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Final Report

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Project Title: "Line Identification and Lifetime Measurements
In the XUV and Soft X-Ray Regions"

by

The University of Tennessee
Knoxville 37916



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A. Introduction

An accurate summary of the voluminous data acquired concerning line identification and lifetime measurements in the xuv and soft x-ray regions for a wide variety of both resonance transitions and forbidden transitions in ions of astrophysical interest during the period of this grant is provided in the detailed list of publications supported in part by this grant in Section C. We call particular attention to a few papers among the many we have listed which have appeared in the *Astrophysical Journal*. These are of special relevance to specific astrophysical data needs.

We also note the many experiments completed in areas related to but somewhat outside the confines of the project title. These areas include: 1) the charge state dependence of innershell ionization cross-sections for very highly ionized beams incident on lighter targets; 2) the measurement of the mean lives of metastable states of few-electron ions; 3) the electron spectroscopy of autoionizing states of highly ionized ions and associated Auger lifetimes; 4) the discovery of coherent electron density distribution oscillation in charge transition excitation of the $n=2$ hydrogen levels; 5) the measurement of the charge states of energetic ions while inside solid targets; 6) the measurement of production cross-sections for characteristic x-ray production in the region connecting the adiabatic and sudden collision regimes; 7) the measurement of directional anisotropies of non-characteristic x-rays emitted in heavy ion collisions; 8) electron emission spectroscopy on optically inaccessible autoionizing states of the alkali metals; 9) the measurement of differences in the production

of non-characteristic radiation in solids vs. gas targets; 10) study of the forward peak of electrons accompanying projectile ions with the same vector velocity subsequent to both ion-atom and ion-solid collisions; 11) study of the breakdown of one-electron molecular orbital transition models in ion-atom collisions.

In Section B, many of the lifetime data concerning soft x-ray and for uv transitions studied in our experiments appear in convenient tabular form.

In Section D, a listing of resident and visiting scientists, postdoctoral research associates, and graduate students (including two who received Ph.D. degrees during the grant period) is provided.

B. Summary of Principal Transitions Studied

Table 1. Radiative Lifetimes (nsec) of the 2p Levels of Li-like Ions

Level	Al XI	Si XII	S XIV	Cl XV	Fe XXIV
$(1s^2 2p)^2 P_{1/2}$	1.35 ± 0.06^a	—	0.92 ± 0.09	0.95 ± 0.05	0.55 ± 0.02^b
$(1s^2 2p)^2 P_{3/2}$	1.19 ± 0.05^a	1.01 ± 0.10	0.77 ± 0.04	0.76 ± 0.04	0.235 ± 0.01^b
	1.12 ± 0.10				

^aMeasurements made in Uppsala, Sweden. (A collaboration of the Uppsala-Lund-Tennessee Groups.)

^bMeasurement made in Berkeley-Superhilac. (A collaboration of the Berkeley-Arizona-BNL-Tennessee Groups.)

Table 2. Oscillator Strengths for the 2s-2p Principal Resonance Transitions in Li-like Ions

Transition	Al XI	Si XII	S XIV	Cl XV	Fe XXIV
$(2s)^2 S_{1/2} - 2p^2 P_{1/2}$	0.036	—	0.032	0.028	0.018
$(2s)^2 S_{1/2} - 2p^2 P_{3/2}$	0.076	0.074	0.068	0.057	0.047

Fractional errors on f value entries are estimated to be the same as for the lifetimes in Table 1. (All wavelengths have been measured to much higher accuracy.)

Table 3. Radiative Lifetimes (nsec) of the $n=2$ Levels of Be-like Ions

Level	Al X	Si XI	P XII	S XIII	Cl XIV
$(1s^2 2s 2p) ^1P_1$		0.18 ± 0.03	0.17 ± 0.03	0.16 ± 0.03	0.15 ± 0.03
$(1s^2 2p^2) ^1D_2$	1.03 ± 0.05^a	0.76 ± 0.04	—	0.69 ± 0.04	0.60 ± 0.06
$(1s^2 2p^2) ^1S_0$	—	—	—	0.079 ± 0.02	0.067 ± 0.01
$(1s^2 2s 2p) ^3P_2$	0.19 ± 0.03^a	0.19 ± 0.01	0.18 ± 0.01	0.17 ± 0.01	0.16 ± 0.01

^aMeasurements made in Uppsala, Sweden. (A collaboration of the Uppsala-Lund-Tennessee Groups.)

Table 4. Oscillator Strengths for $\Delta n=0$ Transitions ($n=2$) in Be-like Ions

Transition	Al X	Si XI	P XII	S XIII	Cl XIV
$(2s^2) ^1S - (2s 2p) ^1P$	—	0.23	0.21	0.19	0.17
$(2s 2p) ^1P - 2p^2 ^1D$	0.11	0.12	0.10	0.091	0.088
$(2s 2p) ^1P - 2p^2 ^1S$	—	—	—	0.057	0.058
$(2s 2p) ^3P - 2p^2 ^3P$	—	0.105	0.094	0.085	0.076

Fractional uncertainties on f value entries same as for lifetime entries of Table 3.

Table 5. Radiative Lifetimes (nsec) of the n=3 Levels of Na-like Ions

Level	Ni XVIII	Cu XIX	Br XXV
$(3p) \ ^2P_{1/2}$	0.14 ± 0.01	0.085 ± 0.02	0.11 ± 0.03
$(3p) \ ^2P_{3/2}$	0.11 ± 0.01	0.085 ± 0.01	0.062 ± 0.01
$(3d) \ ^2D_{3/2}$	0.066 ± 0.007	0.051 ± 0.005	0.042 ± 0.005
$(3d) \ ^2P_{3/2}$	—	0.054 ± 0.006	—

All measurements made at Brookhaven National Laboratory. (A collaboration of the BNL-Tennessee groups.)

Table 6. Oscillator Strengths for $\Delta n=0$ Transitions (n=3) in Na-like Ions

Transition	Ni XVIII	Cu XIX	Br XXV
$(3s) \ ^2S_{1/2} - 3p \ ^2P_{1/2}$	0.11	0.16	0.072
$(3s) \ ^2S_{1/2} - 3p \ ^2P_{3/2}$	0.24	0.26	0.17
$(3p) \ ^2P_{3/2} - 3d \ ^2D_{3/2}$	0.19	0.22	0.15

Accuracy of f value entries is estimated to be at same level as lifetime entries of Table 5.

Table 7. Summary of Those Wavelengths of Those Classified Lines of Br Investigated

Transition	Wavelength (Å)	
	Present Result [†]	Edlén [*]
$3^2S_{1/2} - 3^2P_{1/2}$	229.0 ± 0.2	229.194
$3^2S_{1/2} - 3^2P_{3/2}$	189.6 ± 0.1	189.593
$3^2P_{3/2} - 3^2D_{3/2}$	166.8 ± 0.1	166.726

[†]Corrected for first and second order Doppler Effect.

^{*}Reference: Physica Scripta 17, 565 (1978); semi-empirical extrapolation from measured wavelengths of other Na-like ions.

Table 8. Radiative Lifetimes and Oscillator Strengths for Allowed $\Delta n=0$ Transitions in Multiply Charged Chlorine Ions

Ion	Wavelength (Å)	Transition	Lifetime of Upper Level (nsec)	Multiplet Oscillator Strengths	
				Present	Theory
Cl XV	384.0	$(2s)^2S_{1/2} - (2p)^2P_{3/2}$	$0.76 \pm .04$		
	415.6	$(2s)^2S_{1/2} - (2p)^2P_{1/2}$	$0.95 \pm .05$	$0.085 \pm .004$	$0.090^d, 0.087^d, 0.082^e$
Cl XIV	277.9	$(2s2p)^3P_1 - (2p^2)^1S_0$	$0.067 \pm .010$	$0.058 \pm .009$	$0.052^b, 0.049^e$
	458.4	$(2s2p)^3P_1 - (2p^2)^1D_2$	$0.60 \pm .06$	$0.088 \pm .009$	$0.082^b, 0.078^e$
	237.8	$(2s^2)^1S_0 - (2s2p)^3P_1$	$0.15 \pm .03$	$0.17 \pm .03$	$0.22^b, 0.21^d, 0.21^e, 0.22^f$
	286.1	$(2s2p)^3P_2 - (2p^2)^3P_2$	$0.16 \pm .01$	$0.076 \pm .004$	0.079^e
Cl XIII	215.3	$(2s2p^2)^2D_{3/2} - (2p^3)^2P_{3/2}$	$0.055 \pm .006$	—	—
	272.9	$(2s2p^2)^2S_{1/2} - (2p^3)^2P_{3/2}$			
	419.5	$(2s^2)^2P_{3/2} - (2p^3)^2D_{3/2}$	$0.12 \pm .01$	—	—
	209.9	$(2s^2 2p)^2P_{1/2} - (2s2p^2)^2S_{1/2}$	$0.080 \pm .008$	$0.029 \pm .003$	$0.026^b, 0.029^c, 0.026^e$
	205.5	$(2s^2 2p)^2P_{3/2} - (2s2p^2)^2P_{1/2}$	$0.058 \pm .006$	$0.10 \pm .01$	$0.137^b, 0.14^c, 0.14^e$
	264.6	$(2s^2 2p)^2P_{1/2} - (2s2p^2)^2D_{3/2}$	$0.33 \pm .03$	$0.057 \pm .006$	$0.054^b, 0.054^c, 0.053^e$
224.6	$(2s2p^2)^4P_{3/2} - (2p^3)^4S_{3/2}$	$0.053 \pm .005$	$0.047 \pm .005$	$0.055^c, 0.052^e$	
Cl XII	197.5	$(2s2p^3)^3D_1 - (2p^4)^3P_1$	$0.035 \pm .004$	—	—
	197.6	$(2s2p^3)^3D_2 - (2p^4)^3P_1$			
	202.5	$(2s2p^3)^3D_1 - (2p^4)^3P_2$			
	202.6	$(2s2p^3)^3D_3 - (2p^4)^3P_2$	$0.033 \pm .004$		
	174.4	$(2s^2 2p^2)^3P_1 - (2s2p^3)^3S_1$	$0.027 \pm .005$	$0.055 \pm .010$	$0.077^b, 0.075^e$
	223.2	$(2s^2 2p^2)^3P_1 - (2s2p^3)^3P_0$	$0.13 \pm .01$	$0.058 \pm .003$	$0.064^b, 0.062^e$
	223.1	$(2s^2 2p^2)^3P_1 - (2s2p^3)^3P_1$			
	262.4	$(2s^2 2p^2)^3P_1 - (2s2p^3)^3D_2$			
	262.2	$(2s^2 2p^2)^3P_1 - (2s2p^3)^3D_1$	$0.32 \pm .01$	$0.055 \pm .003$	$0.055^b, 0.058^e$
	271.2	$(2s2p^3)^1D_2 - (2p^4)^1D_2$	$0.051 \pm .005$	—	—
175.8	$(2s^2 2p^2)^1D_2 - (2s2p^3)^1P_1$	$0.028 \pm .003$			
199.3	$(2s^2 2p^2)^1D_2 - (2s2p^3)^1D_2$	$0.070 \pm .004$	$0.085 \pm .004$	$0.085^b, 0.145^e$	
Cl XI	195.6	$(2s2p^4)^2D_{3/2} - (2p^5)^2P_{3/2}$	$0.026 \pm .005$		
	192.1	$(2s^2 2p^3)^2P_{3/2} - (2s2p^4)^2S_{1/2}$	$0.040 \pm .004$	$0.046 \pm .005$	$0.049^b, 0.049^e$
	166.1	$(2s^2 2p^3)^2D_{3/2} - (2s2p^4)^2P_{3/2}$			
	166.6	$(2s^2 2p^3)^2D_{3/2} - (2s2p^4)^2P_{3/2}$	$0.022 \pm .005$	—	—
Cl XI	209.9	$(2s^2 2p^3)^2D_{3/2} - (2s2p^4)^2D_{3/2}$			
	209.4	$(2s^2 2p^3)^2D_{3/2} - (2s2p^4)^2D_{3/2}$	$0.064 \pm .06$		
	242.7	$(2s^2 2p^3)^4S_{3/2} - (2s2p^4)^4P_{3/2}$	$0.18 \pm .02$	$0.15 \pm .015$	$0.141^b, 0.149^e$
Cl X	215.7	$(2s2p^5)^1P_1 - (2p^6)^1S_0$	$0.033 \pm .007$	$0.11 \pm .02$	0.133^e
	164.5	$(2s^2 2p^4)^1D_2 - (2s2p^5)^1P_1$	$0.024 \pm .005$	$0.10 \pm .015$	$0.116^b, 0.120^e$
	205.4	$(2s^2 2p^4)^3P_2 - (2s2p^5)^3P_2$	$0.062 \pm .009$		
Cl IX	180.7	$(2s^2 2p^5)^2P_{3/2} - (2s2p^6)^2S_{1/2}$	$0.030 \pm .006$	$0.055 \pm .01$	$0.063^b, 0.071^e$

^aRef. 1 Y-K. Kim and J. P. Desclaux, Phys. Rev. Lett., 36, 139 (1976).

^bRef. 2 O. Sinanoglu, in *Beam-Foil Spectroscopy* (edited by S. Bashkin), Springer-Verlag, Berlin (1976).

^cRef. 3 W. Dankwort and E. Treffitz, J. Phys., B10, 2541 (1977) and private communication.

^dRef. 4 L. Armstrong, Jr., W. R. Fielder, and D. L. Liu, Phys. Rev., A14, 1114 (1970).

^eRef. 5 U. I. Satronova, A. N. Ivanova, and V. N. Kharitonova, Theor. and Expt. Chem., 5, 325 (1969).

^fRef. 6 K. T. Cheng and W. R. Johnson, Phys. Rev., A15, 1326 (1977).

C. Publications

C.1. List of Publications on Research Accomplished under NASA Support, 1974 to date (present grant period):

Books, General Articles, Reviews:

"Ions," to be published in the McGraw-Hill Annual Yearbook of Science and Technology, 1978, D. Lapides, ed., McGraw-Hill Book Co., New York (1978).

Structure and Collisions of Ions and Atoms, I. A. Sellin, ed. (Springer-Verlag, Heidelberg, 1978).

Op. cit., Chapter 6, "Extensions of Beam Foil Spectroscopy."

"Optical, X-ray, and Auger Beam Foil Studies," in Methods of Experimental Physics, Vol. 14, P. Richard, ed. (Academic Press, New York), to be published in 1979.

"The Violent Many-Electron Chemistry of Highly Charged Ions," in Physics News - 1977, G. Present, ed. (American Institute of Physics, New York), p. 18 (1977).

Beam Foil Spectroscopy: Vol. 1, Atomic Structure and Lifetimes, Vol. 2, Collisional and Radiative Interactions, I. A. Sellin and D. J. Pegg, eds., Plenum Press, New York (1976).

"Highly Ionized Ions," in Advances in Atomic and Molecular Physics, Vol. 12, D. R. Bates and B. Bederson, eds., Academic Press, New York (1976), p. 215.

"Measurement of Auger Lifetimes and Energy Levels by Projectile Electron Spectroscopy," in Topics in Current Physics, Vol I: Beam-Foil Spectroscopy, S. Bashkin, ed., Springer-Verlag, Heidelberg (1976), Chap. 10, p. 265.

Articles in Major Journals and Proceedings:

"Z, Velocity, and Target-Material Dependence of Convoy Electrons from Solids." Phys. Rev. Lett. 41, 712 (1978).

"Observation of Oscillatory (Interference?) Structure in the Forward Peak from Fast-Projectile Electron Loss," Phys. Rev. Lett. 41, 399, (1978).

"Continuum Electron Capture Dependence on Projectile Z and Velocity," Z. Physik A 286, 233 (1978).

"Z, Velocity, and Charge Dependence of Zero-Degree Electron 'Cusps' from Charge Transfer to Continuum States of Bare and Highly Ionized Projectiles," Phys. Rev. Lett. 40, 1020 (1978).

Invited paper, "Electron 'Cusp' Spectroscopy of the Forward Peak in Continuum Electron Capture and Loss in Gases and Solids," to be published in the Proceedings of the International Conference on Fast Ion Spectroscopy, Université de Lyon, by the Journal de Physique in 1979.

"Oscillator Strength Determinations for $\Delta n = 0$ Transitions in Be-like Ions of the Third Period Elements," to be published in the Proceedings of the Fifth International Conference on Beam-Foil Spectroscopy. Université de Lyon, by the Journal de Physique in 1979.

"Coherent Electron Density Distribution Oscillations in Electron Capture by Fast Protons in He," to be published in Z. Physik-Short Notes (1978).

"Electron 'Cusp' Spectroscopy of the Forward Peak in Continuum Electron Capture and Loss in Gases and Solids," to be published in the Proceedings of the International Conference on Fast Ion Spectroscopy, Université de Lyon, by the Journal de Physique (1979).

"Electron Capture Collisions at keV Energies of Boron and Other Multiply Charged Ions with Atoms and Molecules, I: Ar, H₂, and He," submitted to Phys. Rev. A.

"Delayed Coincidence Auger Electron Lifetime Measurements," to be published in the Proceedings of the International Conference on Fast Ion Spectroscopy, Université de Lyon, by the Journal de Physique (1979).

"Orbital Angular Momentum State Coherence in Charge Transfer to the n=2 Hydrogen Levels by Fast Protons in Gases," to be published in the Proceedings of the International Workshop on Coherence and Correlation in Atomic Collisions, Plenum Press, New York, 1979.

"A Systematic Study of the $2s^2 2p^k - 2s 2p^{k+1} - 2p^{k+2}$ Transitions in Multiply-Charged Cl Ions," to be published in the Proceedings of the Fifth International Conference on Beam-Foil Spectroscopy, Université de Lyon, by the Journal de Physique in 1979.

"Radiative Lifetimes of Highly Ionized and Foil-Excited Al," to be published in the Proceedings of the Fifth International Conference on Beam-Foil Spectroscopy, Université de Lyon, by the Journal de Physique in 1979.

"Observation of Mixed Parity Electric Dipole Oscillations in Charge-Transfer to the n=2 Hydrogen Levels by Fast Protons in Gases," submitted to Phys. Rev. Lett.

Invited Paper, "Electron Capture to Continuum States," to be published in the Proceedings of the Fifth Conference on Application of Small Accelerators, North Texas State University, November 6-8, 1978, in the February 1979 issue of IEEE Transactions on Nuclear Science.

Invited Paper, "Failure of Single Electron Descriptions of Molecular Orbital Collision Processes," to be published in the Proceedings of the Fifth Conference on Application of Small Accelerators, North Texas State University, November 6-8, 1978, in the February 1979 issue of IEEE Transactions on Nuclear Science.

Invited Paper, "A Scanning Proton Microprobe for Trace Element Analysis," to be published in the Proceedings of the Fifth Conference on Application of Small Accelerators, North Texas State University, November 6-8, 1978, in the February 1979 issue of IEEE Transactions on Nuclear Science.

"Many-electron Transitions in Violent Encounters of Highly Ionized Ions with Atoms and Molecules," Comments on Atomic and Molecular Physics 8, 1/2 21 (1978).

"Observation of Quantum Beats in Gas-excited Helium Projectiles,"
Zeitschrift für Physik, A 283, 299 (1977).

"Radiative Lifetimes and Oscillator Strengths for Allowed Intra L-Shell Transitions in Multiply-Charged Chlorine Ions," Phys. Rev. A 18, 1476 (1978).

"Radiative Lifetimes and Oscillator Strengths for Allowed Transitions in Li-like and Be-like Silicon," Physica Scripta 18, 18 (1978).

"Oscillator Strengths of the $2s^2S_{1/2} - 2p^2P^{\circ}_{1/2\ 3/2}$ Transitions in Fe XXIV and the $2s^2\ ^1S_0 - 2s2p^3P_1$ Transition in Fe XXIII," Phys. Rev. A 18, 208 (1978).

"A Measurement of Oscillator Strengths for Solar XUV Flare Lines in Ni XVIII," Astrophysical J. 224, 1056 (1978).

"Radiative Lifetimes of the Low-lying Levels of Na-like Copper," Phys. Rev. A 16, 2008 (1977).

"Studies of Neon L-Shell Excitation by Impact of Highly Ionized Heavy Ions," Z. Physik A 283, 329 (1977).

"A Survey of Problems in Beam-Foil Spectroscopy of Iron and Copper at Energies from 16 to 110 MeV," Nucl. Inst. and Meth. 154, 169 (1978).

"An Experimental Survey of Electron Transfer in keV Collisions in Multiply Charged Ions with Atomic Hydrogen," p. 126 in Atomic Physics 5 (Proceedings of the Fifth International Conference on Atomic Physics, Berkeley, California, July 1976) edited by R. Marrus, M. Prior and H. Shugart, Plenum Press, New York, 1977.

"Many-Electron Aspects of Molecular Promotion in Ion-Atom Collisions: Production of Core-Excited States of Li in $Li^+ - He$ Collisions," submitted to Phys. Rev. A.

"Spin-dependent Excitation of Autoionizing States of Li Produced in Collisions with Noble Gas Targets," in Proceedings, Tenth International Conference on the Physics of Electronic and Atomic Collisions, M. Barat, J. Reinhardt, and G. Watel, eds. (Commissariat a l'Energie Atomique, Paris), p. 1014 (1977).

"Neon Characteristic X-ray Production in Neon-Neon Collisions as a Function of Incident Projectile Charge State," in Proceedings, Tenth International Conference on the Physics of Electronic and Atomic Collisions, M. Barat, J. Reinhardt, and G. Watel, eds. (Commissariat a l'Energie Atomique, Paris), p. 894 (1977).

"Recoil Ion Spectroscopy in the XUV-Soft X-ray Region Following Heavy Ion Impact on Thin Gas Targets," in Proceedings, Tenth International Conference on the Physics of Electronic and Atomic Collisions, M. Barat, J. Reinhardt, and G. Watel, eds. (Commissariat a l'Energie Atomique, Paris), p. 634 (1977).

"High Resolution Studies of Extensive Ne L-Shell Excitation by Energetic Heavy Ion Impact," in Proceedings, Tenth International Conference on the Physics of Electronic and Atomic Collisions, M. Barat, J. Reinhardt, and G. Watel, eds. (Commissariat a l'Energie Atomique, Paris), p. 632 (1977).

"Overcoming the Doppler Limitation in Beam-Foil Experiments by Target Ion Spectroscopy," in Proceedings, Fourth Conference on Scientific and Industrial Applications of Small Accelerators, J. L. Duggan and I. L. Morgan, eds. (International Association of Electrical and Electronic Engineers, Report 76 CH 1175-9 NPS, New York), p. 319 (1977).

"Intensity Modulations in the Decay of the $3^2P_{1/2}$ Level in the Sodiumlike Ion, Cu^{18+} ," Phys. Rev. Lett. 38, 1471 (1977).

"Oscillator Strengths for In-Shell ($\Delta n = 0$) Dipole Transitions in Li- and Be-like Sulfur," Phys. Rev. A15, 1958 (1977).

"The Splitting and Oscillator Strengths for the $2s^2s, -2p^2p^0$ Doublet in Lithiumlike Sulfur," Astrophysical J. 214, 331 (1977).

"Production of Soft X-Ray Emitting Slow Multiply Charged Ions: Recoil Ion Spectroscopy," Phys. Lett. 61A, 107 (1977).

"Projectile Charge-State Dependence in K-Shell Ionization of Neon, Silicon, and Argon Gases by Lithium Projectiles," Physics Lett. 60A, 292 (1977).

"Charge Dependence of K X-Ray Production in Nearly Symmetric Collisions of Highly Ionized S and Cl Ions in Gases," Phys. Rev. A14, 1997 (1976).

"Radiative Lifetimes and Transition Probabilities for Electric-dipole $\Delta n = 0$ Transitions in Highly Stripped Sulfur Ions," Phys. Rev. A14, 1036 (1976).

"Dipole Oscillator Strengths for $\Delta n = 0$ Transitions in Highly Ionized Sulfur," Physics Lett. 58A, 349 (1976).

"Strong Isotope Dependence of K-Vacancy Production in Slow $Ne^+ - Ne$ Collisions," Phys. Rev. Lett. 37, 984 (1976).

"Differences in the Production of Non-Characteristic Radiation in Gaseous and Solid Targets," Phys. Rev. Lett. 36, 1574 (1976).

"An Experimental Survey of Electron Transfer in keV Collisions in Multiply Charged Ions with Atomic Hydrogen," in Proceedings of the Fifth International Conference on Atomic Physics, R. Marrus, M. H. Prior, and H. A. Shugart, eds., University of California, Berkeley, California (1976), p. 126.

"Lifetimes and Transition Rates for Allowed In-Shell Transitions in Highly Stripped Sulfur," in Proceedings of the Fifth International Conference on Atomic Physics, R. Marrus, M. H. Prior, and H. A. Shugart, eds., University of California, Berkeley, California (1976), p. 166.

"Polarization Measurements on the Non-Characteristic Radiation Emitted from Collisions Between High Energy Aluminum Ions," Phys. Letters A56, 89 (1976).

"Applications of Beam-Foil Spectroscopy to Atomic Collisions in Solids," Nucl. Inst. and Meth. 132, 397 (1976).

"Differences in the Production of Non-Characteristic Radiation in Solid and Gas Targets," in Beam-Foil Spectroscopy: Heavy Ion Atomic Physics, I. A. Sellin and D. J. Pegg, eds., Plenum Press, New York (1976), Vol. 2, p. 497.

"Angular Distribution Studies on Non-Characteristic X-Radiation," in Beam-Foil Spectroscopy: Heavy Ion Atomic Physics, I. A. Sellin and D. J. Pegg, eds., Plenum Press, New York (1976), Vol. 2, p. 497.

"Autoionizing States in Highly Ionized O, F, and Si," in Beam-Foil Spectroscopy: Heavy Ion Atomic Physics, I. A. Sellin and D. J. Pegg, eds., Plenum Press, New York (1976), Vol. 1, p. 451.

"Autoionizing States in the Alkalis," in Beam-Foil Spectroscopy: Heavy Ion Atomic Physics, I. A. Sellin and D. J. Pegg, eds., Plenum Press, New York (1976), Vol. 1, p. 419.

"Extreme Ultraviolet Spectra of Highly Stripped Si Ions," in Beam-Foil Spectroscopy: Heavy Ion Atomic Physics, I. A. Sellin and D. J. Pegg, eds., Plenum Press, New York (1976), Vol. 1, p. 321.

"Core-Excited Autoionizing States in the Alkalis," Phys. Rev. A12, 1330 (1975).

"Autoionizing States Formed in $\text{Na}^+ + \text{Ne}$ and $\text{Mg}^+ + \text{He}$ Collisions at 70 keV," in Electronic and Atomic Collisions, J. S. Risley and R. Geballe, eds., University of Washington Press, Seattle, p. 869 (1975).

"Photon Energy Dependence of the Asymmetry of Non-Characteristic X-Radiation in Si-Al and Al-Al Collisions," in Electronic and Atomic Collisions, J. S. Risley and R. Geballe, eds., University of Washington Press, Seattle, p. 312 (1975).

"Heliumlike ^{19}F ; 2^3P_2 and 2^3P_0 Lifetimes," Phys. Rev. A11, 2198 (1975).

"Symmetric Ion-Atom Collisions at Medium Energies: Non-Characteristic Radiation," Phys. Rev. A11, 468 (1975).

"Charge State Dependence of Si K X-Ray Production in Solid and Gaseous Targets by 40 MeV Oxygen Ion Impact," in Atomic Collisions in Solids, S. Datz, ed., Plenum Press, New York (1975), p. 461.

"Lifetimes of the Metastable Autoionizing $(1s2s2p)^4\text{P}_{5/2}$ States of Lithiumlike Al^{10+} and Si^{11+} Ions; Comparisons with theory over the Isoelectronic sequence $Z = 8-18$," Phys. Rev. A11, 468 (1975).

25. "Variation of the Anisotropy of the Non-Characteristic X-Rays Emitted from Fast Ion-Atom Collisions," in Proceedings of the Third Conference on Applications of Small Accelerators, ERDA CONF-74 1040 P1, p. 78 (1975).
26. "Symmetric Ion-Atom Collisions at Medium Energies: Characteristic X-Rays," Phys. Rev. A11, 135 (1975).
27. "Projectile Electron Emission Spectroscopy on Optically Inaccessible Autoionizing States in the Alkali Metals," Physics Lett. 50A, 447 (1975).
28. "Observation of Large and Strongly Energy Dependent Directional Anisotropies in Non-Characteristic K X-Rays Emitted in Heavy Ion Collisions," Phys. Rev. Lett. 34, 64 (1975).
29. "Characterization of Charge States of Energetic Ions in Solids from Associated K X-Ray Production," Phys. Rev. Lett. 33, 733 (1974).
30. "Autoionization Lifetimes of the Metastable $(1s2s2p)^4P_{5/2}$ State in the Lithiumlike Ions Al^{10+} , Si^{11+} , and S^{13+} ," published in Proceedings, The Fourth International Conference on Atomic Physics, Heidelberg, Heidelberg Univ. Press, Heidelberg, W. Germany (1974), p. 79.
31. "XUV Spectra of Highly Ionized Fluorine and Oxygen," Phys. Rev. A 10, 745 (1974).
32. "New Lines in the XUV Spectrum of Heliumlike Fluorine," Physics Letters 47A, 469 (1974).
33. "Radiative Transitions in Two-Electron Oxygen," Physics Letters 47A, 433 (1974).
34. "Neon K_{α} , K_{β} Satellite Structure Induced by 80-MeV Argon Ion Impact," Phys. Rev. A10, 1446 (1974).
35. "Lifetime and Binding Energy of the Metastable $(1s2s2p)^4P_{5/2}^0$ States in S^{13+} ," Phys. Rev. A9, 1112 (1974).
36. "Observation of K X-Rays from Highly Ionized States of Neon Produced by 40 MeV Cl^{+7} , Cl^{+11} , and Cl^{+13} Beams," Phys. Rev. A9, 1470 (1974).
37. "Initial UNISOR Research: New Isotopes ^{186}Tl , ^{188}Tl , ^{116}I ; Decays of $^{189,190}Tl$, ^{111}Xe , and ^{111}I ; and Off-Line Atomic and Nuclear Studies," published in the Proc. of the 24th Ann. National Conf. of the Academy of Sci. USSR on Nuclear Spectroscopy and Structure of the Atomic Nucleus (1974).
38. "Projectile Charge State Dependence of K X-Ray Production by 1-4 MeV/amu Heavy Ions in Gases," Phys. Rev. A9, 644 (1974).

Other Papers:

"Consequences for Parity Violation Experiments of Creation of Mixed-Parity Excited States in $H(n=2)$ Following Single Collisions of Fast H^+ in Gases," to be published in Bull. Am. Phys. Soc. in 1978.

"Molecular Modulation of $H(n=4)$ Quantum Beats Following Single Foil Excitation of H^+ , H_2^+ and H_3^+ Beams," to be published in Bull. Am. Phys. Soc. in 1978.

"Search for Correlation Effects Between Multiple Electron Loss to Continuum Events in High Energy O^{4+} - Ar Collisions," to be published in Bull. Am. Phys. Soc. in 1978.

"Observation of Strong Structure in the Forward Peak from Fast-Projectile Electron Loss," to be published in Bull. Am. Phys. Soc. in 1978.

"Systematics of Continuum Capture and Loss by Rare and Highly Ionized H, C, O and Si Projectile Ions Traversing He, Ne, and Ar Targets," to be published in Bull. Am. Phys. Soc. in 1978.

"Electron Capture to Continuum States by Bare Projectile Ions," to be published in Bull. Am. Phys. Soc. in 1978.

"Time-Resolved Spectroscopic Measurements on Multiply-Charged Si, P, and Cl Ions." Tenth Conference of the European Group on Atomic Spectroscopy, Munich, Germany, July 11-14, 1978. Book of Abstracts, p. 63.

"Projectile Charge State Dependence of Zero Degree 'Cusps' from C^{q+} ($q = 4-6$) and O^{q+} ($q = 4-8$) Traversing Ar at 1.6 MeV/A to 2.8 MeV/A," Bull. Am. Phys. Soc. 23, 513 (1978).

"Creation of Mixed-Parity Excited States in $H(n=2)$ Following Single, Charge Transfer Collisions of Fast H^+ in Gases," presented at the International Conference on Fast Ion Spectroscopy, Université de Lyon, September, 1978.

"Charge Transfer to Continuum States of Bare and Highly Ionized Projectiles," Bull. Am. Phys. Soc. 23, 512 (1978).

"Z Dependence and Velocity Dependence of Zero Degree Electron 'Cusps' from C^{6+} and O^{8+} Traversing Ar at 1.6 MeV/A to 2.8 MeV/A," Bull. Am. Phys. Soc. 23, 512 (1978).

"Projectile Velocity Dependence of Li-Core Excitation in Single Collisions with He Targets," Bull. Am. Phys. Soc. 23, 513 (1978).

"Lebensdauer messung von Metastabilen Zuständen mit verzögerter Koinzidenz nach Anregung mit gepulstem UNILAC - Strahl," In Beitrag für GSI-Nachrichten 2-78 (1978).

"Lebensdauern metastabiler Dreielektronen-Zustände mit einer Koinzidenz Technik," Verhandl., Deutsche Physikalische Gesellschaft, February, 1978, 424 (1978).

"Stark Shifts and Broadening of Auger Lines of Highly Ionized Atoms in Molecules After Heavy Ion Impact," Bull. Am. Phys. Soc. 22, 1320 (1977).

- "Quantum Beat Method Of Measuring Alignments in Single Ion-Atom Collisions," Bull. Am. Phys. Soc. 22, 1320 (1977).
- "Metastable Auger Emitter Lifetimes by a Delayed Coincidence Technique," Bull. Am. Phys. Soc. 22, 1320 (1977).
- "Radiative Lifetime Measurements on the $n = 2$ Levels of Al XI and P XII," Bull. Am. Phys. Soc. 22, 1321 (1977).
- "Target Specificity Effects on the Production of Core-Excited States of Li and Li⁺ for 10 to 50 keV Collisions of Li⁺ with Gas Targets," Bull. Am. Phys. Soc. 22, 1334 (1977).
- "Decay Studies of $n = 3$ Transitions in Sodiumlike Bromine," Bull. Am. Phys. Soc. 22, 1321 (1977).
- "Lifetimes of the $2p^2 P_{1/2} 3/2$ States of Fe XXIV and the $2s2p^3 P_1^o$ State of Fe XXIII," Bull. Am. Phys. Soc. 22, 1322 (1977).
- "Lifetimes and Oscillator Strengths for $\Delta n = 0$ Dipole Transitions in C-, N-, O-, and F-like Chlorine," Bull. Am. Phys. Soc. 22, 1321 (1977).
- "Decay Measurements on the $n = 2$ States of Li-, Be-, and B-like Chlorine," Bull. Am. Phys. Soc. 22, 1321 (1977).
- "Oscillator Strengths for the Principal Resonance Transitions in Si XI and XII," Bull. Am. Phys. Soc. 22, 1321 (1977).
- "Measurement of Alignments in Single Ion-Atom Collisions by a Quantum Beat Method," presented at the Fourth International Seminar on Ion-Atom Collisions, Darmstadt, Germany, July 1977.
- Invited paper, "Multiple Electron Rearrangement in Heavy Ion-Atom Collisions," presented at the Gordon Research Conference on Atomic Physics, Wolfsborough, New Hampshire, July 1977.
- Invited paper, "Charge Exchange in Slow Collisions," presented at the Gordon Research Conference on Atomic Physics, Wolfsborough, New Hampshire, July 1977.
- "Recoil Ion Spectroscopy: Reduction of Doppler Shifts and Spreads in Fast Beam Experiments," Bull. Am. Phys. Soc. 22, 610 (1977).
- "Lower Limits on Resolved Neon L-shell Excitation Cross-sections by Impact of $1.5 \text{ MeV/A } \sim \text{Si}^{12+}$, Cl^{12+} Ions," Bull. Am. Phys. Soc. 22, 609 (1977).
- "Projectile Charge-State Dependence in K-shell Ionization of Neon, Silicon, and Argon Gases by Lithium Projectiles," Bull. Am. Phys. Soc. 22, 655 (1977).
- "Production of Core-Excited States of Li and Li⁺ in Collisions with Gas Targets," Bull. Am. Phys. Soc. 22, 655 (1977).
- "Auger Electron Emission from Target Ions Under Heavy Ion Impact After Molecular Dissociation," Bull. Am. Phys. Soc. 22, 610 (1977).
- "Lifetime Measurements in Cu XIX," Bull. Am. Phys. Soc. 22, 609 (1977).

" $\Delta n = 0$ Transitions in Highly Ionized Ions," in Proceedings, Nordic Symposium on Atomic and Molecular Transition Probabilities, I. Martinson, ed. (Lunds Univeristet, Lund), p. 8 (1977).

"Der $2s^2S-2p^2P^0$ Doublettübergang in Li-ähnlichem Schwefel," Verhandl., Deutsche Physikalische Gesellschaft 2/1977, 500 (1977).

"Lebensdauern und Oszillatörstärken von $n = 2$ Zuständen in Be-ähnlichem S," Verhandl., Deutsche Physikalische Gesellschaft 2/1977, 500 (1977).

Invited paper, "Contributions of Beam-Foil Spectroscopy to Oscillator Strengths of Interest in High Temperature Plasmas," presented at the American Physical Society-Topical Conference on Atomic Processes in High Temperature Plasmas, Knoxville, February 1977.

"An Application of the Beam Foil Method to Transitions of Astrophysical Interest," presented at the American Physical Society Topical Conference on Atomic Processes in High Temperature Plasmas, Knoxville, February 1977.

"Decay Studies of $n = 3$ States of Sodiumlike Copper Using Foil Excitation," presented at the American Physical Society Topical Conference on Atomic Processes in High Temperature Plasmas, Knoxville, February 1977.

Invited paper, "High Ionization-Excitation States of Ne^{9+} Ions and their Mass-Dependent Symmetric Collision Interactions," presented at the Annual Meeting of the American Physical Society, Division of Electron and Atomic Physics, Lincoln, Nebraska, December 1976, Bull. Am. Phys. Soc. 21, 1250 (1976).

"Radiative Lifetimes and Oscillator Strength for the $n = 2$ States of Be-like Sulfur," Bull. Am. Phys. Soc. 21, 1253 (1976).

"A Beam-Foil Study of the $2s^2S-2p^2P^0$ Doublet in Li-like Sulfur," Bull. Am. Phys. Soc. 21, 1252 (1976).

"Mass Dependence of Ne K X-Ray Yields from Ne^+-Ne Collisions at keV Energies," Bull. Am. Phys. Soc. 21, 1248 (1976).

"Measurement of the H^+H Charge Exchange Cross Section, 0.8-2.5 MeV," in Bull. Am. Phys. Soc. 21, 1265 (1976).

Invited paper, "Overcoming the Doppler Limitation in Beam-Foil Experiments by Target Ion Spectroscopy," presented at the Fourth Conference on Application of Small Accelerators, Denton, Texas, October 1976, Bull. Am. Phys. Soc. 21, 1333 (1976).

"Beam Foil Radiative Lifetime Measurement in Si IX - Si XIII," Bull. Am. Phys. Soc. 21, 689 (1976).

"Characteristic K X-Ray Production from High Energy Al-Al Collisions," Bull. Am. Phys. Soc. 21, 650 (1976).

"Radiative Electron Capture Cross Sections for High Energy Al-Al and Al-C Collisions," Bull. Am. Phys. Soc. 21, 650 (1976).

"Lifetimes and Spectra of Highly Ionized Sulfur," Bull. Am. Phys. Soc. 21, 626 (1976).

"Single and Double Electron Transfer in Bq^+ ($q=2,3,4$) Collisions with He, Ar, and H_2 ," Bull. Am. Phys. Soc. 21, 549 (1976).

Invited Paper, "Beam-Foil Studies of Highly Ionized Atoms," Bull. Am. Phys. Soc. 21, 508 (1976).

Invited Paper, "Highly Ionized Ions," Bull. Am. Phys. Soc. 21, 186 (1976).

"Comparison of Production of Non-Characteristic X-Ray Radiation in Solid (Al) and Gaseous (SiH_4) Targets," Bull. Am. Phys. Soc. 20, 1450 (1975).

"Beam-Foil Spectra of Iron, Copper, and Silicon," Bull. Am. Phys. Soc. 20, 1452 (1975).

Invited Paper, "Projectile Electron Spectroscopy of Autoionizing States in the Alkalis," Bull. Am. Phys. Soc. 20, 826 (1975).

"Autoionizing States in Lithiumlike Si and Sodiumlike Cl," Bull. Am. Phys. Soc. 20, 679 (1975).

"Electron Spectra from Autoionizing States of Highly Stripped Oxygen and Fluorine," Bull. Am. Phys. Soc. 20, 679 (1975).

"Non-Characteristic Spectra from Symmetric and Asymmetric Collision Systems," Bull. Am. Phys. Soc. 20, 675 (1975).

"Electron Spectra from the Autoionizing Decay of Collisionally Excited Mg^+ and K^+ Beams," Bull. Am. Phys. Soc. 20, 674 (1975).

"Charge State Dependence of X-Ray Production of Collisions of Ni (~ 1 MeV/amu) with SiH_4 ," Bull. Am. Phys. Soc. 20, 639 (1975).

Invited Paper, "Directional Anisotropies in Non-Characteristic X-Ray Emission," Bull. Am. Phys. Soc. 20, 607 (1975).

"Energy Dependence of the Directional Anisotropy Exhibited by Quasimolecular K X-Radiation," Bull. Am. Phys. Soc. 20, 75 (1975).

"Electron Spectroscopy of Autoionizing States in LiI and NaI," Bull. Am. Phys. Soc. 19, 1184 (1974).

"Lifetimes and Binding Energies of the Metastable Autoionizing $(1s2s2p)^4P_{5/2}$ State in Al^{10+} and Si^{11+} ," Bull. Am. Phys. Soc. 19, 1176 (1974).

"Characterization of Charge States of Energetic Ions in Solids from Associated K X-Ray Production," Bull. Am. Phys. Soc. 19, 1184 (1974).

Invited Paper, "Recent Coherent Excitation and XUV-X-Ray Spectroscopy Experiments of Some Interest to Nuclear and Optical Physicists," Bull. Am. Phys. Soc. 19, 586 (1974).

"Observations of Non-Characteristic Combined Atom K-shell X-Ray Band in Al-Al Collisions," Bull. Am. Phys. Soc. 19, 590 (1974).

"X-Ray Cross Sections in Symmetric Ion-Atom Collisions," Bull. Am. Phys. Soc. 19, 570 (1974).

"Charge State Dependent Energy Shifts of KX-Rays Accompanying Nearly Symmetric Collisions of ~ 3 MeV/amu S and Cl Ions," Bull. Am. Phys. Soc. 19, 590 (1974).

" $n=2$ Finestructure Decays in He-Like F," Bull. Am. Phys. Soc. 19, 468 (1974).

"K X-Ray Yields from Single Collisions of ~ 100 MeV Cl Ions with Si," Bull. Am. Phys. Soc. 19, 590 (1974).

"Ne and Ar K X-Ray Satellite Production," Bull. Am. Phys. Soc. 19, 570 (1974).

"Improvements in the Use of Grazing Incidence Spectrometers to Study Spectra of Low Intensity, Highly Stripped Ion Beams," Bull. Am. Phys. Soc. 19, 469 (1974).

"XUV Spectra of Highly Stripped Oxygen and Fluorine," Bull. Am. Phys. Soc. 19, 469 (1974).

"Observation of K X-Rays from Highly Ionized States of Neon Produced by 40 MeV Cl^{+7} , Cl^{+11} , and Cl^{+13} Beams," Bull. Am. Phys. Soc. 19, 89 (1974).

"One- and Two-Electron Excited States Produced by Electron Exchange, Excitation, and Electron Capture in Collisions of Fluorine Ions in Argon Gas at 34.8 MeV," Phys. Rev. Lett. 31, 684 (1973).

"Exponential Projectile Charge Dependence of Ar K and Ne X-Ray Production by Fast, Highly-Ionized Argon Beams in Thin Neon Targets," Phys. Rev. Lett. 30, 1289 (1973).

"Metastable Autoionizing States," Nucl. Instr. and Meth. 110, 477 (1973).

"Electron Spectroscopy of Foil-Excited Chlorine Beams," Nucl. Instr. and Meth. 110, 489 (1973).

"Mean Life of the Metastable 2^3P_1 State of the Two-Electron Fluorine Ion," Phys. Rev. A8, 145 (1973).

"Exponential Projectile Charge Dependence of Ar K and Ne K X-Ray Production by Fast, Highly Ionized Argon Beams in Thin Neon Targets," Proceedings, Eighth International Conference on the Physics of Electronic and
B. Cobic and M. Kurepa, editors, Graficko Preduzece Buducnost, Zrenjanin, Yugoslavia (July, 1973), p. 72.

"Metastable States of Highly Excited Heavy Ions," in Atomic Physics 3, Plenum Press, London, p. 327 (1973).

"Equilibrium Fractions for the Lowest Metastable Quartet States of Lithiumlike Oxygen and Fluorine Ions Traversing Carbon Foils," Phys. Rev. A7, 487 (1973).

"Metastable Autoionizing States in Sodium-like Chlorine," Phys. Rev. Lett. 28, 1615 (1972).

"Metastable Autoionizing States of Highly Excited Heavy Ions," Phys. Rev. Lett. 28, 1229 (1972).

"Observation of Coherently Excited Dipole Charge Distribution Oscillations in Collision - Averaged Foil Excitation of the $n=2$ H Levels," Bull. Am. Phys. Soc. 18, 1527 (1973).

"Effective Charge State of Heavy Ions Penetrating Solids Deduced from Comparing X-Ray Yields in Gases and Solids," Bull. Am. Phys. Soc. 18, 1508 (1973); presented at the Third International Conference on Atomic Collisions in Solids, Gatlinburg, Tenn., Sept., 1973 .

"Projectile Structure Effects in Heavy-Ion-Induced K X-Rays: Projectile X-Rays," Bull. Am. Phys. Soc. 18, 1508 (1973).

"Projectile Structure Effects in Heavy-Ion-Induced K X-Rays: Target X-Rays," Bull. Am. Phys. Soc. 18, 1508 (1973).

"Binding Energy and Lifetime of the $(1s2s2p)^4P_{5/2}^0$ State in Lithiumlike Sulfur," Bull. Am. Phys. Soc. 18, 1527 (1973).

"Electron Spectra from the Decay-in-Flight of Metastable Autoionizing States Associated with Highly Excited Heavy Ions," Bull. Am. Phys. Soc. 18, 1527 (1973).

"Mean Life of the Metastable 2^3P_1 State of the Two-Electron Fluorine Ion," Bull. Am. Phys. Soc. 18, 610 (1973).

Invited Paper: "Autoionization of Atoms Produced in Heavy Ion Collision," in Proceedings of the ORNL Heavy-Ion Summer Study Oak Ridge, Tennessee, AEC CONF-720669, 551 (1972).

D. List of Personnel Associated with the University of Tennessee/Oak Ridge National Laboratory Accelerator-based Atomic and Molecular Physics Collaboration

D. 1. Personnel who have regularly participated in the collaboration

<u>Name</u>	<u>Title</u>
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S. B. Elston*	Visiting Assistant Professor
J. P. Forester [†]	Assistant Professor (UT-Chattanooga)
G. A. Glass*	Graduate Research Assistant
P. M. Griffin	Physicist, ORNL
K. O. Groeneveld	Visiting Professor (Germany)
H. H. Haselton	Section Head (ORNL Fusion Energy Division)
H. Hayden	Visiting Associate Professor (Univ. of Conn.)
R. Laubert	Visiting Professor (N.Y.U.)
K. H. Liao	Postdoctoral Research Associate
J. R. Mowat	Assistant Professor (North Carolina State Univ.)
D. J. Pegg*	Associate Professor
R. S. Peterson§	Visiting Assistant Professor (Univ. of Conn.)
I. A. Sellin*	Professor
S. Schumann	Postdoctoral Research Associate (Germany)
M. Suter*	Postdoctoral Research Associate (Switzerland)
R. S. Thoe*	Assistant Professor
C. R. Vane*	Graduate Research Assistant
J. Wright	Visiting Associate Professor (Univ. of New Hampshire)
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James Bayfield	Professor, University of Pittsburgh
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J. Cecci	Physicist, Princeton Plasma Physics Laboratory
D. Crandall	Physicist, Oak Ridge National Laboratory
S. Datz	Associate Director, Chemistry Division, Oak Ridge National Laboratory
D. Dietrich	Postdoctoral Research Associate, LBL
B. L. Donnally	Dean, Lake Forest College
H. J. Frischkorn	Graduate Research Assistant, Univ. of Frankfurt/M
L. Gardner	Postdoctoral Research Associate, Univ. of Pittsburgh
H. Gould	Physicist, LBL
B. Johnson	Physicist, BNL
K. Jones	Physicist, BNL
R. Kauffman	Physicist, Bell Telephone Laboratories
H. Kim	Physicist, Oak Ridge National Laboratory
T. Kruse	Professor, Rutgers University
P. Koch	Assistant Professor, Yale University
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R. Marrus	Professor, University of California at Berkeley
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W. W. Smith	Professor, University of Connecticut
R. R. Turtle	Postdoctoral Research Associate, Univ. of Tennessee