a blocking capacitor with a lock-in amplifier. The observed impedance changes per unit absorbed laser power are $-16\ \mu\Omega/mW$ (Hg arc, 577nm) and $-2\ \mu\Omega/mW$ (Na arc 568.8nm) using a chopper frequency of 80 Hz. The frequency dependence of amplitude and phase of the optogalvanic effect up to 5 kHz shows the characteristics of two relaxation processes. An analysis of the experimental results was made in terms of two linear relaxation processes, using a model for the energy flow in an LTE arc. For the Hg arc the two characteristic times are 0.40 ms and $\leq 4\ \mu s$. For the Na arc only one of the two characteristic times has been measured, its value being 53 μs.

LA-2 Properties of high-pressure sodium arcs at frequencies above 50 Hz, J.W.F. DORLEIJN and R.L.A. van der HEIJDEN, Lighting Division, Philips Eindhoven, The Netherlands -- A study has been made of the radiative and electrical properties of high-pressure Na/Hg/Xe arcs with different partial pressures of Na, Hg and Xe and various discharge tube radii. The lamps were supplied with a sinusoidal current in the frequency range 50 Hz - 10 kHz. We measured as a function of the frequency the modulation depth of the radiation output, the reignition peak in the lamp voltage and the luminous efficacy. At a frequency between 1 kHz and 10 kHz, depending on plasma composition and tube radius, the modulation in the luminous flux and the reignition peak disappear. No significant variation of the luminous efficacy as a function of the supply frequency is found, in contrast to results from literature[1]. All observations are described quantitatively using an arc model[2], in which LTE is assumed.

[1] J.H. Campbell, Illuminating Eng. 64, (1969), 713
[2] J.A.J.M. van Vliet and B.R.P. Nederhand, 29th Gaseous Electro. Conf. (1976), paper FB 4.

LA-3 Calculations of Radiation Transport and Tempera-
ture Profile in a Metal Halide Lamp Containing Sodium,
B F JONES and D A J MOTTRAM, Thorn Lighting Ltd., Leices-
ter U.K.--The energy balance equation has been solved to
give the temperature profile of a high pressure discharge
containing Na/Dy/I/Hg. The cylindrically symmetric arc
was assumed to be in the steady state under D.C. opera-
tion; LTE was assumed everywhere. Radial demixing effects
were included in the determination of the chemical compo-
sition. Net emission coefficients for the Na 589, 568 and
818nm lines were calculated [1] assuming that the lines
were broadened by resonance, Stark and van der Waal's
interactions. The Dy radiation was assumed to be optical-
ly thin, and calculated [1] using the data of Penkin [2]
and Corliss and Bozman [3]. Self absorption in the Dy
lines will introduce inaccuracies into the Dy spectrum,
but will have little effect on the calculated temperature
profile and electrical characteristics of the lamp.

[1] Jones B.F., Mottram D.A.J., Eardley G., Paper 10, 2nd
Int. Symp. on Incoherent Light Sources, Enschede (1979).
[2] Penkin N.P., Komarovski V.A., J.Q.S.R.T. 16, 217
(1976).
[3] Corliss C.H., Bozman W.R., NBS Monograph 53 (1962).

LA-4 On Modeling Vertical High Pressure Arcs with
Axial Segregation of Additives. R. J. ZOLLWEG and D.K.
McLAIN, Westinghouse R&D Center.--Vertical high pressure
mercury arcs containing additives to improve the radia-
tive characteristics suffer from axial segregation of
these additives. This results from radial diffusion
coupled with free convection within the confining quartz
arc tube. Such segregation causes axial variations in
the radial arc tempera ure profiles which modify convec-
tion velocities and these, in turn, contribute to fur-
ther changes in the axial segregation of additives. We
have successfully described mercury arcs with sodium and
scandium iodide additives by modification of an earlier
steady-state convection model. This modification treats
two of the material parameters, the electrical conduc-
tivity and net radiation coefficient, as functions of
both temperature and axial position whereas the other
material parameters are treated as functions of tempera-
ture alone. The calculated temperature and velocity
distributions are found to be sensitive functions of
the additive compositions. Away from the electrodes,
the calculated change in axial convection velocity
tends to be correlated with change in the axial tempera-
ture. A small radial inflow or outflow results from
variation in the axial velocity with vertical position.

LA-5 Acoustic Resonances in High Pressure Mercury Discharges - R.SCHÄFER and H.-P. STORMBERG, Philips Forschungslabor Aachen/W.-Germany--High pressure mercury discharge lamps with and without additives were operated at supply frequencies up to 25 KHz. It was found that at certain "resonance frequencies" arc instabilities due to acoustic resonances of the gas volume occur[1]. A measure for the intensity of these acoustic resonances is obtained from the sound spectrum emitted by the lamp. By this means resonances were detected without appearance of visual arc instabilities. This result leads to the question about the correlation between instabilities and acoustic resonances. With respect to this question time resolved arc temperature profiles were determined spectroscopically for a stable arc which shows acoustic resonances. Based on the experimental observations an interpretation of the occurence of arc instabilities will be given.

[1]H.L. Witting, J. Appl. Phys. **49**, 2680 (1978)

LA-6 Phase Dependent Plasma Temperature and Electrical Conductivity for Intermediate Pressure Sodium Arcs - E. F. WYNER and W. M. KEEFFE, GTE Sylvania.--The effect on plasma temperature and electrical conductivity of sodium vapor in the range 20-50 Torr has been studied. This range is below that normally found in sodium arcs for lighting applications. Effective cross sections for a Boltzmann electron distribution have been calculated. From the Saha equations for specie densities, conductivity has been determined as a function of temperature and integrated radially to obtain the effective conductance. At 50 Torr Na and 700 Torr Xe, using Bartel's method, a maximum phase resolved temperature of 4700 K was found. With a cubic radial temperature distribution, agreement was achieved between measured and calculated conductance. The cubic profile is consistent with the "flat-top" distribution suggested by Rautenberg and Johnson[1] and the measured profile of de Groot[2] at 130 Torr Na, 800 Torr Xe.

1. J. Appl. Phys. **48**, 2270 (1977).
2. "Investigation of the High Pressure Sodium and Mercury/Tin Iodide Arc," Thesis, Tech. U., Eindhoven (1974).

LA-7   Voltage-Current Relationship for Pulsed Arc Dis-
charges - P. WALSH, Fairleigh Dickinson U., W. LAMA and
T. HAMMOND, Xerox.--A theoretical treatment of the elec-
trical behavior of high current plasmas, typical of
pulsed discharges in gas-filled flashlamps is presented.
The theory is based on a simple model of the plasma
wherein the ohmic resistivity is a sum of terms due to
electron-atom and electron-ion collisions. Both terms de-
pend on the electron temperature, T, determined by balan-
cing the electrical power input and the radiant output.
It is assumed that the plasma radiates as a grey body at
temperature T, with an emissivity that depends on the
electron density. The electron-atom resistivity also de-
pends on the ratio of atom and electron densities, which
are related to T by the Saha equation. The principal re-
sult is an analytic expression for the arc voltage as a
function of current, with initial voltage, arc length
and diameter, and atom density as parameters. The expres-
sion describes the entire voltage pulse, including the
initial fall, the following minimum and the peak when the
current peaks. The predicted voltages substantially agree
with measured dependences on lamp length and diameter and
initial voltage. The theory is an improvement on the em-
pirical V-I relation commonly used in flashlamp circuit
analyses.

SESSION LB
9:00 A.M., FRIDAY, OCTOBER 10, 1980
ROOM B

ULTRAVIOLET LASERS

CHAIRPERSON: S. G. LESLIE
               WESTINGHOUSE RESEARCH AND DEVELOPMENT CENTER

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LB-1 Determination of the excitation kinetics of ArH*.
J.SHMULOVICH and S. YATSIV,oHebrew U Jerusalem.--The
ArH* emission band at 7670 A is observed in X-ray irradi-
ated Ar:H_2 mixtures. Its intensity is enhanced by a sim-
ultaneous application of an electric field in an X-ray
sustained discharge. If the intensities of different li-
nes emitted by the gas are plotted against the electric
field each curve features a bend followed by a steep rise.
With the field at the bend as a characteristic parame-
ter the emitting states can be arranged in an ascending
sequence according to their increasing excitation energy.
We find that the ArH* emission and the argon line emitted
from the 4p state follow the same field dependence curve.
In the X-ray sustained discharge a space charge is formed
near the cathode due to the different mobilities of ele-
ctrons and positive ions. This is associated with a
strong local electric field and a pronounced peak in em-
ission intensity. Lines of common origin such as the ArH*
band and the emission from Ar(4p) have indeed the same
geometrical profile. These observations serve as evidence
that the excitation is due to the Ar(4p)+$H_2 \rightarrow$ArH+H reac-
tion. We use this result to show that the ArH* emitting
state correlates with an excited hydrogen and a ground
state argon atom in the dissociative limit.

LB-2   Recombination Spectrum in X-ray Photoionized
Xenon and Hg-Vapour, J. DEGANI and S. YATSIV, Hebrew
University--Intense emission of a few Hg lines is obser-
ved when xenon mixed with Hg vapour at room temperature
is irradiated by X-rays. Hg^+ ions, originally formed by
charge transfer from Xe_2, associate with xenon atoms to
produce heavier cluster ions. A small number of excited
states is populated by dissociative recombination (DR)
of a mercury containing polyatomic ion. The recombina-
tional nature of this spectrum is evident from its be-
haviour in the presence of an electric field. An exten-
ded sequence of ionic reactions terminating by DR of a
cluster ion is characteristic for X-ray irradiation of
high pressure gases. The charge transfer reactions are
associated with energy funneling from the xenon buffer
gas to the Hg, explaining the intense emission of Hg. At
higher Hg densities the recombination spectrum declines
and a normal spectrum due to impact excitation of Hg
atoms appears. These changes are explained by the roles
of slow and fast electrons in these systems.

LB-3 A GAIN PREDICTION FOR A HELIUM, NITROGEN SYSTEM
BASED ON RADIATIVE COLLISIONS, L.W.DOWNES, J.D.KINNE,
S.D.MARCUM, R.A.TILTON, W.E.WELLS, Physics, Miami U.,
Oxford, Ohio[*]--Gudzenko and Yakovlenko[1] have made
theoretical predictions of the possibility of gain
through radiative collisions, and Harris et al[2] have
measured large radiative collisional cross sections, e.g.
8×10^{-13} cm^2, in intense photon flux fields.

We propose stimulating one channel of the He(2^3s),
N_2 Penning reaction:

$$h\nu + He(2^3s) + N_2 \rightarrow He + N_2^*(x,v) + 2 h\nu$$
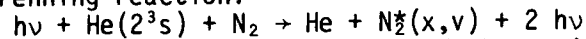
followed by the auto-ionization of the excited nitrogen:

$$N_2^*(x,v) \rightarrow N_2^+(x,v-1) + e^-$$
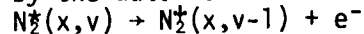
for the self destruction of the lower level.

Calculated cross sections and gains will be presented.

[1] Gudzenko and Yakovlenko, Soviet Physics JETP,35,877
 (1972).
[2] Harris et al, Laser Induced Colisions, Proceedings
 of the Conference on Tunable Lasers and Applications,
 6-11 June 1976.

LB-4 Transient Absorption in Argon and Neon from
2500 Å to 3700 Å - L. F. CHAMPAGNE, L. J. PALUMBO and
R. S. F. CHANG, Naval Research Laboratory--The broad
band absorption was measured in electron beam excited
neon and argon plasmas. A broad continuum emission
from a xenon flashlamp was used as probe source.
Absorption data was obtained over a 1200 Å range. The
absorption peaks in argon and neon correlate well with
the predicted peak absorption for these gases. The
absorption cross section for the gases under specific
pumping conditions is calculated using the number den-
sities of excited state species supplied by a numeri-
cal model. The results are compared with ab-initio
calculations of the absorption cross section.

LB-5 Long-pulse N_2 UV Lasers at 357.7, 380.5 and 405.9 nm in N_2/Ar/Ne/He Mixture - M.S. CHOU and G.A. ZAWADZKAS, Exxon Res. and Eng. Co.--In long-pulse electron beam pumping ($\sim$1 μS) in the above mixture three intense laser emissions occur sequentially in the order of 357.7, 380.5 and 405.9 nm, corresponding to $N_2(C)$, $V'=0 \rightarrow N_2(B)$,$V''=1,2,3$, respectively. The pulse durations (FWHM) are 150, 400 and 400 nS, and the peak powers are 56, 44 and 66 kW/cm^2, respectively. The addition of excess diluent gases of Ne and He to the mixture of N_2 and Ar improved the peak powers 40 times and efficiencies 3.8 times compared to those obtained only with N_2 and Ar. Furthermore, we observe that: (1) the delay times for the 380.5 and 405.9 nm lines vary only slightly when the laser emission at 357.7 and 380.5 nm, respectively, were suppressed, (2) the side fluorescence shows that the delay times are not caused either by pumping of the upper laser states or by the depopulation of the lower laser states, and (3) the single-path losses derived from the relation between the output power and the output coupling are relatively high for all the three lines. These three observations together with the effect of diluent gases on the laser performance will be discussed in terms of optical transient absorption.

LB-6 Plasma Shielding Effects on Ionic Recombination - W.L. MORGAN, Lawrence Livermore Lab, B.L. WHITTEN, Miami U., J.N. BARDSLEY, U. of Pittsburgh[*]--Interest in the theory of ion-ion recombination has been revived recently because of its application to high power excimer lasers. In electron beam pumped rare-gas-halide and metal vapor-halide lasers, ion-ion recombination is primarily responsible for the formation of the upper laser state. In such lasers the ion densities are at least 10^{13} cm^{-3}, and may exceed 10^{15} cm^{-3} in lasers being developed for fusion applications. Past calculations of termolecular recombination rates have not included shielding effects of the plasma, and are therefore valid only for low ion densities. For moderate ion densities, one may use the Debye shielded potential; at higher densities it is necessary to solve the hypernetted chain equation to obtain the potential. We report Monte Carlo calculations of recombination rates of Kr+/F- in Ar, taking plasma shielding effects into account. We find that, at 2 atmospheres, the recombination rates for ion densities of 10^{13}, 10^{14}, and 10^{15} cm^{-3}, are 84%, 62%, and 32%, respectively, of the rate for the unshielded Coulomb potential.

SESSION MA

10:30 A.M., FRIDAY, OCTOBER 10, 1980

ROOM A

ARCS II

CHAIRPERSON: H. MERCURE
             INSTITUT DE RECHERCHES D'HYDRO-QUEBEC

MA-1 Potential Probe Measurements in a Butt-Electrode
Vacuum Arc with a Transverse Magnetic Field - C.P.
SCHEFFLER, R. DOLLINGER, J. SULLIVAN and C. KING, St. U.
of NY at Buffalo.*--The Hall voltage and field as pre-
dicted by theory[1] was obtained[2] by measuring the
potential difference as a function of time between two
wires 2 mm in diameter, 1.2 cm apart, that stick through
the anode $\sim$ 1 mm. Typical Hall voltages and fields of
$\sim$ 50 V and 4 kV/m, respectively, were measured for arc
currents of 600 A and magnetic fields of 0.07 T. The
probe measurements also show the majority of the arc
voltage, generated by the application of the magnetic
field, is across an anode sheath. These probe measure-
ments are correlated by high speed framing photographs
($\sim$ 25 μs/frame, 12 frames) of the arc.

MA-2 Clustering of Vacuum Arc Cathode Spots-
L.P. HARRIS,General Electric Corp. R&D.--The
electrostatic repulsions and magnetic attractions
between the plasmas of two cathode spot cells are
described. The cell separation at which these opposing
forces are equal defines a characteristic length R_c for
the size of cell clusters. Numerical results are given
for the sizes of stable clusters of 2 to 12 cells
arranged in circular patterns yielding minimum energies
of formation. Use then is made of the principle that
individual cells operate with a maximum possible
current per unit cell radius r, determined by the
thermal characteristics of the cathode material, to
show that clusters are limited in maximum possible
size, and that no stable clusters are possible unless
$R_c/r > 4$. The conclusion results, in accord with
experiment, that clustering is favored by conditions
producing small cells. Numerical calculations indicate
that stable cell clusters should not occur on clean
copper cathodes in vacuum, where the cell current is
near 100 amperes.

MA-3 Effect of Magnetic Field on Transport Coeffi-
cients of Plasma Maintained by cw CO_2 Laser, J. KURZYNA,
Inst. of Fund. Technol. Res., PAS, Poland -- The reduc-
tion of heat conductivity and charged particles losses
in magnetic field are of a great interest for the sus-
tenance threshold of plasma maintained by cw CO_2 laser.
The coefficients of diffusion and heat conductivity for
argon LTE plasma have been estimated by 8 moments Grad's
approximation. This method simplifies the calculations
as compared to more accurate Chapman-Enskog one proposed
by Devoto [1]. The significant decrease of charged par-
ticles losses and heat currents has been noticed for
high magnetic field intensity $\gtrsim$ 100 kOe and gas pres-
sures of 1/5 atm. Characteristic times for charged
particles and magnetic field diffusion and for heat
transfer have been estimated as well. The device for
quasistationary magnetic field of 100 kOe has been de-
signed.

[1] R. S. Devoto, Rept. ARL 71-0075, April 1971.

MA-4 Arcs in High Speed Flows - T.F. BERNECKI, Y.C. LAU,
and D.M. BENENSON, State University of New York at
Buffalo* --Experiments are being conducted with dynamic
plasmas immersed in supersonic (cold) flows. A
converging-diverging nozzle is employed, having throat
diameter of 10 mm and exit (cold flow) Mach number of 2.4
(argon) or 2.1 (air or nitrogen). Tests in argon are
being carried out at about 11.6 atmospheres stagnation
pressure with a mass flow of approximately 290 g/s. Peak
value of the imposed sinusoidal current pulse is 1.2 kA
with dI/dt $\sim$18 A/μs near current zero; arc length is about
14 cm. Through various argon lines (e.g., Ar II 4806Å),
temperature measurements are being obtained at different
times during the current pulse. Results at the higher
current levels are in good agreement with the analysis
of Bhansali[1].

[1] C.H. Bhansali, "Analysis of Static and Dynamic Electric
Arcs in Supersonic Nozzle Flow," Ph.D. Dissertation,
State University of New York at Buffalo, 1980.

MA-5 Power Losses From a DC SF$_6$ Arc in Gas Flow -
Y. CHIEN, A. LEE, Westinghouse R&D Center--The power
losses from a steady-state DC SF$_6$ arc in gas flow were
measured. The arc was initiated by parting a pair of
copper electrodes at the throat of a Teflon nozzle.
Measurements were made for gas flow rates from $\sim$20-50g/s
and arc currents up to 800A. The visible and IR
radiation was measured by a pyroelectric detector
through windows in the nozzle wall, and the convective
power was measured by fast thermocouple probes located
downstream from the arc. Over the range of flow rates
and currents considered, measured radiative power
accounted for less than 1% of the input arc power and
the convective power was the dominating loss. Our
results support the basic assumption of Airey's model.[1]
Based on the measured luminous arc diameter and the arc
voltage and current, an estimate was made of the arc
temperature and UV power emission.

[1]D. R. Airey, "Simple Convection Dominated Model for
Optically Thick SF$_6$ Arcs", Proc. IEE, 125, 770 (1978).

MA-6 Experimental Determination of the Population
Densities of the Ar 3p^{5}4p - 3p^{5}4s States in the Non-
Equilibrium Region of a Fluid Transpiration Arc - H. J.
DAAMS, C. G. STOJANOFF+ RWTH* Aachen, Germany -- A
Krypton pumped, Oxazine 1 dye-laser was used to perform
high resolution absorption spectroscopy measurements in
the anode region of a fluid transpiration argon arc.
The emission and the absorption line profiles point to
the existence of "hot" and "cold" electrons in the non-
equilibrium region extending 1 cm in front of the anode.
The "hot" electron density is 3 times larger and their
temperature is 10% higher than those of the cold
electron gas. A model based on the assumption of domin-
ant emission in the "hot" regions and absorption in the
"cold" regions is used to analyze the $^3p_0s_3$ & $^3p_2s_5$
methastable states and the $^3p_1s_2$ & $^3p_1s_2$ & $^3p_1s_4$ resonant
levels. These states are in equilibrium with each other
and their population densities are order of magnitude
higher than the calculated equilibrium densities. They
are, however, factor of 10 smaller in comparison to
densities obtained by electron beam excitation of Ar-N$_2$
plasma.
+At present DRI, Univ. of Nevada
*Supported by DFG-SFB83 Contract

MA-7 Plasma Jet Momentum in a Tip-Plane Arc Configuration J. CONVERTI, W.C.UNKEL, M.I.T.*--The plasma jet momentum for a variety of conditions is determined from a momentum balance by measuring the deflection of the arc caused by a known external magnetic field. The results are compared with published results obtained by other methods (scales and pressure scans). For typical DC GTA welding conditions, the present results indicate that the force exerted by the plasma jet on a plate is roughly three times the force computed based on the radial pressure gradient alone and that the force varies with the square of the current, as expected from simple analytical calculations using the observed cathode spot size and arc width. Some previous measurements of the force using different methods indicated an order of magnitude higher value and had not given the expected square dependence on current. The technique can be used to evaluate and guide the development of more detailed plasma jet models.

MA-8 Electric Arc Radius and Characteristics - TA-MING FANG,* U. of California, Lawrence Livermore National Laboratory†--Heat transfer equation of an arc discharge has been solved. The arc is assumed to be a cylinder with negligible axial variation and the dominant heat transfer process is conduction radially inside the column and radiation/convection at the outside edge. The symmetric consideration allows a simple one dimensional formulation. By taking into account proper variation of the electrical conductivity as function of temperature, the heat balance equation has been solved analytically. The radius of the arc and its current-field characteristics have also been obtained. The conventional results that $E \sim I^{0.5385}$ and $R \sim I^{-0.7693}$ have been proved to be simply limiting cases of our more general characteristics. The results can be applied quite widely including, among others, neutral beam injection project in nuclear fusion and M.H.D. energy conversion.

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SESSION MB
10:30 A.M., Friday, October 10, 1980
Room B

INFRARED LASERS

Chairperson: A. Garscadden
Aero Propulsion Laboratory

MB-1 Fission Fragment Lasing of Ar-Xe - R. J. De Young, Miami U.* and M. D. Williams, NASA-Langley Research Center--Nuclear-pumped lasing of Ar-Xe at 2.65 and 2.62 μm has been achieved with fission fragment pumping using the $^{235}UF_6(n,ff)FF$ reaction. Fission fragments (165MeV) were emitted from a coating of several uranium compounds which formed on the inner surface of a quartz tube. Also, fission fragments were generated simultaneously by adding gaseous $^{235}UF_6$ to 600 Torr Ar-(3%)Xe. The laser cavity consisted of two dielectric mirrors, an Rmax and an output mirror R=99% at 2.65 μm. With 3 Torr $^{235}UF_6$ added to 600 Torr Ar-(3%)Xe, 38% of the power deposited was from $^{235}UF_6$ fission, the remainder from the wall-coated uranium compounds as measured by a fast pressure transducer in the laser cell. The measured power deposited was 18 Watts/cm^3 (no UF$_6$ added) which produced a peak laser output of 4.8 Watts or an efficiency of $\sim$0.1%. This is the first nuclear-pumped laser to be at least partially pumped by $^{235}UF_6$ fission fragments. The plasma kinetics with UF$_6$ will be discussed.

MB-2 Steady-State Numerical Solutions of Complex Plasma Chemistry Models, G.L. JONES, M.A. PRELAS, and S.K. LOYALKA, U. of MO-Columbia--Steady state solutions to complex plasma chemistry models represent a means of simplifying several difficult problems in nuclear-pumped plasma theory. The specific problems which may utilize steady-state numerical models are: 1) quasi steady-state plasmas generated by the long excitation sources; and 2) steady-state plasmas characteristic of steady-state excitation sources. A technique was developed in which the dependent equations in a series of rate equations, subject to equilibrium constraints, could be identified and replaced by a particle balance. Modeling of the atomic carbon nuclear pumped laser, one in which a time dependent solution had been reported,[1] was successfully completed and will be described. Extension of this technique to other problems will be discussed.

[1] M.A. Prelas and G.H. Miley, "Kin. of the Atomic Carbon NPL Using He & CO$_2$ Mixtures," Pro. of the Intn. Conf. on Lasers '79, pp. 159-166.

MB-3 Theoretical analysis of a potential electrically pumped oxygen-iodine laser[+] - D. Pigache, J. Bonnet, D. David and G. Fournier, ONERA, 92320 Châtillon, FRANCE -- The electron beam controlled discharge in a rare gas-oxygen-iodine mixture at atmospheric pressure is proposed as a possible mean of pumping the $O_2(^1\Delta_g)$-atomic iodine energy transfer laser. The electron collision rates are calculated with a Boltzman code which includes superelastic collisions and excitation processes of $O_2(^1\Delta_g)$. The time evolution of the species is obtained with a kinetics code (66 reactions). It is shown that population inversion of the $I^2P^1/_2 - I^2P^3/_2$ transition is hardly reached at room temperature. Laser effect with a good efficiency appears to be possible if the gas temperature is reduced by supersonic expansion. Preliminary E-beam discharge experiments in rare gas-oxygen mixture indicate that the $O_2(^1\Delta_g)$ pumping rate is properly calculated.

MB-4 Kinetic Modeling of Fast-Axial-Flow CO_2 EDL's, R. E. BEVERLY III, Consulting Physicist, Columbus, OH* --A six-temperature Boltzmann-equilibrium kinetics model has been developed for simulating the performance of fast-axial-flow, longitudinal-discharge CO_2 lasers. In deference to previous models using spatially averaged parameters, the coupled differential equations describing the vibrational and translational temperatures and photon intensities are integrated along the flow direction consistent with initial conditions imposed by the gas flow and boundary conditions specified by the optical resonator. The model includes the effects of electrical excitation, VV and VT collisional relaxation, thermal energy transport, distributed optical losses, and coherent radiation extraction for a $CO_2/N_2/He/H_2O$ mixture. The geometry considers a number of identical discharge tubes which are in series optically but which are supplied with separate flow ducting and electrical circuits. Numerical predictions of the model are compared with experimental results obtained with HRL's 2.5-kW device. The role of a drift region is discussed in terms of optimization of the discharge efficiency.

MB-5 Plasma Kinetic Effects of the Addition of Oxygen to CO Laser Discharges - G.A. MURRAY, Wesleyan U., and A.L.S. SMITH, Strathclyde U., Scotland.*--The mechanism responsible for the beneficial effect of oxygen addition to room temperature sealed off CO-He-Xe cw gas lasers has been investigated. This has been carried out by observing the changes in gain, electron density, discharge voltage, and positive ion spectrum as O_2 is added. It has been established that the electron density is increased and the gas heating decreased resulting in increased gain, but there is no need to postulate a change in the electron energy distribution. Finally, one self consistent hypothesis is shown to explain the effect of O_2 addition as well as that of Xenon, Krypton and Argon.

*Work carried out at the University of St. Andrews.

MB-6 High Frequency Opto-Galvanic Laser Stabilisation A.L.S. SMITH and S. MOFFATT, Strathclyde U. Scotland, U.K.*-- The speed of response of the normal opto-galvanic technique of active frequency stabilisation of the CO_2 laser has an upper limit of about 2kHz due to the V-V-T relaxation rate of the $00^{o}1$ upper laser level[1]. We report that the field induced current fluctuation reappears at higher frequencies, but with reversed phase. The molecular and electron kinetic processes leading to the high frequency effect have been analysed in detail and sealed high efficiency CW CO_2 lasers have been frequency stabilised to better than 3 parts in 10^8 using piezo-electric cavity length modulation and high frequency opto-galvanic detection operating in the 10-20kHz regime.

*Supported by UK Science Research Council

[1]A.L.S. Smith and S. Moffatt, Opt. Comm. 30, 213 (1979)

MB-7   Vibrational Temperature of $N_2X^1\Sigma_g^+$ State in a Weakly Ionized Nitrogen Plasma -- S. ONO and S. TEII*, Musashi Institute of Technology, Setagaya-Ku, Tokyo, Japan -- Informations on the excitation of molecules in weakly ionized plasmas are of interest in the investigation of molecular lasers which utilizing the vibrational -rotational transition. So that, the vibrational energy distribution function of $N_2X^1\Sigma_g^+$ state has been calculated numerically here for various values of the electron density ($N_e=10^9\sim10^{11}$ cm^{-3}) and the electron temperature ($T_e=0.2\sim2$ eV) by taking into account the V-V, V-T energy transfer and some collisional excitation and de-excitation by electrons. The results show that, (1) The vibrational temperature T_v ranging from approximately 3 to 5×10^3K increases with increasing N_e and decreasing gas pressure P for a fixed T_e. (2) For a fixed N_e and P, T_v has a maximum value at $T_e=0.7\sim1$ eV. Experiment has been done in a glow discharge nitrogen plasma. Experimental T_v are obtained from tne side light emission of the discharge using a spectrograph and compared with the theory. Experimental values agree with those of theoretical within the maximum error of 20 %.

* Former name : Sin-Li Chen.

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