Bibliography on The Analyses of Optical Atomic Spectra Section 3

$^{42}Mo - {}^{57}La$

$^{72}Hf - {}^{89}Ac$

United States Department of Commerce

National Bureau of Standards

Special Publication 306--3

UNITED STATES DEPARTMENT OF COMMERCE
Maurice H. Stans, *Secretary*

NATIONAL BUREAU OF STANDARDS • A. V. Astin, *Director*

Bibliography on The Analyses of Optical Atomic Spectra Section 3

The Spectra of Molybdenum, Technetium, Ruthenium, Rhodium, Palladium, Silver, Cadmium, Indium, Tin, Antimony, Tellurium, Iodine, Xenon, Cesium, Barium, Lanthanum—Hafnium, Tantalum, Tungsten, Rhenium, Osmium, Iridium, Platinum, Gold, Mercury, Thallium, Lead, Bismuth, Polonium, Astatine, Radium and Actinium

Charlotte E. Moore

Office of Standard Reference Data
National Bureau of Standards
Washington, D.C. 20234

National Bureau of Standards Special Publication 306—3

Nat. Bur. Stand. (U.S.), Spec. Publ. 306-3, Section 3, 37 pages (May 1969)
CODEN: XNBSA

Issued May 1969

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 50 cents

Abstract

The three published volumes on "Atomic Energy Levels", NBS Circ. 467, contain for each spectrum the bibliography that was used in compiling the data. The present work is a continuation of these bibliographies arranged in the same form. The time interval is the span from the respective dates of the earlier publications to the present. The selection of references is restricted to those needed for the preparation of revised tables of atomic energy levels and multiplets.

The bibliography is being published by Sections, each of which covers the same elements as the respective volumes of AEL. Section 1 was issued in September 1968; it contains references for the elements ^{1}H through ^{23}V, corresponding to AEL Volume I. Section 2 appeared in February 1969; as in AEL Volume II, the references cover the elements ^{24}Cr through ^{41}Nb.

The present Section is similarly arranged, giving references to the spectra of the elements, ^{42}Mo through ^{57}La and ^{72}Hf through ^{89}Ac, similar to AEL Volume III. For a given element the spectra are listed in order of increasing stage of ionization.

The original papers have been examined for nearly all of the quoted references.

Key Words: Spectra, Atomic; Analyses of Atomic Spectra; Elements, Spectra of Mo through La, Hf through Ac; Bibliography, Atomic Spectra; Atomic Spectra, Mo through La, Hf through Ac; References to Atomic Spectra.

Library of Congress Catalog Card Number: 68-62107

Index to Spectra

Index to Spectra—Continued

Bibliography on The Analyses of Optical Atomic Spectra

Charlotte E. Moore

The present bibliography is a continuation of the series of which two Sections have been published; the first in September 1968 and the second in February 1969 [1].[1] Selected references are listed to meet a steady demand for data on atomic spectra. No attempt has been made to give complete reference lists on atomic spectra including numerous specialized subjects. Those listed have been chosen for individual spectra on the same basis of selection as was used for the Volumes on "Atomic Energy Levels" [2]. They are references that deal with the outer structure of atoms as revealed by their optical spectra. They cover the time interval between the publication of the respective Volumes of "Atomic Energy Levels" and the present time.

Section 1 [1] deals with the elements ^{1}H through ^{23}V from 1949 to the middle of 1968. Earlier references were given in "Atomic Energy Levels" Volume I. Section 2 [1] covers the elements ^{24}Cr through ^{41}Nb, corresponding to AEL Volume II, which was issued in 1952. The present Section contains references to the elements ^{42}Mo through ^{57}La and ^{72}Hf through ^{89}Ac, i.e., similar to those in AEL Volume III, issued in 1958.

This publication will conclude with Section 4 which will deal with rare-earth spectra, and thus complete the elements in the Periodic Table. The "Atomic Energy Levels" for rare-earth spectra scheduled to comprise Volume IV of the AEL set, are not yet compiled. This Volume has been delayed because many of the very complex spectra to be included are at present under active investigation. Meanwhile, it is felt that a bibliography on rare-earth spectra may help to meet present needs.

[1] Figures in brackets indicate the literature references on page IV.

As in the preceding Sections the content of individual papers is briefly described by key letters or words. The letters have the following meanings:

C L	Classified lines
E D	Energy level diagram
G D	Grotrian diagram
I P	Ionization potential
I S	Isotope shift
T	Terms (and/or energy levels)
W L	Wavelength
Z E	Zeeman effect
[ ]	Forbidden transitions
hfs	Hyperfine structure
Osc. Str.	Oscillator strength
x	Correction connecting sets of terms of different multiplicities

The letters "A" and "L" entered in parentheses before the date of the reference denote respectively, that the paper is an Abstract or a Letter to the Editor.

In general, the references have been selected as those needed to revise and extend the author's Tables of Atomic Energy Levels [2] and Multiplets [3, 4, 5]. They refer mostly to laboratory observations and analyses. There are a few special cases where forbidden lines observed in coronal or nebular spectra provide reliable information on intervals of ground terms of selected spectra. Similarly, some papers on theoretical work are also extremely useful. Such references are included.

A limited number of scattered references on related topics such as hyperfine structure, Stark Effect, Isotope Shift, etc., are also included, but no effort has been made to cover these related subjects completely.

In tabulating the references for a given spectrum the overall plan has been to arrange them in alphabetical order by author and by year, starting with the earlier papers. Owing to the use of the photographic method for publication, this order has not been followed strictly. If excellent reference material became available after the final typing had been completed, additional references were inserted under the proper spectra where space permitted. This has introduced some irregularities in arrangement, but it has also made the bibliography more useful.

Nearly all of the references quoted here have been examined by the author. Only a few which were not available have been copied on the basis of abstracts found in the literature.

The author is grateful to all who have generously contributed material for inclusion here. Some have made special effort to furnish current references and reprints, and to outline programs in progress in various laboratories. She appreciates the useful additions to the bibliography kindly furnished by L. Minnhagen. Special thanks are also due Isabel D. Murray for her meticulous care in preparing the press copy of the manuscript.

References

[1] C. E. Moore, Nat. Bur. Stand. Special Publ. 306, Section 1, 80 pp. (1968); Section 2, 57 pp. (1969).

[2] C. E. Moore, Nat. Bur. Stand. Circ. 467, Vol. I, 309 pp. (1949); Vol. II, 227 pp. (1952); Vol. III, 245 pp. (1958).

[3] C. E. Moore, Nat. Bur. Stand. Circ. 488, Section 1, 78 pp. (1950); Section 2, 115 pp. (1952); Section 3, 94 pp. (1962); Section 4, 65 pp. (1962); Section 5, 30 pp. (1962).

[4] C. E. Moore, Reprinting of 1945 Princeton Multiplet Table, Nat. Bur. Stand. Tech. Note 36 (PB 151395), 245 pp. (1959).

[5] C. E. Moore, Nat. Stand. Ref. Data Series, Nat. Bur. Stand. NSRDS–NBS 3, Section 1 (1965); Section 2 (1967).

Washington, D.C.
January 21, 1969.

General References

A. P. Striganov and U. P. Dontsov, Uspekhi Fiz. Nauk **55**, 315 to 390 (1955). I S

R. E. Trees, Phys. Rev. **123**, 1293 to 1300 (1961). Theory; "Repulsion of Energy Levels" in Complex Atomic Spectra.

R. D. Cowan, J. Opt. Soc. Am. **58**, 924 to 933 (1968). Theory p^m—$p^{m-1}l$ transitions, Ar I and Cl I sequences.

C. Roth, J. Res. Nat. Bur. Stand. **72A** (Phys. and Chem.) No. 5, 505 to 520 (1968). Theory Third Spectra of Iron Group.

MOLYBDENUM (Z = 42)

Mo I

C. E. Moore and P. W. Merrill, Appendix A: Partial Grotrian Diagrams (1956); Nat. Std. Ref. Data Series, Nat. Bur. Std. NSRDS-NBS 23, 55 (1968). C L

Yu. P. Dontsov, Opt. i Spektr. 8, 446 to 451 (1960). I S, C L

R. H. Hughes, Phys. Rev. 121, 499 to 500 (1961). I S, C L

Mo II

H. D. Goldgraber, Phys. Rev. 91, 456 (A) (1953). Theory

C. E. Moore and P. W. Merrill, Appendix A: Partial Grotrian Diagrams (1956); Nat. Std. Ref. Data Series, Nat. Bur. Std. NSRDS-NBS 23, 53 (1968). C L

F. R. Rico, An. Real Soc. Esp. Fis. y Quim. [A] 53, 185 to 200 (1957). W L

I. I. Gromova, Opt. i Spektr. 4, 687 to 689 (1958). T, C L, W L
Vac. Ultraviolet

Y. Shadmi, Bull. Research Council Israel 9F, 141 to 170 (1961). Theory

Mo III

F. R. Rico, An. Real Soc. Esp. Fis. y Quim. (Madrid) [A] 53, 185 to 200 (1957); 61, 103 to 118 (1965). T, C L, W L

Y. Shadmi, J. Research Nat. Bur. Std. 70A, 435 to 445 (1966). Theory

Mo IV

F. R. Rico, An. Real Soc. Esp. Fis. y Quim. [A] 53, 185 to 200 (1957). W L

Mo V

F. R. Rico, An. Real Soc. Esp. Fis. y Quim. (Madrid) [A] 53, 185 to 200 (1957). W L

Mo VI

R. D. Cowan, J. Opt. Soc. Am. 58, 924 to 933 (1968). Theory

Mo VII

R. D. Cowan, J. Opt. Soc. Am. 58, 924 to 933 (1968). Theory

M. S.-Z. Chaghtai, unpublished analysis (Orsay, Lund) (1969). I P, T, C L

Mo VIII

R. D. Cowan, J. Opt. Soc. Am. 58, 924 to 933 (1968). Theory

M. S.-Z. Chaghtai, unpublished analysis (Orsay, Lund) (1969). T, C L

Mo IX

R. D. Cowan, J. Opt. Soc. Am. 58, 924 to 933 (1968). Theory

M. S.-Z. Chaghtai, unpublished analysis (Orsay, Lund) (1969). T, C L

Mo X

R. D. Cowan, J. Opt. Soc. Am. 58, 924 to 933 (1968). Theory

Mo XI

R. D. Cowan, J. Opt. Soc. Am. 58, 924 to 933 (1968). Theory

Mo XVI

B. Edlén, "Atomic Spectra", Hand. der Phys., Encycl. of Phys. 27, 160 (1964). T

TECHNETIUM (Z = 43)

Tc I

P. W. Merrill, Science 115, 484 (A) (1952); Astroph. J. 116, 21 to 26 (1952). Stellar Ident.

P. W. Merrill, Publ. Astron. Soc. Pacific 68, 70 to 71 (1956). Stellar Ident.

C. E. Moore and P. W. Merrill, Appendix A: Partial Grotrian Diagrams (1956); Nat. Std. Ref. Data Series, Nat. Bur. Std. NSRDS-NBS 23, 59 (1968). C L

W. R. Bozman and R. E. Trees, J. Research Nat. Bur. Std. 58, 95 to 100, RP2739 (1957). Theory

S. Katcoff, Phys. Rev. 111, 575 to 578 (1958). Isotopes, Half-Life Meas.

W. R. Bozman, W. F. Meggers and C. H. Corliss, J. Research Nat. Bur. Std. 71A, 547 to 565 (1967). W L

W. R. Bozman, C. H. Corliss and J. L. Tech, J. Research Nat. Bur. Std. 72A, in press (December 1968). T, C L

Tc II

C. E. Moore and P. W. Merrill, Appendix A: Partial Grotrian Diagrams (1956); Nat. Std. Ref. Data Series, Nat. Bur. Std. NSRDS-NBS 23, 57 (1968). C L

Y. Shadmi, Bull. Research Council Israel 9F, 141 to 170 (1961). Theory

W. R. Bozman, W. F. Meggers and C. H. Corliss, J. Research Nat. Bur. Std. 71A, 547 to 565 (1967). W L

Tc III

M. A. Catalán y F. R. Rico, An. Real Soc. Esp. Fis. y Quim. (Madrid) [A] 53, 85 to 94 (1957). I P

Y. Shadmi, J. Research Nat. Bur. Std. 70A, 435 to 445 (1966). Theory

RUTHENIUM (Z = 44)

Ru I

K. Murakawa, J. Phys. Soc. Japan 11, 182 (1956). hfs

K. G. Kessler, J. Research Nat. Bur. Std. 63A, 213 to 251 (1959). I P, T, C L, Z E, W L

J. R. McNally, Jr. and K. G. Kessler, J. Research Nat. Bur. Std. 63A, 253 to 254 (1959). Z E

R. E. Trees, J. Opt. Soc. Am. 49, 838 to 843 (1959); J. Research Nat. Bur. Std. 63A, 255 to 260 (1959). Theory

R. H. Hughes, Phys. Rev. 121, 499 to 500 (1961). I S, C L

W. H. King, Proc. Roy. Soc. London A280, 430 to 438 (1964). I S

Ru II

A. G. Shenstone and W. F. Meggers, J. Research Nat. Bur. Std. 61, 373 to 411, RP2908 (1958). I P, T, C L, Z E, W L

Y. Shadmi, Bull. Research Council Israel 9F, 141 to 170 (1961). Theory

Ru III

K. G. Kessler and W. F. Meggers, J. Research Nat. Bur. Std. 55, 97 to 126, RP2609 (1955). W L

A. G. Shenstone, unpublished analysis (June 1960). I P, T, C L, W L

Y. Shadmi, J. Research Nat. Bur. Std. 70A, 435 to 445 (1966). Theory

RHODIUM (Z = 45)

Rh I

Y. W. Chan and L. S. Goodman, Bull. Am. Phys. Soc. 12, 653 (A) (1967). hfs, Z E

RHODIUM

Rh II

F. J. Sancho, An. Real Soc. Esp. Fiz. y Quim. (Madrid) A54, 41 to 64, 65 to 74 (1958). T, C L, E D, W L

Y. Shadmi, Bull. Research Council Israel 9F, 141 to 170 (1961). Theory

Rh III

A. G. Shenstone, private communication (1961). Published analysis needs revision

L. Iglesias, Canadian J. Phys. 44, 895 to 915 (1966). T, C L, W L

Y. Shadmi, J. Research Nat. Bur. Std. 70A, 435 to 445 (1966). Theory

PALLADIUM (Z = 46)

Pd I

K. G. Kessler, W. F. Meggers and C. E. Moore, J. Research Nat. Bur. Std. 53, 225 to 228, RP2538 (1954). C L, W L

H. G. Kuhn and A. G. Warner, Proc. Roy. Soc. London A245, 330 to 334 (1958). I S

H. Chantrel, Ann. de Phys. [13] 4, 979 to 983 (1959). hfs

Y. Shadmi, Thesis (1960). Theory, Pd I Group

R. H. Hughes and F. A. Sharpton, Phys. Rev. 121, 1702 to 1703 (1961). I S

K. H. Channappa and J. M. Pendlebury, Proc. Phys. Soc. (London) 86, 1145 to 1146 (L) (1965). hfs

B. Budick, Phys. Rev. 168, 89 to 92 (1968). hfs

PALLADIUM

Pd II

Y. Shadmi, Bull. Research Council Israel 9F, 141 to 170 (1961). Theory

Y. Shadmi, Physica 33, 183 to 187 (1967). Theory

Pd III

A. G. Shenstone, J. Research Nat. Bur. Std. 67A, 87 to 112 (1963). I P, T, C L, E D, W L

Y. Shadmi, J. Research Nat. Bur. Std. 70A, 435 to 445 (1966). Theory

Pd XX

B. Edlén, "Atomic Spectra", Hand. der Phys., Encycl. of Phys. 27, 160 (1964). T

SILVER (Z = 47)

Ag I

M. Elbel und W. Fischer, Zeit. Phys. 166, 504 to 509 (1962). C L, I S

W. B. Ewbank and H. A. Shugart, Phys. Rev. 129, 1617 to 1621 (1963). hfs

A. G. Blachman, D. A. Landman and A. Lurio, Phys. Rev. 150, 59 to 68 (1966). hfs

H. Dahmen und S. Penselin, Zeit. Phys. 200, 456 to 466 (1967). hfs

Ag II

Y. Shadmi, Bull. Research Council Israel 9F, 141 to 170 (1961). Theory

M. Elbel und W. Fischer, Zeit. Phys. 166, 504 to 509 (1962). C L, I S

SILVER

Ag III

Y. Shadmi, J. Research Nat. Bur. Std. 70A, 435 to 445 (1966). Theory

Ag XXI

B. Edlén, "Atomic Spectra", Hand. der Phys., Encycl. of Phys. 27, 160 (1964). T

CADMIUM (Z = 48)

Cd I

K. Burns and K. B. Adams, J. Opt. Soc. Am. 46, 94 to 99 (1956). T, C L, Interf. W L

C. J. Humphreys and E. Paul, Jr., NAVORD Report 4600, 23 to 36 (1957); 5963, 56 to 58 (1959). Interf. W L Infrared

J. Blaise, Ann. de Phys. [13] 3, 1062 to 1067 (1958). I S

J. J. McNeill, J. Opt. Soc. Am. 49, 441 to 445 (1959). W L

W. Faust, M. McDermott and W. Lichten, Phys. Rev. 120, 469 (1960). hfs

C. F. Bruce and R. M. Hill, Australian J. Phys. 14, 64 to 88 (1961). Interf. W L

C. J. Humphreys, unpublished material (1961). Interf. W L Infrared

F. M. Kelly and E. Tomchuk, Proc. Phys. Soc. (London) 78, 1304 to 1306 (1961). I S

I. Khr. Pacheva, Bulgar. Akad. Nauk 9, 93 to 104 (1961); See Chem. Abstr. 56, 4253e (1962). I S

R. H. Garstang, J. Opt. Soc. Am. 52, 845 to 851 (1962). C L, hfs

K. M. Baird, D. S. Smith and K. H. Hart, J. Opt. Soc. Am. 53, 717 to 720 (1963). Interf. W L

H. Danker, Spectrochim. Acta 19, 1443 to 1448 (1963). T, [C L]

Cd I - Continued

R. J. Hull and H. H. Stroke, J. Opt. Soc. Am. 53, 1147 to 1152 (1963). hfs, I S

International Committee on Weights and Measures, J. Opt. Soc. Am. 53, 401 (1963). W L Standards

J. Séguier, Compt. Rend. 256, 1703 to 1704 (1963). C L, W L Infrared

M. Barrat, Compt. Rend. 259, 1504 to 1506 (1964). hfs

B. Edlén, Trans. Intern. Astron. Union 12A, 137 to 143 (1964). W L, C L

J. J. Forney et E. Geneux, Phys. Lett. (Amsterdam) 20, 632 to 634 (1966). Z E, Stark Effect

W. R. S. Garton and J. P. Connerade, Astroph. J., in press (1968). Absorption Series Vac. Ultraviolet

A. Khadjavi, A. Lurio and W. Happer, Phys. Rev. 167, 128 to 135 (1968). Stark Effect

Cd II

K. Burns and K. B. Adams, J. Opt. Soc. Am. 46, 94 to 99 (1956). T, C L, Interf. W L

F. M. Kelly and J. B. Sutherland, Can. J. Phys. 34, 521 to 522 (1956). hfs

J. Blaise, Ann. de Phys. [13] 3, 1062 to 1067 (1958). I S

Y. Shadmi, Bull. Research Council Israel 9F, 141 to 170 (1961). Theory

M. Barrat, Compt. Rend. 259, 1504 to 1506 (1964). hfs

F. Lés, Acta Phys. Polon. 26, 951 to 962 (1964). hfs, I S

G. R. Fowles and W. T. Silfvast, IEEE J. Qu. Electronics QE-1, 131 (1965). Laser Obs.

W. T. Silfvast, G. R. Fowles and B. D. Hopkins, Appl. Phys. Lett. 8, 318 to 319 (1966). Laser Transitions

CADMIUM

Cd III

Y. Shadmi, J. Research Nat. Bur. Std. 70A, 435 to 445 (1966). Theory

Cd XXII

B. Edlén, "Atomic Spectra", Hand. der Phys., Encycl. of Phys. 27, 160 (1964). T

INDIUM (Z = 49)

In I

C. E. Moore and P. W. Merrill, Appendix A: Partial Grotrian Diagrams (1956); Nat. Std. Ref. Data Series, Nat. Bur. Std. NSRDS-NBS 23, 23 (1968). C L

T. G. Eck and P. Kusch, Phys. Rev. 106, 958 to 964 (1957). hfs

T. G. Eck, A. Lurio and P. Kusch, Phys. Rev. 106, 954 to 957 (1957). hfs

D. A. Jackson, J. Phys. Rad. (Paris) [8] 18, 459 to 467 (1957). I S

D. A. Jackson, Proc. Roy. Soc. London [A] 241, 283 to 298 (1957); 246, 344 (1958). hfs

W. R. S. Garton and K. Codling, Proc. Phys. Soc. (London) 78, 600 to 606 (1961). Series Vac. Ultraviolet

W. R. S. Garton, J. Quant. Spectrosc. Rad. Transfer 2, 335 to 341 (1962). Series, Autoionization

N. P. Penkin and L. N. Shabanova, Opt. i Spektr. 18, 749 to 755, 941 to 946 (1965). I P, E D, Absorption Series

J. Séguier, Compt. Rend. 261, 3561 to 3562 (1965). C L, W L Infrared

W. R. S. Garton, W. H. Parkinson and E. M. Reeves, Can. J. Phys. 44, 1745 to 1752 (1966). C L, Absorption Series Vac. Ultraviolet

G. V. Marr and R. Heppinstall, Proc. Phys. Soc. (London) 87, 547 to 549 (1966). C L Autoionization

In I - Continued

W. W. Duley and W. R. S. Garton, Proc. Phys. Soc. (London) 92, 830 to 832 (1967). Autoionizing Transitions

I. Johansson and U. Litzén, Ark. Fys. (Stockholm) 34, No. 46, 573 to 587 (1967). I P, T, C L, W L, hfs

In II

R. A. Nodwell and A. M. Crooker, Phys. Rev. 96, 845 (A) (1954). C L

D. A. Jackson, J. Phys. Rad. (Paris) [8] 18, 145 to 156 (1957). hfs

W. T. Silfvast, G. R. Fowles and B. D. Hopkins, Appl. Phys. Lett. 8, 318 to 319 (1966). Laser Transitions

In XXIII

B. Edlén, "Atomic Spectra", Hand. der Phys., Encycl. of Phys. 27, 160 (1964). T

TIN (Z = 50)

Sn I

R. A. Fisher, W. C. Knopf, Jr. and F. E. Kinney, Astroph. J. 130, 683 to 687 (1959). W L, C L Infrared

C. J. Humphreys and E. Paul, Jr., J. Opt. Soc. Am. 51, 488 (A) (1961). Obs. 1.1μ to 2.5μ

W. G. Brill and K. L. Andrew, J. Opt. Soc. Am. 54, 566 (A) (1964). T, C L, W L

W. J. Childs and L. S. Goodman, Phys. Rev. 134, A66 to A69 (1964); 137, A35 to A42 (1965). Z E, hfs

Sn I - Continued

R. H. Garstang, Proc. Phys. Soc. (London) 84, 175 to 176 (L) (1964). Z E Theory

M. Wilson, Thesis, unpublished (1964). T, Absorption Series Ultraviolet

I. Agirbiceanu, V. Tatu, N. Comaniciu and V. Draganescu, Rev. Roumaine Phys. 9, 637 to 644 (1964); See Chem. Abstr. 62, 12613c (1965). I S

T. Kornalewski, Acta Phys. Polon. 27, 987 to 988 (L) (1965). [C L]

M. Brieger und P. Zimmerman, Zeit. Naturforsch. 22a, 2001 to 2004 (1967). hfs

A. Dymanus, M. H. Prior and H. A. Shugart, Bull. Am. Phys. Soc. 12, 1046 (A) (1967). hfs

T. Kornalewski and H. Niewodniczański, Acta Phys. Polon. 32, 197 to 199 (1967). [C L]

G. M. Lawrence, Astroph. J. 148, 261 to 268 (1967). Theory

Sn II

D. N. Stacey, Proc. Roy. Soc. London A280, 439 to 446 (1964). hfs, I S

A. G. Shenstone, Analysis in progress (1966).

W. T. Silfvast, G. R. Fowles and B. D. Hopkins, Appl. Phys. Lett. 8, 318 to 319 (1966). Laser Transitions

Sn IV

M. A. Mazing and N. A. Vrublevskaya, Opt. i Spektr. 16, 11 to 15 (1964). C L, W L Plasma Observations

Sn XXIV

B. Edlén, "Atomic Spectra", Hand. der Phys., Encycl. of Phys. 27, 160 (1964). T

ANTIMONY (Z = 51)

Sb I

P. C. B. Fernando, G. K. Rochester, I. J. Spalding and K. F. Smith, Phil. Mag. 5, 1291 to 1298, 1309 (1960). hfs

F. Lés, Acta Phys. Polon. 20, 775 to 782 (1961). hfs

M. Hults and S. Mrozowski, J. Opt. Soc. Am. 54, 855 to 858 (1964). hfs

G. J. Garrett, A. D. Jackson, Jr. and E. H. Rogers, Bull. Am. Phys. Soc. [2]12, 509 (A) (1967). hfs

Sb II

M. Hults and S. Mrozowski, J. Opt. Soc. Am. 54, 855 to 858 (1964). hfs

Sb XXV

B. Edlén, "Atomic Spectra", Hand. der Phys., Encycl. of Phys. 27, 160 (1964). T

TELLURIUM (Z = 52)

Te I

P. M. Griffin and K. L. Vander Sluis, J. Opt. Soc. Am. 45, 901 to 902 (A) (1955). Z E

S. Yanagawa, J. Phys. Soc. Japan 10, 1029 to 1032 (1955). Theory

S. Axensten, G. Liljegren and I. Lindgren, Ark. Fys. (Stockholm) 20, No. 31, 473 to 478 (1962). hfs, Z E

R. Gáspár, Acta Phys. (Budapest) 15, 257 to 273 (1963). Theory

K. E. Ädelroth, I. Lindgren, M. Olsmats and L. Sanner, Ark. Fys. (Stockholm) 30, No. 10, 111 to 119 (1965). hfs, Z E

Te I - Continued

J. Heldt, J. Opt. Soc. Am. 57, 865 to 867 (1967). [C L], Z E

G. W. Charles, J. Opt. Soc. Am. 58, 275 to 276 (L) (1968). Z E, Theory

Te II

R. H. Hughes, W. A. Hilton and F. A. Sharpton, J. Opt. Soc. Am. 51, 696 (L) (1961). I S

H. G. Kuhn and R. Turner, Proc. Roy. Soc. London A265, 39 to 45 (1961). I S, hfs

M. B. Handrup and J. E. Mack, Physica 30, 1245 to 1275 (1964). I P, T, C L, Z E

Te III

A. M. Crooker and Y. N. Joshi, J. Opt. Soc. Am. 54, 553 to 554 (L) (1964). I P, T

Te IV

A. M. Crooker and Y. N. Joshi, J. Opt. Soc. Am. 54, 553 to 554 (L) (1964). I P, T

Te V

A. M. Crooker and Y. N. Joshi, J. Opt. Soc. Am. 54, 553 to 554 (L) (1964). I P, T

Te VI

A. M. Crooker and Y. N. Joshi, J. Opt. Soc. Am. 54, 553 to 554 (L) (1964). I P, T

IODINE (Z = 53)

I I

K. Murakawa, J. Phys. Soc. Japan 13, 484 to 492 (1958). T, C L, W L, hfs

C. C. Kiess and C. H. Corliss, J. Research Nat. Bur. Std. 63A, 1 to 18 (1959). I P, T, C L, Z E, W L

E. Lipworth, H. L. Garvin and T. M. Green, Phys. Rev. 119, 2022 to 2025 (1960). hfs

L. Minnhagen, Ark. Fys. (Stockholm) 21, No. 26, 415 to 478 (1962). I P, T, C L, E D, W L

I. A. Berezin and G. N. Yanovskaya, Opt. i Spektr. 14, 23 to 28 (1963). W L

J. V. V. Kasper and G. C. Pimentel, Appl. Phys. Lett. 5, 231 to 233 (1964). [C L] Laser Observations

L. Minnhagen and C. J. Humphreys, NAVWEPS Report 8213, 25 to 30 (1964). T, C L 4μ, Theory

B. Kjöllerstrom, N. H. Möller and H. Svensson, Ark. Fys. (Stockholm) 29, No. 19, 275 to 284 (1965). Theory

R. E. Huffman, J. C. Larrabee and Y. Tanaka, J. Chem. Phys. 47, 856 to 857 (1967). I P, Absorption Series

G. M. Lawrence, Astroph. J. 148, 261 to 268 (1967). Theory

K. Bockasten, Appl. Phys. Lett. 4, 118 to 119 (1964). C L Laser Transitions

I II

W. C. Martin and C. H. Corliss, J. Research Nat. Bur. Std. 64A, 443 to 479 (1960). I P, T, C L, Z E, W L

I. A. Berezin and G. N. Yanovskaya, Opt. i Spektr. 14, 23 to 28 (1963). W L

G. R. Fowles and R. C. Jensen, Appl. Opt. 3, 1191 to 1192 (1964). C L, E D Laser Observations

K. Murakawa, J. Phys. Soc. Japan 19, 1539 to 1541 (1964). T, hfs

W. B. Bridges and A. N. Chester, IEEE J. Qu. Electronics QE-1, 66 to 84 (1965). C L, W L Laser Observations

I II - Continued

C. S. Willett and O. S. Heavens, Opt. Acta 13, 271 to 274 (1966); 14, 195 to 197 (1967). C L, E D Laser Transitions, hfs

C. S. Willett, IEEE J. Qu. Electronics QE-3, 33 (1967). C L Laser Observations

Xenon (Z = 54)

Xe I

J. C. McLennan and F. M. Quinlan, Trans. Roy. Soc. Can. [3] 24, 47 to 52 (1930). Interf. W L Infrared

E. K. Plyler, L. R. Blaine and E. D. Tidwell, J. Research Nat. Bur. Std. 55, 279 to 284, RP2630 (1955). Interf. W L Infrared

M. Thekaekara, G. H. Dieke and H. M. Crosswhite, Johns Hopkins Spectr. Report No. 12, 101 pp. (1955). T, C L, E D, W L

P. G. Wilkinson, J. Opt. Soc. Am. 45, 1044 to 1046 (1955). W L

M. Thekaekara and G. H. Dieke, Phys. Rev. 109, 2029 to 2031 (1958). T, C L, W L

C. J. Humphreys and E. Paul, Jr., NAVWEPS Report 5996, 23 to 40 (1960). C L, W L Infrared

L. Minnhagen, B. Petersson and L. Stigmark, Ark. Fys. (Stockholm) 16, No. 45, 541 to 544 (1960). Observations

W. L. Faust and M. N. McDermott, Phys. Rev. 123, 198 to 204 (1961). hfs

G. Hepner, Ann. de Phys. [13] 6, 735 to 750 (1961). C L, W L Infrared

C. J. Humphreys, E. Paul, Jr. and K. B. Adams, NAVWEPS Report 7205, 25 to 52 (1961). C L, W L Infrared, E D

C. J. Humphreys and E. Paul, Jr., NAVWEPS Report 8150, 33 to 39 (1963). C L 4μ Region, Theory

J. A. R. Samson, Phys. Rev. 132, 2122 to 2124 (1963); Phys. Lett. (Amsterdam) 8, 107 to 109 (1964). Autoionization Series

Xe I - Continued

R. der Agobian, J. L. Otto, R. Cagnard et R. Echard, J. de Phys. (Paris) 25, 887 to 897 (1964). C L, W L Infrared

K. Codling and R. P. Madden, Phys. Rev. Lett. 12, 106 to 108 (1964). Inner Shell Absorption Series

W. L. Faust, R. A. McFarlane, C. K. N. Patel and C. G. B. Garrett, Phys. Rev. 133, A1476 to A1486 (1964). Maser W L, C L, Theory

C. J. Humphreys and E. Paul, Jr., NAVWEPS Report 8213, 9 to 25 (1964). C L, Interf. W L 1.2μ to 3.5μ

R. P. Madden and K. Codling, J. Opt. Soc. Am. 54, 268 to 269 (L) (1964). Autoionizing Series

B. Petersson, Ark. Fys. (Stockholm) 27, No. 23, 317 to 319 (1964). T, C L, W L Vac. Ultraviolet

W. T. Walter and S. M. Jarrett, Appl. Opt. 3, 789 to 790 (1964). C L Laser Observations

P. O. Clark, Phys. Lett. (Amsterdam) 17, 190 to 192 (1965). C L Laser Observations

S. Liberman, Compt. Rend. 261, 2601 to 2604 (1965). C L, Laser Observations 2μ to 9μ

J. D. Dow and R. S. Knox, Phys. Rev. 152, 50 to 56 (1966). Theory

C. J. Humphreys and E. Paul, Jr., Naval Ord. Lab. Cor. NOLC Report 688, 7 to 24 (1966). T, C L, Interf. W L

R. H. Neusel, IEEE J. Qu. Electronics QE-2, 758 (L) (1966). Laser Observations

K. Sakurai and K. Shimoda, J. Phys. Soc. Japan 21, 1214 (1966). hfs Maser Transitions

H. R. Schlossberg and A. Javan, Phys. Rev. Lett. 17, 1242 to 1244 (1966). hfs, Z E Laser Observations

O. Andrade, M. Gallardo and K. Bockasten, Appl. Phys. Lett. 11, 99 to 100 (1967). C L, Laser Observations

C. J. Humphreys, E. Paul, Jr., R. D. Cowan and K. L. Andrew, J. Opt. Soc. Am. 57, 855 to 864 (1967). T, C L, W L 4μ Region

R. Vetter, Compt. Rend. 265B, 1415 to 1418 (1967). I S, C L Infrared

Xe I - Continued

F. J. Comes, H. G. Sälzer und G. Schumpe, Zeit. Naturforsch. 23a, 137 to 151 (1968). Autoionization

D. L. Ederer and R. P. Madden, Bull. Am. Phys. Soc. [2] 13, 38 (1968). Autoionizing Series

S. Liberman, Compt. Rend. 266B, 236 to 239 (1968). hfs, C L Laser Observations

L. Minnhagen, unpublished observations (1969). W L Vac. Ultraviolet

Xe II

M. Thekaekara, G. H. Dieke and H. M. Crosswhite, Johns Hopkins Spectr. Report No. 12, 70 to 71 (1955). W L

L. Minnhagen, B. Petersson and L. Stigmark, Ark. Fys. (Stockholm) 16, No. 45, 541 to 544 (1960). Observations

P. Laures, L. Dana et C. Frapard, Compt. Rend. 259, 745 to 747 (1964). C L Laser Observations

W. B. Bridges and A. N. Chester, IEEE J. Qu. Electronics QE-1, 66 to 84 (1965). C L, W L Laser Observations

R. H. Neusel, IEEE J. Qu. Electronics QE-2, 334 (L) (1966). C L Laser Observations

K. G. Ericsson and L. R. Lidholt, IEEE J. Qu. Electronics QE-3, 94 (1967). C L Superradiant Transitions

L. Minnhagen, unpublished observations (1969). W L Vac. Ultraviolet

Xe III

L. Minnhagen, B. Petersson and L. Stigmark, Ark. Fys. (Stockholm) 16, No. 45, 541 to 544 (1960). Observations

W. B. Bridges and A. N. Chester, IEEE J. Qu. Electronics QE-1, 66 to 84 (1965). C L, W L Laser Observations

R. H. Neusel, IEEE J. Qu. Electronics QE-2, 70, 334, 758 (L) (1966). C L. Laser Observations

Xe III - Continued

R. G. Ericsson and L. R. Lidholt, IEEE J. Qu. Electronics QE-3, 94(1967). C L Superradiant Transitions

L. Minnhagen, On program at Lund (1967).

Xe IV

L. Minnhagen, B. Petersson and L. Stigmark, Ark. Fys. (Stockholm) 16, No. 45, 541 to 544 (1960). Observations

W. B. Bridges and A. N. Chester, IEEE J. Qu. Electronics QE-1, 66 to 84 (1965). W L? Laser Observations

L. Minnhagen, On program at Lund (1967).

Xe V

B. C. Fawcett, B. B. Jones and R. Wilson, Proc. Phys. Soc. (London) 78, 1223 to 1226 (1961). W L

Xe VI

B. C. Fawcett, B. B. Jones and R. Wilson, Proc. Phys. Soc. (London) 78, 1223 to 1226 (1961). W L

Xe VII

B. C. Fawcett, B. B. Jones and R. Wilson, Proc. Phys. Soc. (London) 78, 1223 to 1226 (1961). C L

Xe VIII

B. C. Fawcett, B. B. Jones and R. Wilson, Proc. Phys. Soc. (London) 78, 1223 to 1226 (1961). C L

Xe IX

B. C. Fawcett, B. B. Jones and R. Wilson, Proc. Phys. Soc. (London) 78, 1223 to 1226 (1961). W L

B. C. Fawcett, A. H. Gabriel, B. B. Jones and N. J. Peacock, Proc. Phys. Soc. (London) 84, 257 to 262 (1964). C L

CESIUM (Z = 55)

Cs I

C. E. Moore and P. W. Merrill, Appendix A: Partial Grotrian Diagrams (1956); Nat. Std. Ref. Data Series, Nat. Bur. Std. NSRDS-NBS 23, 9 (1968). C L

H. Bucka, Zeit. Phys. 151, 328 to 339 (1958). hfs

T. Skalinski, J. Phys. Rad. 19, 890 to 900 (1958). hfs, Z E

R. A. Fisher, W. C. Knopf, Jr. and F. E. Kinney, Astroph. J. 130, 683 to 687 (1959). C L Infrared

D. Conrad, Zeit. Phys. 162, 160 to 168 (1961). hfs, Z E

I. Johansson, Ark. Fys. (Stockholm) 20, No. 7, 135 to 146 (1961). I P, T, C L, E D hfs Infrared Observations

W. Wilke, Zeit. Phys. 165, 562 to 568 (1961). hfs, Z E

P. Barbey et E. Geneux, Helv. Phys. Acta 35, 561 to 562 (1962). hfs

H. Bucka und G. v. Oppen, Ann. der Phys. [7] 10, 119 to 120 (1962). hfs

V. W. Cohen, T. Moran and S. Penselin, Phys. Rev. 127, 517 to 523 (1962). hfs

H. R. Griem, Phys. Rev. 128, 515 to 523 (1962). C L, Stark Effect Theory

C. J. Humphreys and E. Paul, Jr., NAVWEPS Report 8141, 29 to 46 (1962). Theory, C L

H. Kleiman, J. Opt. Soc. Am. 52, 441 to 447 (1962). I P, T, C L, Interf. W L, hfs

Cs I - Continued

J. Séguier, Compt. Rend. 255, 489 to 490 (1962). C L, W L Infrared

B. E. Watt, Los Alamos Sci. Lab., LAMS-2649, 10 pp. (1962). T, Series

C. J. Humphreys and E. Paul, Jr., Appl. Opt. 2, 691 to 698 (1963). C L 3.9μ

K. Bockasten, J. Opt. Soc. Am. 54, 1065 (L) (1964). I P, T, Theory

A. Fröman, J. Linderberg and Y. Öhrn, J. Opt. Soc. Am. 54, 1064 to 1065 (L) (1964). Theory

E. Lipworth and P. G. H. Sandars, Phys. Rev. Lett. 13, 716 to 717 (1964). hfs, Z E

G. V. Markova and M. P. Chaika, Opt. i Spektr. 17, 319 to 326 (1964). hfs, Z E

K. B. Eriksson, I. Johansson and G. Norlén, Ark. Fys. (Stockholm) 28, No. 19, 233 to 238 (1965). I P, T, C L, Interf. W L, hfs

C. J. Humphreys and E. Paul, Jr., NAVWEPS Report 8833, 35 to 36 (1965). T, C L 3.0μ to 3.6μ

K. Murakawa and M. Yamamoto, J. Phys. Soc. Japan 20, 1057 to 1060 (1965). Stark Effect Theory

K. D. Böklen, W. Dankwort, E. Pitz and S. Penselin, Phys. Lett. (Amsterdam) 21, 294 to 295 (1966). hfs, Z E

M. Lapp, Phys. Lett. (Amsterdam) 23, 553 to 554 (1966). [C L]

R. Marrus, D. McColm and J. Yellin, Phys. Rev. 147, 55 to 59 (1966). Stark Effect

H. Hühnermann and H. Wagner, Zeit. Phys. 199, 239 to 243 (1967). I S

U. Knohl, G. zu Putlitz und A. Schenck, Zeit. Phys. 208, 364 to 366 (1968). hfs

Cs II

G. Ya. Zelikina a R. I. Semyonov, Opt. i Spektr. 21, 777 to 778 (1966). C L, Z E

BARIUM (Z = 56)

Ba I

C. E. Moore and P. W. Merrill, Appendix A: Partial Grotrian Diagrams (1956); Nat. Std. Ref. Data Series, Nat. Bur. Std. NSRDS-NBS 23, 19 (1968). C L

W. R. S. Garton and K. Codling, Proc. Phys. Soc. (London) 75, 87 to 94 (1960). T, C L, W L Absorption Series

W. R. S. Garton, J. Quant. Sp. Rad. Transfer 2, 335 to 341 (1962). Absorption Series

N. P. Penkin and L. N. Shabanova, Opt. i Spektr. 18, 749 to 755, 941 to 946 (1965). I P, Series

G. v. Oppen, Zeit. Phys. 213, 254 to 260, 261 to 272 (1968). hfs, Z E

M. W. Swagel and A. Lurio, Phys. Rev. 169, 114 to 119 (1968). hfs, Z E

Ba II

C. E. Moore and P. W. Merrill, Appendix A: Partial Grotrian Diagrams (1956); Nat. Std. Ref. Data Series, Nat. Bur. Std. NSRDS-NBS 23, 13 (1968). C L

R. H. Garstang and S. J. Hill, Publ. Astron. Soc. Pacific 78, 70 to 72 (1966). C L, Osc. Str.

F. M. Kelly and E. Tomchuk, Can. J. Phys. 45, 3931 to 3934 (1967). I S, hfs

T. Lundström and L. Minnhagen, work in progress at Lund (1969). T, C L, W L

Ba III

T. Lundström, work in progress at Lund (1969). T, C L, W L

Ba IV

L. Minnhagen, on program at Lund (1969).

LANTHANUM (Z = 57)

La I

C. E. Moore and P. W. Merrill, Appendix A: Partial Grotrian Diagrams (1956); Nat. Std. Ref. Data Series, Nat. Bur. Std. NSRDS-NBS 23, 43 (1968). C L

R. A. Fisher, W. C. Knopf, Jr., F. E. Kinney, Astroph. J. 130, 683 to 687 (1959). W L, C L Infrared

La I - Continued

K. Murakawa, J. Phys. Soc. Japan 16, 2533 to 2537 (1961). hfs

V. G. Mossotti and V. A. Fassel, Spectrochim. Acta 20, 117 to 127 (1964). C L Absorption Lines

W. R. S. Garton and M. Wilson, Astroph. J. 145, 333 to 336 (1966). I P, E D, Series Autoionization

N. Spector, unpublished material (June 1966). T

J. Stein, J. Opt. Soc. Am. 57, 333 to 335 (1967). T, Z E Theory

W. J. Childs and L. S. Goodman, Bull. Am. Phys. Soc. 13, 20, 891 to 892 (1968). hfs, Z E

A. Giacchetti and M. Wilson, J. Opt. Soc. Am. 58, 740 (A) (1968). Analysis in progress

La II

C. E. Moore and P. W. Merrill, Appendix A: Partial Grotrian Diagrams (1956); Nat. Std. Ref. Data Series, Nat. Bur. Std. NSRDS-NBS 23, 41 (1968). C L

K. Murakawa, Phys. Rev. 110, 393 to 396 (1958). hfs

J. Sugar and J. Reader, J. Opt. Soc. Am. 55, 1286 to 1290 (1965). I P

La III

J. Sugar and V. Kaufman, J. Opt. Soc. Am. 55, 1283 to 1285 (1965). I P, T, C L

H. Odabasi, J. Opt. Soc. Am. 57, 1459 to 1463 (1967). I P, T, C L, G D, W L

HAFNIUM (Z = 72)

Hf I

C. H. Corliss and W. F. Meggers, J. Research Nat. Bur. Std. 61, 269 to 324, RP2904 (1958). W L, Z E

C. J. Humphreys and E. Paul, Jr., NAVWEPS Report 7219, 18 (1962). Infrared Observations

W. F. Meggers, unpublished analysis (1966).

A. F. Golovin and I. F. Kramer, Opt. i Spektr. 23, 195 to 199 (1967). I S

Hf II

C. E. Moore and P. W. Merrill, Appendix A: Partial Grotrian Diagrams (1956); Nat. Std. Ref. Data Series, Nat. Bur. Std. NSRDS-NBS 23, 45 (1968). C L

C. H. Corliss and W. F. Meggers, J. Research Nat. Bur. Std. 61, 269 to 324, RP2904 (1958). W L, Z E

R. J. Melhorn, unpublished material (1966). Theory ?

Y. Bordarier and Z. B. Goldschmidt, unpublished material (Sept. 1967). T, Theory

Hf III

C. H. Corliss and W. F. Meggers, J. Research Nat. Bur. Std. 61, 269 to 324, RP2904 (1958). W L

P. F. A. Klinkenberg, Th. A. M. van Kleef and P. E. Noorman, Physica 27, 151 to 152, 1177 to 1188 (1961). I P, T, C L, G D

M. Fred and Th. A. M. van Kleef, Physica 28, 1007 to 1010 (1962). T, Z E, E D Theory

P. E. Noorman, H. L. Guerts, W. B. Simons and Th. A. M. van Kleef, Physica 29, 901 to 904 (1963). Z E

Hf IV

C. H. Corliss and W. F. Meggers, J. Research Nat. Bur. Std. 61, 269 to 324, RP2904 (1958). W L

P. F. A. Klinkenberg, Th. A. M. van Kleef and P. E. Noorman, Physica 27, 151 to 152, 1177 to 1188 (1961). I P, T, C L, G D

TANTALUM (Z = 73)

Ta I

W. R. Bozman and R. E. Trees, J. Research Nat. Bur. Std. 58, 95 to 100, RP2739 (1957). Theory

Y. Shadmi, unpublished material (1961). T Theory

K. Murakawa, J. Phys. Soc. Japan 17, 891 to 896 (1962). hfs

Ta II

K. Murakawa, Phys. Rev. 110, 393 to 396 (1958). hfs

R. E. Trees, Phys. Rev. 123, 1293 to 1300 (1961). T, Z E Theory

C. C. Kiess, J. Research Nat. Bur. Std. 66A, 111 to 161 (1962). I P, T, C L, Z E, W L

Ta III

P. F. A. Klinkenberg, Analysis in progress (1963).

TUNGSTEN (Z = 74)

W I

C. E. Moore and P. W. Merrill, Appendix A: Partial Grotrian Diagrams (1956); Nat. Std. Ref. Data Series, Nat. Bur. Std. NSRDS-NBS 23, 55 (1968). C L

J. A. Vreeland and K. Murakawa, J. Phys. Soc. Japan 13, 663 to 666 (1958). I S

G. Gluck, Ann. de Phys. [13] 10, 673 to 696 (1965). I S, T, C L

D. D. Laun and C. H. Corliss, J. Research Nat. Bur. Std. 72A, in press (1968). T, C L

W II

D. D. Laun, J. Research Nat. Bur. Std. 68A, 207 to 252 (1964). T, C L, Z E

W LXV

L. Cohen, U. Feldman, M. Swartz and J. H. Underwood, J. Opt. Soc. Am. 58, 843 to 846 (1968). W L, C L ?

RHENIUM (Z = 75)

Re I

C. E. Moore and P. W. Merrill, Appendix A: Partial Grotrian Diagrams (1956); Nat. Std. Ref. Data Series, Nat. Bur. Std. NSRDS-NBS 23, 59 (1968). C L

R. E. Trees, Phys. Rev. 112, 165 to 171 (1958). T, Z E Theory

L. Armstrong, Jr. and R. Marrus, Phys. Rev. 138, B310 to B315 (1965). hfs, Z E

G. Hohberg, K. Krebs, B. Schulz and R. Winkler, Zeit. Phys. 186, 380 to 398 (1965). T, C L, E D, hfs, I S

Re I - Continued

R. G. Schlect, M. B. White and D. W. McColm, Phys. Rev. 138, B306 to B309 (1965). hfs, Z E

J. Kuhl, A. Steudel und H. Walther, Zeit. Phys. 196, 365 to 384 (1966). hfs

Re II

C. E. Moore and P. W. Merrill, Appendix A: Partial Grotrian Diagrams (1956); Nat. Std. Ref. Data Series, Nat. Bur. Std. NSRDS-NBS 23, 57 (1968). C L

W. F. Meggers, M. A. Catalán and M. Sales, J. Research Nat. Bur. Std. 61, 441 to 461, RP2914 (1958). T, C L, Z E

OSMIUM (Z = 76)

Os I

J. Blaise, Ann. de Phys. [13] 3, 1062 to 1067 (1958). I S

Th. A. M. van Kleef, Proc. Kon. Nederl. Akad. Wetensch. [B] 63, 501 to 601 (1960). I P, T, C L, Z E

G. Guthöhrlein, H. Kopfermann, G. Nöldeke und A. Steudel, Zeit. Phys. 165, 356 to 368 (1961). I S, hfs

Th. A. M. van Kleef and P. F. A. Klinkenberg, Physica 27, 83 to 94 (1961). I P, T, Z E

A. P. Hines and J. S. Ross, Phys. Rev. 126, 2105 to 2108 (1962). I S

K. Murakawa, J. Phys. Soc. Japan 17, 891 to 896 (1962). hfs

G. Nöldeke und G. G. Saksena, Zeit. Phys. 166, 216 to 219 (1962). I S

Th. A. M. van Kleef, unpublished analysis (1963). T, C L

Os I - Continued

G. G. Gluck, Y. Bordarier, J. Bauche et Th. A. M. van Kleef, Physica 30, 2068 to 2104 (1964). I S, T, C L, Z E

G. Gluck, Ann. de Phys. [13] 10, 692 to 696 (1965). I S, T, C L, Z E

Os II

Th. A. M. van Kleef, Proc. Kon. Nederl. Akad. Wetensch. [B] 63, 501 to 601 (1960). T, C L, Z E

Th. A. M. van Kleef and P. F. A. Klinkenberg, Physica 27, 83 to 94(1961). T, Z E

Th. A. M. van Kleef, unpublished analysis (1967). T, C L

IRIDIUM (Z = 77)

Ir I

Th. A. M. van Kleef, Physica 23, 843 to 897 (1957). I P, T, C L, Z E

Ir II

Th. A. M. van Kleef, Analysis in progress (1967). T, C L, Z E

PLATINUM (Z = 78)

Pt I

W. J. Childs and L. S. Goodman, Bull. Am. Phys. Soc. [2] 12, 509 (1967). T, hfs, Z E

Y. Shadmi, Physica 33, 183 to 187 (1967). Theory

GOLD (Z = 79)

Au I

R. Gáspár, Acta Phys. Acad. Sci. Hungary 12, 335 to 349 (1960). Theory

E. Recknagel, Zeit. Phys. 159, 19 to 32 (1960). hfs

W. B. Ewbank and H. A. Shugart, Phys. Rev. 135, A358 to A361 (1964). hfs

H. Bucka und J. Ney, Zeit. Phys. 194, 208 to 210 (1966). hfs

A. G. Blachman, D. A. Landman and A. Lurio, Phys. Rev. 161, 60 to 67 (1967). hfs, Z E

H. Dahmen und S. Penselin, Zeit. Phys. 200, 456 to 466 (1967). hfs

A. M. Crooker, Analysis in progress, letter (1968).

Au II

A. S. Douglas, D. R. Hartree and W. A. Runciman, Proc. Cambridge Phil. Soc. 51, 486 to 503 (1955). Theory

A. M. Crooker, Analysis in progress, letter (1968).

S. Davis, On Berkeley Program (1968).

Au III

L. Iglesias, J. Research Nat. Bur. Std. 64A, 481 to 485 (1960). T, C L, W L, E D

Y. Shadmi, J. Research Nat. Bur. Std. 69A, 511 to 516 (1965). T Theory

L. Iglesias, J. Research Nat. Bur. Std. 70A, 465 to 466 (1966). T, C L

H. Mendlowitz, J. Research Nat. Bur. Std. 71A, 149 to 156 (1967). Theory

MERCURY (Z = 80)

Hg I

E. K. Plyler, L. R. Blaine and E. D. Tidwell, J. Research Nat. Bur. Std. 55, 279 to 284, RP2630 (1955). C L, Interf. W L Infrared

P. G. Wilkinson, J. Opt. Soc. Am. 45, 862 to 867, 1044 to 1046 (1955). W L

D. H. Rank, J. M. Bennett and H. E. Bennet, J. Opt. Soc. Am. 46, 477 to 484 (1956). Interf. W L Near Infrared

I. I. Agirbiceanu, N. Ionescu-Pallas et V. Draganescu, Compt. Rend. 245, 1054 to 1056 (1957). hfs

G. S. Bogle, J. N. Dodd and W. L. McLean, Proc. Phys. Soc. (London) 70B, 796 to 800 (1957). hfs

C. J. Humphreys and E. Paul, Jr., NAVORD Report 4600, 23 to 36 (1957); 4636, 32 pp. (1958); 5963, 54 to 58 (1959). Interf. W L Infrared

F. McClung and J. R. Holmes, J. Opt. Soc. Am. 47, 297 to 299 (1957). I S

J.-C. Pebay-Peyroula, J. Brossel et A. Kastler, Compt. Rend. 244, 57 to 59; 245, 840 to 842 (1957). hfs, Z E

R. L. Barger and K. W. Meissner, J. Opt. Soc. Am. 48, 22 to 27 (1958). Interf. W L

J. Blaise, Ann. de Phys. [13] 3, 1038 to 1046 (1958). I S, T, C L

G. W. Charles, J. Opt. Soc. Am. 48, 668 (L) (1958). T, C L

W. Lichten, Phys. Rev. 109, 1191 to 1192 (1958). T

K. Murakawa, Phys. Rev. 110, 393 to 396 (1958). hfs

J. Terrien, Compt. Rend. 246, 2362 to 2364 (1958). Interf. W L, C L

P. L. Sagalyn, A. C. Melissinos and F. Bitter, Phys. Rev. 109, 375 to 380 (1958). hfs

K. M. Baird and D. S. Smith, Can. J. Phys. 37, 832 to 840 (1959). Interf. W L

H. Chantrel, Ann. de Phys. [13] 4, 987 to 990 (1959). hfs

J. J. McNeill, J. Opt. Soc. Am. 49, 441 to 445 (1959). W L

K. Murakawa, J. Phys. Soc. Japan 14, 1624 to 1633, 1836 (1959). T, hfs

J. C. Pebay-Peyroula, J. de Phys. 20, 669 to 679, 721 to 729 (1959). hfs, Z E, E D

H. R. Hirsch and C. V. Stager, J. Opt. Soc. Am. 50, 1052 to 1053 (1960). hfs

I. Johansson and K.-F. Svensson, Ark. Fys. (Stockholm) 16, No. 34, 353 to 360 (1960). W L, C L, Stark Effect

M. N. McDermott and W. L. Lichten, Phys. Rev. 119, 134 to 143 (1960). hfs

D. H. Rank, G. Skorinko, D. P. Eastman, G. D. Saksena, T. K. McCubbin, Jr. and T. A. Wiggins, J. Opt. Soc. Am. 50, 1045 to 1052 (1960). hfs

R. L. Barger and K. G. Kessler, J. Opt. Soc. Am. 51, 827 to 829 (1961). Interf. W L

C. F. Bruce and R. M. Hill, Australian J. Phys. 14, 64 to 88 (1961). W L Stark Effect

J. N. Dodd, Proc. Phys. Soc. (London) 78, 65 to 69 (1961). hfs, Z E

C. J. Humphreys, E. Paul, Jr. and K. B. Adams, NAVWEPS Report 7190, 16 to 22 (1961). W L Standards Near Infrared

R. H. Garstang, J. Opt. Soc. Am. 52, 845 to 851 (1962). C L, hfs, Theory

V. Kaufman, J. Opt. Soc. Am. 52, 866 to 870 (1962). Interf. W L, T, C L

E. R. Peck, B. N. Khanna and N. C. Anderholm, J. Opt. Soc. Am. 52, 536 to 538 (1962). W L Near Infrared

K. M. Baird, D. S. Smith and K. H. Hart, J. Opt. Soc. Am. 53, 717 to 720 (1963). Interf. W L

International Committee on Weights and Measures, J. Opt. Soc. Am. 53, 401 (1963). W L Standards

A. Kastler, J. Opt. Soc. Am. 53, 902 to 910 (1963). "Lamp Shift"

Th. A. M. van Kleef and M. Fred, Physica 29, 389 to 404 (1963). T, C L, Z E

H. Kleiman and S. P. Davis, J. Opt. Soc. Am. 53, 822 to 827 (1963). hfs, I S

W. G. Schweitzer, Jr., J. Opt. Soc. Am. 53, 1055 to 1072 (1963). hfs, I S

W. G. Schweitzer, Jr., J. Opt. Soc. Am. 53, 1250 to 1252 (1963). Interf. W L

W. G. Schweitzer, Jr. and K. G. Kessler, J. Opt. Soc. Am. 53, 1382 to 1388 (1963). Interf. W L

W. J. Tomlinson III and H. H. Stroke, J. Opt. Soc. Am. 53, 828 to 830 (1963). hfs, I S

P. G. Wilkinson and K. L. Andrew, J. Opt. Soc. Am. 53, 710 to 717 (1963). W L

B. Edlén, Trans. Intern. Astron. Union 12A, 137 to 139 (1964). W L Standards

K. Bockasten, M. Garavaglia, B. A. Lengyel and T. Lundholm, J. Opt. Soc. Am. 55, 1051 to 1053 (1965). C L, W L, G D Laser Observations 1.1μ to 6.5μ

C. J. Humphreys and E. Paul, Jr., NAVWEPS Report 8833, 27 to 34 (1965). T, C L, G D, E D 3.2μ to 4.0μ

K. Murakawa, J. Phys. Soc. Japan 20, 1094 (1965). hfs, Z E

W. W. Smith, Phys. Rev. 137, A330 to A339 (1965). hfs, Z E

K. G. Kessler, Physica 33, 29 to 46 (1967). hfs, Z E

R. C. M. Learner, unpublished material, Imperial College, London (1967). Extended Series

D. R. Beck, Thesis, Lehigh Univ., 220 pp. (1968). Theory

W. R. S. Garton and J. P. Connerade, Astroph. J., in press (1968). Absorption Series Vac. Ultraviolet

A. Khadjavi, A. Lurio and W. Happer, Phys. Rev. 167, 128 to 135 (1968). Stark Effect

D. Lacler, Compt. Rend. 266B, 1509 to 1512 (1968). hfs, I S, Z E

J. C. McConnell and B. Moiseiwitsch, J. Phys. B (Proc. Phys. Soc. London) [2] 1, 406 to 413 (1968). Theory

M. W. Swagel and A. Lurio, Phys. Rev. 169, 114 to 119 (1968). hfs, Z E

Hg II

P. G. Wilkinson, J. Opt. Soc. Am. 45, 862 to 867 (1955). Vac. Ultraviolet W L

J. Blaise, Ann. de Phys. [13] 3, 1038 to 1046 (1958). I S, T, C L

R. W. Shorthill and G. R. Fowles, J. Opt. Soc. Am. 48, 459 to 460 (1958). I S, C L

O. Loebich und A. Steudel, Zeit. Phys. 166, 56 to 61 (1962). hfs, [C L], I S

Th. A. M. van Kleef and M. Fred, Physica 29, 389 to 404 (1963). C L, Z E

P. G. Wilkinson and K. L. Andrew, J. Opt. Soc. Am. 53, 710 to 717 (1963). W L

W. E. Bell, Appl. Phys. Lett. 4, 34 to 35 (1964). C L Laser Observations

R. L. Beyer, W. E. Bell, E. Hodges and A. L. Bloom, J. Opt. Soc. Am. 55, 1598 to 1602 (1965). Laser Observation

W. B. Bridges and A. N. Chester, IEEE J. Qu. Electronics QE-1, 66 to 84 (1965). C L, W L Laser Observations

K. Murakawa, Phys. Rev. 146, 135 to 136 (1966). Stark Effect

Hg III

P. G. Wilkinson, J. Opt. Soc. Am. 45, 862 to 867 (1955). Vac. Ultraviolet W L

R. W. Shorthill and G. R. Fowles, J. Opt. Soc. Am. 48, 459 to 460 (1958). I S, C L

K. Murakawa, J. Phys. Soc. Japan 14, 1624 to 1633 (1959). hfs

W. B. Bridges and A. N. Chester, IEEE J. Qu. Electronics QE-1, 66 to 84 (1965). C L, W L Laser Observations

Tl I

G. V. Marr, Proc. Roy. Soc. London [A] 224, 83 to 90 (1954). C L, Autoionization

G. O. Brink, J. C. Hubbs, W. A. Nierenberg and J. L. Worcester, Phys. Rev. 107, 189 to 195 (1957). hfs

O. I. Odintsov, Opt. i Spektr. 9, 142 to 146 (1960). hfs, I S

W. R. S. Garton, J. Quant. Sp. Rad. Transfer 2, 335 to 341 (1962). Series, Autoionization

C. J. Schuler, M. Ciftan, L. C. Bradley, III and H. H. Stroke, J. Opt. Soc. Am. 52, 501 to 503 (1962). hfs, I S

W. Gough and G. W. Series, Proc. Phys. Soc. (London) 85, 469 to 475 (1965). hfs

N. P. Penkin and L. N. Shabanova, Opt. i Spektr. 18, 749 to 755, 941 to 946 (1965). I P, Absorption Series

E. M. Reeves, W. R. S. Garton and A. Bass, Proc. Phys. Soc. (London) 86, 1077 to 1080 (1965). Absorption Series, Vac. Ultraviolet

S. P. Davis, H. Kleiman, D. Goorvitch and T. Aung, J. Opt. Soc. Am. 56, 1604 to 1607 (1966). hfs, I S

W. R. S. Garton, W. H. Parkinson and E. M. Reeves, Can. J. Phys. 44, 1745 to 1752 (1966). C L, Absorption Series, Vac. Ultraviolet

G. V. Marr and R. Heppinstall, Proc. Phys. Soc. (London) 87, 293 to 298 (1966). C L, Autoionization

J. Séguier, Compt. Rend. 263B, 147 to 150 (1966). C L, W L Infrared

B. W. Shore, J. Opt. Soc. Am. 57, 881 to 884 (1967). Theory Autoionization

H. G. Palmer, F. R. Petersen and R. C. Mockler, Bull. Am. Phys. Soc. [2] 13, 892 (1968). Stark Effect, hfs

F. R. Petersen, H. G. Palmer and J. H. Shirley, Bull. Am. Phys. Soc. [2] 13, 1674A (1968). Stark Effect, hfs

THALLIUM

Tl II

C. B. Ellis and R. A. Sawyer, Phys. Rev. 49, 145 to 150 (1936). I P, T, C L, E D, W L, hfs

A. S. Douglas, D. R. Hartree and W. A. Runciman, Proc. Cambridge Phil. Soc. 51, 486 to 503 (1955). Theory

D. R. Beck, Bull. Am. Phys. Soc. [2] 12, 336 (1967); Thesis, Lehigh Univ., 220 pp. (1968). Theory

Tl IV

A. S. Douglas, D. R. Hartree and W. A. Runciman, Proc. Cambridge Phil. Soc. 51, 486 to 503 (1955). Theory

LEAD (Z = 82)

Pb I

J. Blaise, Ann. de Phys. [13] 3, 1047 to 1062 (1958). I S, T, C L

H. Chantrel, Ann. de Phys. [13] 4, 983 to 987 (1959). hfs

W. R. S. Garton, J. Quant. Sp. Rad. Transfer 2, 335 to 341 (1962). Series, Autoionization

M. E. Hults, Bull. Am. Phys. Soc. [2] 8, 429 (1963). Z E, [C L]

M. Wilson, Thesis, unpublished (1964). T, Absorption Series Ultraviolet

W. R. S. Garton and M. Wilson, Proc. Phys. Soc. (London) 87, 841 to 850 (1966). I P, T, C L, W L Absorption Series Vac. Ultraviolet

E. B. Saloman and W. Happer, Phys. Rev. 144, 7 to 22 (1966). hfs, Z E

G. M. Lawrence, Astroph. J. 148, 261 to 268 (1967). Theory

D. R. Wood and K. L. Andrew, J. Opt. Soc. Am. 58, 818 to 829 (1968). I P, T, C L, Interf. W L [C L]

D. R. Wood, K. L. Andrew, A. Giacchetti and R. D. Cowan, J. Opt. Soc. Am. 58, 830 to 836 (1968). Z E, Theory

LEAD

Pb II

J. Blaise, Ann. de Phys. [13] 3, 1047 to 1062 (1958). I S, T, C L

F. E. Geiger, Jr., J. Opt. Soc. Am. 48, 302 to 303 (1958). I S

H. Chantrel, Ann. de Phys. [13] 4, 983 to 987 (1959). hfs

C. D. Cole, J. Opt. Soc. Am. 54, 859 to 863 (1964). hfs [C L]

W. T. Silfvast, G. R. Fowles and B. D. Hopkins, Appl. Phys. Lett. 8, 318 to 319 (1966). Laser Transitions

Pb III

D. R. Beck, Thesis, Lehigh Univ., 220 pp. (1968). Theory

Pb IV

J. F. Hart and B. H. Worsley, Can. J. Phys. 37, 983 to 988 (1959). Theory

BISMUTH (Z = 83)

Bi I

R. S. Title and K. F. Smith, Phil. Mag. [8] 5, 1281 to 1289 (1960). hfs, Z E

M. Hults and S. Mrozowski, J. Opt. Soc. Am. 54, 855 to 858 (1964). hfs

L. O. Dickie and F. M. Kelly, Can. J. Phys. 45, 2249 to 2251 (1967). hfs

R. Chuckrow, P. C. Magnante and H. H. Stroke, J. Opt. Soc. Am. 58, 922 to 923 (1968). hfs, E D

J. A. Heldt, J. Opt. Soc. Am., in press (1969). hfs

BISMUTH

Bi II

C. D. Cole, J. Opt. Soc. Am. 54, 859 to 863 (1964). hfs

M. Hults and S. Mrozowski, J. Opt. Soc. Am. 54, 855 to 858 (1964). hfs

POLONIUM (Z = 84)

Po I

R. Gáspár and K. Molnár, Acta Phys. Acad. Sci. Hungary 7, 455 to 462 (1957). Theory

C. M. Olsmats, S. Axensten and L. Liljegren, Ark. Fys. (Stockholm) 19, No. 34, 469 to 481 (1961). hfs

G. W. Charles, J. Opt. Soc. Am. 56, 1292 to 1297 (1966). I P, T, C L, W L, hfs

Po II

G. W. Charles, J. Opt. Soc. Am. 56, 1292 to 1297 (1966). T, hfs Estimates

ASTATINE (Z = 85)

At I

H. L. Garvin, T. M. Green, E. Lipworth and W. A. Nierenberg, Phys. Rev. Lett. 1, 74 to 75 (1958). hfs

R. McLaughlin, J. Opt. Soc. Am. 54, 965 to 967 (1964). T, C L Absorption Observations

RADIUM (Z = 88)

Ra I

F. S. Tomkins, Program, At. Sp. Symposium Nat. Bur. Std. p. 25 (A) (September 1967). Absorption Series

ACTINIUM (Z = 89)

Ac I

N. I. Kaliteevskii and A. N. Razumovskii, Atomnaya Energiya 3, 548 to 550 (1957). W L

W. F. Meggers, Spectrochim. Acta 10, 195 to 200 (1957). C L, W L

Ac II

N. I. Kaliteevskii and A. N. Razumovskii, Atomnaya Energiya 3, 548 to 550 (1957). W L

W. F. Meggers, Spectrochim. Acta 10, 195 to 200 (1957). C L, W L

Ac III

N. I. Kaliteevskii and A. N. Razumovskii, Atomnaya Energiya 3, 548 to 550 (1957). W L

W. F. Meggers, Spectrochim. Acta 10, 195 to 200 (1957). C L, W L

Ac IV

W. F. Meggers, Spectrochim. Acta 10, 195 to 200 (1957). W L?

☆ U. S. GOVERNMENT PRINTING OFFICE : 1969 O - 337-259

NBS TECHNICAL PUBLICATIONS

PERIODICALS

JOURNAL OF RESEARCH reports National Bureau of Standards research and development in physics, mathematics, chemistry, and engineering. Comprehensive scientific papers give complete details of the work, including laboratory data, experimental procedures, and theoretical and mathematical analyses. Illustrated with photographs, drawings, and charts.

Published in three sections, available separately:

• Physics and Chemistry

Papers of interest primarily to scientists working in these fields. This section covers a broad range of physical and chemical research, with major emphasis on standards of physical measurement, fundamental constants, and properties of matter. Issued six times a year. Annual subscription: Domestic, $6.00; foreign, $7.25*.

• Mathematical Sciences

Studies and compilations designed mainly for the mathematician and theoretical physicist. Topics in mathematical statistics, theory of experiment design, numerical analysis, theoretical physics and chemistry, logical design and programming of computers and computer systems. Short numerical tables. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75*.

• Engineering and Instrumentation

Reporting results of interest chiefly to the engineer and the applied scientist. This section includes many of the new developments in instrumentation resulting from the Bureau's work in physical measurement, data processing, and development of test methods. It will also cover some of the work in acoustics, applied mechanics, building research, and cryogenic engineering. Issued quarterly. Annual subscription: Domestic, $2.75; foreign, $3.50*.

TECHNICAL NEWS BULLETIN

The best single source of information concerning the Bureau's research, developmental, cooperative and publication activities, this monthly publication is designed for the industry-oriented individual whose daily work involves intimate contact with science and technology—*for engineers, chemists, physicists, research managers, product-development managers, and company executives.* Annual subscription: Domestic, $3.00; foreign, $4.00*.

*Difference in price is due to extra cost of foreign mailing.

NONPERIODICALS

Applied Mathematics Series. Mathematical tables, manuals, and studies.

Building Science Series. Research results, test methods, and performance criteria of building materials, components, systems, and structures.

Handbooks. Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

Special Publications. Proceedings of NBS conferences, bibliographies, annual reports, wall charts, pamphlets, etc.

Monographs. Major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

National Standard Reference Data Series. NSRDS provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated.

Product Standards. Provide requirements for sizes, types, quality and methods for testing various industrial products. These standards are developed cooperatively with interested Government and industry groups and provide the basis for common understanding of product characteristics for both buyers and sellers. Their use is voluntary.

Technical Notes. This series consists of communications and reports (covering both other agency and NBS-sponsored work) of limited or transitory interest.

Federal Information Processing Standards Publications. This series is the official publication within the Federal Government for information on standards adopted and promulgated under the Public Law 89–306, and Bureau of the Budget Circular A–86 entitled, Standardization of Data Elements and Codes in Data Systems.

CLEARINGHOUSE

The Clearinghouse for Federal Scientific and Technical Information, operated by NBS, supplies unclassified information related to Government-generated science and technology in defense, space, atomic energy, and other national programs. For further information on Clearinghouse services, write:

Clearinghouse
U.S. Department of Commerce
Springfield, Virginia 22151

Order NBS publications from:

Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

UNITED STATES
GOVERNMENT PRINTING OFFICE
DIVISION OF PUBLIC DOCUMENTS
WASHINGTON, D.C. 20402

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
U.S. GOVERNMENT PRINTING OFFICE