NBS SPECIAL PUBLICATION 366



# Bibliography on Atomic Line Shapes and Shifts

## (1889 through March 1972)

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Office of Standard Reference Data—Office of Technical Information and Publications—Library—Office of International Relations.

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# Contents

# BIBLIOGRAPHY ON ATOMIC LINE SHAPES AND SHIFTS (1889 Through March 1972)*

J. R. Fuhr, W. L. Wiese, and L. J. Roszman

This is the first general, annotated bibliography on atomic line shapes and shifts. It covers exhaustively the atomic spectral line broadening literature in about 1400 separate references extending from 1889 through March 1972. The bibliography contains four major parts: (1) All general interest papers are cataloged according to the broadening mechanisms (and, further, according to special topics under several of the mechanisms) and as to whether the work is a general theory, a general review, a table of profiles or parameters, a comment on existing work, a study of general experimental measurement techniques, or an experimental effort of general importance. Also included are selected papers on important applications of line broadening and on miscellaneous topics relating to atomic spectral line shapes and shifts. (2) In Part 2, all papers containing numerical data are ordered as to element, ionization stage, broadening mechanism (in the case of foreign gas broadening the perturbing species are listed), and it is indicated whether the data are experimentally or theoretically derived. (3) While in the two preceding parts of the bibliography the references are listed for brevity by identification numbers only, in Part 3 all references are listed completely by journal, authors, and title and are arranged chronologically and alphabetically within each year according to the principal author. (4) A final section contains a list of all authors and their papers.

Key words: Atomic; instrumental broadening; line shapes; line shifts; pressure broadening; resonance broadening; Stark broadening; Van der Waals broadening.

# A. INTRODUCTION

## 1. OBJECTIVES AND BACKGROUND

A Data Center on Atomic Spectral Line Shapes and Shifts has been established recently in the Optical Physics Division of the National Bureau of Standards. The objectives of the Center are to collect and catalog the relevant literature and to prepare and publish bibliographies and critical reviews on various topics in atomic line broadening.

The collection of literature on line broadening was started some time ago parallel to a collection of the literature on atomic transition probabilities, which is an ongoing activity of this NBS group. Starting in 1970, all references in recent line broadening papers were scanned, and simultaneously, several title and abstracting journals were searched backward for several years. This latter search gradually overlapped completely with the independently found references. Reprints or copies of all articles were collected, cataloged, and filed according to a classification scheme which will be given in detail below. The literature collection is completely up-to-date through March 1972, and the current literature is constantly being monitored through several title and abstracting journals. However, we have been unable to secure a few older theses and technical reports, and we have several as yet untranslated Russian papers which could be potentially valuable for this collection. These papers are presently not included, but will be added in future bibliographies after we are able to make a definite classification.

* Research supported in part by the Advanced Research Projects Agency of the Department of Defense under the Strategic Technology Office.

## 2. SCOPE OF THIS COLLECTION

A general bibliography on atomic line broadening seems to be long overdue, since the large number of articles we have collected indicates much continuing activity in this field. Nevertheless, no general annotated bibliography has been published.

In this first bibliography we have stressed the complete presentation of all relevant modern literature without regard to the quality of the paper. Therefore, all line broadening work back to the year 1930 and a number of important earlier papers have been included. In many instances the early work is superseded by more refined experimental or theoretical determinations, but there are still a number of cases where nothing but some older material is available. In such cases this older material should still be valuable for applications where a rough estimate will suffice.

In addition to the regular journal literature, we list books which are primarily devoted to the subject of line broadening or contain a special detailed chapter on line broadening. However, we do not list books which contain only a few pages of basic discussion on line broadening mechanisms.

Conference talks are quoted only if they are published in proceedings which can be generally obtained in libraries. However, if it appears that such a talk is superseded by a later paper of the same title in a journal, we quote only the more accessible journal publication. The above statement implies that we do not quote conference talks which are only published in abstract form or which are distributed on some typewritten proceedings available essentially to conference participants only.

We also do not quote interim or final technical reports. Since many of these are written to fulfill either educational requirements at a university or serve to satisfy contract requirements, these reports are generally not available—except maybe for a short time—so that their listing in this bibliography does not represent any significant service to the scientific public. The large majority of these reports have become available later as publications in the open literature if they contained new and original results.

The situation on doctoral theses is quite similar, i.e., most theses are subsequently published in a shortened version which contains all the significant data. Again, we feel that we serve the scientific public most by listing only the journal publication which gives the shortened version of the thesis. If a full thesis is desired, the journal publication will usually list the author and his address.

While the bibliography is restricted to line shape and line shift data of atomic and ionic lines, we have included a representative cross section of recent papers on the broadening of molecular lines (Part 1.5.3). Also, we have included a cross section of representative recent papers on important applications of line broadening (Part 1.4)—usually about 20 to 25 papers for each major subject.

## 3. ARRANGEMENT OF THE BIBLIOGRAPHY

The bibliography is arranged in four main parts. In the first part we list all papers which are of general interest, i.e., papers which describe a general theory, give a general review of line broadening mechanisms or have comments on refinements of existing work, refer to general experimental measurement techniques, etc. Specifically, these articles are arranged under seven major headings. A detailed listing of these headings is given in the Contents under Part 1 "LITERATURE REFERENCES OF GENERAL INTEREST." Under each of the individual headings the papers are given by an identification number only in order to keep the size of this compilation compact. This identification number is fully referenced by author, journal, and title of the paper in Part 3.

In Part 2 of the bibliography we list all papers which contain numerical data, either theoretical or experimental. The papers are now ordered to element and within the elements to the successive stages of ionization. The elements are listed in alphabetical order of their symbols. One paper (No. 651) contains data for the whole isoelectronic sequence of hydrogen and is listed after the papers on hydrogen.

For each spectrum we have grouped together all papers dealing with the same line broadening mechanism and have subdivided them further into experimental (E) and theoretical (T) papers and comments (C). The explanatory code words and letters are given in the column "Description." The papers for each group are listed in the column "Reference No." according to the identification numbers assigned in Part 3. Since these numbers, as we shall see in Part 3, are in chronological order, this means that the most modern papers are at the end of each list, and one should preferably, in looking up the litera-

ture, go from the high numbers back to the low ones.

For papers on Van der Waals broadening we also show the species which cause the broadening, if these are explicitly given by the authors. On natural line broadening we have presented only the directly determined numerical material. But since the natural line width or "damping constant" is given by the inverse sums of the lifetimes of upper and lower state of the line, one may use lifetime data for obtaining these widths. Available lifetime data are given in the recent NSRDS compilations on atomic transition probabilities [1, 2] [1] or may be obtained from the NBS bibliography on atomic transition probabilities. [3].

In Part 3 of the bibliography the complete body of references is presented in chronological order, and the listings include the full titles. Within each year the references are arranged alphabetically according to the names of the principal author. For the current year 1972 this arrangement is, of course, preliminary since new papers will be added. If a paper is written in a foreign language, the title is translated, and the language in which the paper is written is added to the reference in parenthesis. The table at the end of this introduction contains a complete list of the applied abbreviations. Each reference in this part has been assigned a running number which serves as the identification number for the preceding parts of this bibliography.

The journal abbreviations were applied according to the "ACCESS" compilation of the American Chemical Society [4]. The authors' names were alphabetized according to the "Anglo-American Cataloging Rules" prepared by the American Library Association, The Library of Congress, The Library Association, and The Canadian Library Association [5].

Part 4 of the bibliography is an author list, where each reference is given by its identification number from Part 3.

To facilitate the sorting of the reference material according to each of the four parts of the bibliography, computer programs were developed and applied. Punched cards for each reference contain: the author(s) of paper, year of paper, language of paper, description (theoretical, experimental or comment), and the classification of paper.

## 4. FUTURE PLANS OF THE DATA CENTER ON ATOMIC LINE SHAPES AND SHIFTS, AND ACKNOWLEDGEMENTS

We intend to issue supplements to this bibliography from time to time depending on the volume of the new incoming literature. We also plan to undertake critical reviews on certain well-defined subjects of line broadening. A first review on the present status of our knowledge of hydrogen Stark broadening is in the planning stage.

We gratefully acknowledge the assistance of Mrs. Georgia Martin in developing a computer program which allowed the easy cataloging and sorting of all articles for the various parts of this bibliography and Dean Pershing for assisting in the initial literature search. We also would like to thank Mrs. Roberta Jones for her competent assistance in typing and organizing this bibliography.

## References

[1] Wiese, W. L. Smith, M. W., and Glennon, B. M., Atomic Transition Probabilities—Hydrogen through Neon (A Critical Data Compilation), Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 4, Vol. 1 (May 1966).

[2] Wiese, W. L., Smith, M. W., and Miles, B. M., Atomic Transition Probabilities—Sodium through Calcium (A Critical Data Compilation), Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 22, Vol. 2 (Oct. 1969).

[3] Miles, B. M. and Wiese, W. L., Bibliography on Atomic Transition Probabilities (January 1916 through June 1969), Nat. Bur. Stand. (U.S.), Spec. Publ. 320 (Feb. 1970), and Fuhr, J. R. and Wiese, W. L., Nat. Bur. stand. (U.S.), Spec. Publ. 320, Suppl. 1 (Sept. 1971).

[4] Access—Key to the Source Literature of the Chemical Sciences, (Chemical Abstracts Service, American Chemical Society, Columbus, Ohio, 1969).

[5] Anglo-American Cataloging Rules, Ed. C. Sumner (Spalding, American Library Assoc., Chicago, 1967).

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

## 5. TABLE OF CODE LETTERS AND ABBREVIATIONS

A. Description
   1. T—theoretical method
   2. E—experimental method
   3. C—comment

B. Language
   1. Dut.—Dutch
   2. Fr.—French
   3. Ger.—German
   4. Ital.—Italian
   5. Russ.—Russian

# B. BIBLIOGRAPHICAL MATERIAL

## I. LITERATURE REFERENCES OF GENERAL INTEREST

### 1.0. GENERAL ARTICLES ON LINE SHAPES AND SHIFTS (GENERAL THEORIES AND COMMENTS, ETC.)

Theoretical papers: 443, 1559, 1641, 1820, 1821

### 1.1. PRESSURE BROADENING

Comments: 267, 342, 849, 1293

Experimental papers: 63, 64

Theoretical papers: 6, 11, 77, 113, 126, 137, 150, 153, 154, 165, 168, 188, 189, 193, 213, 219, 230, 246, 282, 283, 316, 318, 325, 343, 356, 368, 388, 402, 404, 423, 444, 454, 473, 520, 558, 559, 560, 676, 730, 793, 832, 842, 889, 896, 899, 904, 931, 966, 973, 976, 986, 1042, 1049, 1050, 1051, 1057, 1061, 1078, 1103, 1145, 1155, 1159, 1163, 1187, 1195, 1202, 1309, 1342, 1386, 1391, 1392, 1396, 1432, 1433, 1436, 1437, 1489, 1497, 1512, 1584, 1709, 1723, 1788, 1797, 1813, 1814, 1816, 1825, 1826, 1830, 1862

#### 1.1.1. Stark broadening and shifts

Comments: 604, 657, 848, 1884

Theoretical papers: 47, 48, 69, 152, 370, 432, 480, 482, 498, 506, 532, 537, 544, 558, 570, 571, 572, 574, 620, 652, 662,

Theoretical papers (cont.): 667, 727, 736, 788, 850, 858, 860, 893, 894, 916, 917, 997, 1055, 1056, 1151, 1161, 1184, 1259, 1275, 1298, 1338, 1400, 1424, 1425, 1460, 1461, 1492, 1498, 1502, 1519, 1520, 1570, 1662, 1666, 1696, 1711, 1729, 1730, 1735, 1737, 1748, 1749, 1811, 1819, 1859, 1871, 1873, 1885

Combined theoretical-comments: 1782

1.1.1.1. Hydrogen and hydrogen-like (overlapping) lines

Theoretical papers: 411, 535, 596, 711, 927, 1184, 1218, 1345, 1377, 1508, 1513, 1594, 1753, 1874

1.1.1.2. Isolated lines of neutral spectra

Theoretical papers: 770, 772, 1356, 1408, 1421, 1501, 1569, 1611, 1728, 1755

1.1.1.3. Isolated lines of ionic spectra

Theoretical papers: 1069, 1213, 1214, 1265, 1283, 1385, 1444, 1501, 1576, 1610, 1694, 1754, 1771, 1772

1.1.1.4. Topics of particular interest

A. Line wings

Theoretical papers: 659, 768, 981, 1222

B. Effects of collective electric fields

Comments: 1720

Experimental papers: 965, 1043, 1276, 1301, 1382, 1592, 1599, 1625, 1651, 1671, 1751, 1836

Theoretical papers: 698, 934, 1070, 1304, 1457, 1574, 1577, 1597, 1661, 1705, 1718, 1818, 1869

Combined theoretical-experimental: 1467

C. Asymmetries of H-lines

Experimental papers: 1833

Theoretical papers: 851, 852, 858, 1509

Combined theoretical-experimental: 448

D. Microfield distributions

Comments: 521, 657, 774, 841, 1079, 1186

Theoretical papers: 46, 445, 471, 526, 564, 568, 593, 597, 598, 618, 658, 666, 668, 706, 719, 721, 732, 756, 783, 915, 984, 1015, 1077, 1289, 1290, 1291, 1334, 1352, 1413, 1414, 1418, 1426, 1427, 1438, 1462, 1578, 1579, 1711, 1732, 1740, 1811, 1876

E. Magnetic fields

Experimental papers: 1423

Theoretical papers: 1073, 1267, 1418, 1869

Combined theoretical-experimental: 1091, 1205, 1266

1.1.2. Broadening in foreign gases (Van der Waals broadening)

Comments: 319, 1556, 1761, 1812

Theoretical papers: 94, 108, 114, 167, 170, 171, 182, 204, 207, 214, 238, 250, 275, 290,

Theoretical papers (cont.): 327, 384, 385, 409, 455, 495, 671, 672, 794, 863, 1039, 1182, 1201, 1226, 1299, 1389, 1404, 1415, 1434, 1455, 1477, 1494, 1495, 1499, 1507, 1510, 1564, 1586, 1588, 1602, 1664, 1715, 1731, 1763, 1766, 1824, 1880

Combined experimental-comments: 1287

Combined theoretical-experimental: 1443, 1716

1.1.2.1. Satellite bands

Comments: 1875

Theoretical papers: 1274, 1449, 1459, 1500, 1566, 1567, 1872

Combined theoretical-experimental: 1443

1.1.3. Resonance broadening

Comments: 1092

Theoretical papers: 41, 124, 245, 264, 270, 664, 839, 961, 1003, 1011, 1144, 1221, 1308, 1355, 1389, 1395, 1410, 1548, 1565, 1626, 1704, 1710, 1744, 1747, 1793

Combined theoretical-experimental-comments: 1466

## 1.2. BASIC ARTICLES ON DOPPLER AND NATURAL LINE SHAPES

### 1.2.1. Doppler broadening

Theoretical papers: 1, 650, 731, 840, 1260, 1473, 1624, 1861

Combined experimental-comments: 1287

Combined theoretical-experimental: 1448

### 1.2.2. Natural line broadening

Theoretical papers: 127, 128, 161, 403, 421, 449, 594, 612, 926, 995, 996, 1470, 1698, 1779

### 1.2.3. Radiation induced broadening

Experimental papers: 1639

Theoretical papers: 446, 595, 790, 1071, 1692, 1738, 1739, 1770

## 1.3. BASIC PAPERS ON INSTRUMENTAL BROADENING, DECONVOLUTION, SUPERPOSITION OF TWO OR MORE SIMULTANEOUSLY ACTING BROADENING MECHANISMS

### 1.3.1. Determination of instrumental line profiles; experimental techniques for determining line shapes

Experimental papers: 483, 722, 824, 900, 1048, 1216, 1278, 1585, 1794, 1810

Theoretical papers: 123, 576, 1074, 1337, 1801, 1803

Combined theoretical-experimental: 93, 825

### 1.3.2. Deconvolution

Theoretical papers: 134, 146, 160, 345, 371, 426, 470, 576, 648, 649, 762, 792, 885, 970, 1005, 1040, 1101, 1185, 1254, 1271, 1317, 1329, 1582, 1607, 1726, 1864

Combined theoretical-experimental: 937, 1475, 1476

### 1.3.3. Superposition of broadening mechanisms

Comments: 990, 1790

Theoretical papers: 31, 335, 425, 430, 707, 718, 823, 829, 903, 910, 933, 983, 1008, 1017, 1018, 1050, 1053, 1100,

Theoretical papers (cont.): 1138, 1203, 1210, 1211, 1269, 1277, 1323, 1351, 1723, 1780

## 1.4. IMPORTANT LINE BROADENING APPLICATIONS

### 1.4.1. Laser applications

Comments: 1148

Experimental papers: 1007, 1045, 1106, 1141, 1279, 1305, 1409, 1442, 1481, 1490, 1514, 1786, 1886

Theoretical papers: 699, 1100, 1210, 1286, 1299, 1463, 1562, 1598, 1609, 1652, 1656, 1707, 1735, 1770, 1861, 1868

Combined theoretical-experimental: 1046, 1108, 1448, 1887

### 1.4.2. Astrophysical applications

Comments: 1551, 1796

Experimental papers: 617, 1411, 1480, 1695, 1727, 1798, 1833

Theoretical papers: 891, 993, 1059, 1088, 1197, 1208, 1340, 1346, 1347, 1441, 1632, 1637, 1668, 1713, 1743, 1781, 1792, 1817, 1822

Combined theoretical-experimental: 1600

### 1.4.3. Plasma diagnostics

Experimental papers: 575, 795, 906, 923, 929, 965, 1113, 1524, 1528, 1549, 1625, 1671, 1834, 1836, 1837

Theoretical papers: 266, 366, 698, 835, 859, 1082, 1302, 1577, 1882.

Combined theoretical-experimental: 566, 1016

1.4.4. Other applications

Experimental papers: 969, 1076, 1194, 1757

Theoretical papers: 373, 1006, 1014, 1136

## 1.5. OTHER TOPICS INVOLVING LINE SHAPES AND SHIFTS

1.5.1. The line shape in the presence of self-absorption; effects of radiative transfer

Comments: 517, 1172

Experimental papers: 107, 800, 801, 1714

Theoretical papers: 148, 334, 351, 352, 386, 422, 452, 613, 621, 759, 859, 911, 962, 998, 1001, 1209, 1260, 1693, 1713, 1744, 1745

Combined theoretical-experimental: 735

1.5.2. Broadening of scattered radiation

Experimental papers: 1722

Theoretical papers: 288, 421, 431, 1623, 1640, 1752

1.5.3. Some important papers on molecular line broadening

Experimental papers: 1268

Theoretical papers: 350, 474, 760, 765, 963, 1041, 1044, 1140, 1152, 1204, 1256, 1344, 1432, 1437, 1505, 1526, 1527, 1703, 1823, 1829, 1888

Combined theoretical-experimental: 1147

1.5.4. Miscellaneous topics

A. Broadening of x-ray lines

Theoretical papers: 192

B. Light shifts

Theoretical papers: 847, 1093, 1717, 1863

Combined theoretical-experimental: 1307

C. Zeeman broadening

Experimental papers: 890, 1216

D. Computer program calculation of line shapes, assuming a Voigt profile

Theoretical papers: 1378

## 1.6. REVIEW ARTICLES

### 1.6.1. General line broadening reviews

101, 159, 175, 194, 254, 260, 484, 500, 701, 861, 895, 908, 1294, 1653

### 1.6.2. Reviews on pressure broadening

217, 303, 519, 545, 579, 645, 663, 729, 797, 1054, 1078, 1343, 1407

#### 1.6.2.1. Reviews on Stark broadening

607, 757, 1004, 1016, 1504

#### 1.6.2.2. Reviews on foreign gas broadening

505, 523

### 1.6.3. Reviews on Doppler and natural line broadening

#### 1.6.3.1. Doppler broadening reviews

656, 977

#### 1.6.3.2. Natural line broadening reviews

No papers in this category.

## 1.7. REFERENCES ON LINE BROADENING TABLES AND BIBLIOGRAPHIES

### 1.7.1. General line broadening tables

822, 1010, 1094

1.7.2. Pressure broadening tables

369, 903

1.7.2.1. Special Stark broadening tables

619, 843, 907, 908, 999, 1166, 1603, 1706, 1769

1.7.2.2. Special foreign gas broadening tables

No papers in this category.

1.7.2.3. Special resonance broadening tables

No papers in this category.

1.7.3. Doppler and natural line broadening tables

No papers in this category.

1.7.4. Tables of Voigt functions

983

1.7.5. Line broadening bibliographies

1257

# 2. LITERATURE REFERENCES CONTAINING NUMERICAL DATA

(References on individual elements and stages of ionization, classified according to broadening mechanism)

| Description | Reference No.* |
|---|---|
| **Ag (Silver)** | |
| Ag I | |
| Resonance, E | 890 |
| Stark, E | 76 |
| Van der Waals, E | 405 by Ar |
| | 405 by He |
| | 531 by $N_2$ |
| Ag II | |
| Stark, E | 469 |
| **Al (Aluminum)** | |
| Al I | |
| Pressure, E | 220 |
| Stark, E | 1613 |
| Stark, T | 1706 |
| Van der Waals, E | 1451 by Ar |
| Van der Waals, T | 1750 by Ar |
| | 1750 by $H_2$ |
| | 1750 by He |
| Al II | |
| Stark, E | 784,1310 |
| Al III | |
| Stark, E | 784,921,922 |
| Stark, T | 1733 |
| Stark, T,E | 857 |
| Stark-Doppler, T | 1733 |
| **Ar (Argon)** | |
| Ar I | |
| Resonance, E | 536,600,715,930, 938,1472 |
| Resonance, T | 1196 |
| Stark, E | 708,764,831,985, 1000,1080,1090, 1157,1167,1183, 1248,1292,1310, 1333,1394,1397, 1491,1629,1633, 1635,1644,1806 |
| Stark, T | 769,1249,1706, 1775 |
| Van der Waals, E | 938,1465 by Ar |
| Van der Waals, T | 1590,1604,1775 by Ar |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|
| **Ar II** | |
| Natural, E | 1886 |
| Pressure, E | 1774 |
| Stark, E | 139,580,603,605, 608,708,784,785, 965,1000,1081, 1090,1102,1157, 1183,1251,1261, 1292,1326,1327, 1405,1454,1464, 1491,1615,1629, 1806 |
| Stark, T | 1069,1150,1160, 1169,1213,1214, 1247,1264,1282, 1283,1324,1501, 1646 |
| Stark, T,E | 857,1212,1255 |

## B (Boron)

| | |
|---|---|
| **B I** | |
| Stark, T | 1706 |

## Ba (Barium)

| | |
|---|---|
| **Ba I** | |
| Resonance, E | 1487 |
| Stark, E | 557 |
| Van der Waals, E | 1488 by Ar<br>1488 by He<br>1488 by Kr<br>531,716,1605 by $N_2$<br>1488 by Ne |
| Van der Waals, T | 1750 by Ar<br>1750 by $H_2$<br>1750 by He |
| **Ba II** | |
| Stark, E | 543,557,614,1456, 1802,1879 |
| Stark, T | 1160 |
| Van der Waals, E | 773 by Ar<br>773 by He |
| Van der Waals, T | 1750 by Ar<br>1750 by $H_2$<br>1750 by He |

## Be (Beryllium)

| | |
|---|---|
| **Be I** | |
| Stark, T | 1706 |
| **Be II** | |
| Stark, E | 1802,1879 |
| **Be III** | |
| Stark, E | 1276 |
| **Be IV** | |
| Stark, C | 1670 |
| Stark, E | 1276 |

## Bi (Bismuth)

| | |
|---|---|
| **Bi I** | |
| Stark, E | 1613 |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|
| **Br (Bromine)** | |
| Br I | |
| Pressure, E | 92 |
| Stark, E | 1253 |
| **C (Carbon)** | |
| C I | |
| Stark, E | 1190,1253,1310, 1484,1633 |
| Stark, T | 1225,1706 |
| C II | |
| Stark, E | 1190,1215,1341, 1589 |
| Stark, T | 1069,1150,1160, 1330,1435,1501, 1771,1815 |
| Stark-Natural, T | 1878 |
| C III | |
| Stark, E | 1341,1860 |
| Stark, T | 1815 |
| C IV | |
| Stark, E | 1860 |
| Stark, T | 1815 |
| Stark-Natural, T | 1878 |
| **Ca (Calcium)** | |
| Ca I | |
| Doppler, E | 546 |
| Line, E | 1714 |
| Pressure, E | 49,546 |
| Resonance, E | 1487 |
| Stark, E | 289,538,785,1621 |
| Stark, T | 432,1706 |
| Van der Waals, E | 392 |
| Van der Waals, E | 1219,1451,1488, 1725 by Ar<br>573 by $H_2$<br>567,599,654,1219, 1488,1725 by He<br>1219,1488 by Kr<br>531,716,785,1605 by $N_2$<br>1219,1488 by Ne |
| Van der Waals, T | 1496,1590,1604, 1750 by Ar<br>1750 by $H_2$<br>1496,1590,1604, 1750 by He<br>1496,1590,1604 by Kr<br>1496,1590,1604 by Ne<br>1496 by Xe |
| Doppler-Pressure, T,E | 1116 |
| Ca II | |
| Stark, E | 1115,1215,1573, 1621,1758,1805, 1879 |
| Stark, T | 432,828,893,894, 1058,1069,1149, 1150,1160,1169, 1283,1501,1554, 1699,1771,1889 |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|
| Stark, T,E | 1871 |
| Van der Waals, E | 1451 by Ar |
| Van der Waals, T | 1750 by Ar |
| | 1750 by $H_2$ |
| | 1750 by He |

## Cd (Cadmium)

### Cd I

| | |
|---|---|
| Resonance, E | 21,136,665,890, 897,994,1200,1315 |
| Resonance, T | 896 |
| Stark, E | 709,758,1192 |
| Van der Waals, E | 237,496,901,1139, 1198,1273,1314, 1430 by Ar<br>136,787 by Cd<br>237,1139,1273, 1430 by He<br>21 by Hg<br>1139 by Kr<br>1555 by $N_2$<br>1139,1314,1316 by Ne<br>1555 by $O_2$<br>1273,1314,1315, 1316,1430,1634 by Xe |
| Van der Waals, T | 1496 by Ar<br>1496 by He<br>1496 by Kr<br>1496 by Ne<br>1496 by Xe |

### Cd II

| | |
|---|---|
| Stark, E | 709,1192 |

| Description | Reference No.* |
|---|---|

## Cl (Chlorine)

### Cl I

| | |
|---|---|
| Stark, E | 1253,1310,1617, 1633,1804 |
| Stark, T | 1325,1706 |
| Van der Waals, E | 1521 by Ar |

### Cl II

| | |
|---|---|
| Stark, E | 1253,1619,1773, 1804 |

## Co (Cobalt)

### Co I

| | |
|---|---|
| Van der Waals, E | 531 by $N_2$ |

## Cr (Chromium)

### Cr I

| | |
|---|---|
| Line, T | 1743 |
| Van der Waals, E | 781,1452 by Ar<br>1452 by He<br>531 by $N_2$ |
| Van der Waals, T | 1750 by Ar<br>1750 by $H_2$<br>1750 by He |

## Cs (Cesium)

### Cs I

| | |
|---|---|
| Resonance, E | 297,611,1086, 1262,1741,1785 |
| Resonance, T | 324,1003,1515, 1642,1663 |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|
| Stark, E | 821,905,1068, 1306,1613,1627, 1867 |
| Stark, T | 769,1282,1501, 1706,1882,1883 |
| Stark, T,E | 796,1650 |
| Van der Waals, C | 1870 by Ar<br>1870 by He |
| Van der Waals, E | 162,184,185,187, 248,472,533,540, 561,616,697,704, 1086,1272,1401, 1403,1431,1440, 1575,1659,1724, 1809,1827,1866 by Ar |
| | 1724,1827 by Ar-He |
| | 206,1741,1875 by Cs |
| | 1402,1440 by $CF_4$ |
| | 1431 by $C_5H_{12}$ |
| | 533 by $D_2$ |
| | 247,248,533,791 by $H_2$ |
| | 162,184,185,187, 248,472,533,561, 697,704,1062,1272, 1431,1440,1659, 1724,1809,1827, by He |
| | 1827 by He-Kr |
| | 1827 by He-Xe |
| | 183,200 by Hg |
| | 533,845 by Hydrocarbons |
| Van der Waals, E (cont.) | 201,533,697,704, 1158,1285,1440, 1659,1827 by Kr |
| | 36,162,163,185, 187,247,248,533, 616,697,716 by $N_2$ |
| | 162,163,184,185, 187,248,533,561, 704,1173,1431, 1440,1659,1866, by Ne |
| | 200,533,697,704, 1272,1285,1402, 1431,1440,1659, 1827 by Xe |
| Van der Waals, T | 166,556,602,606, 670,713,844,1252, 1412,1765,1766, 1858 by Ar |
| | 1881 by H |
| | 556 by $H_2$ |
| | 166,556,602,606, 670,713,1647, 1765,1766 by He |
| | 556,606,670,713, 844,1297,1412, 1872 by Kr |
| | 166,556,606,670, 713 by $N_2$ |
| | 166,556,606,670, 713,1252 by Ne |
| | 556,602,606,713, 844,1297,1658, 1765,1766,1872 by Xe |
| Van der Waals, E,C | 914 by $C_5H_{12}$ |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|
| Van der Waals, E,C (cont.) | 914 by $N_2$ |
| Van der Waals, T,E | 1443 by Kr |
| | 1443 by Ne |
| | 1443,1608 by Xe |
| Stark-Zeeman, E | 1649 |
| Stark-Zeeman, T | 1882 |

Cs II

| | |
|---|---|
| Van der Waals, T,E | 1443 by Kr |

## Cu (Copper)

Cu I

| | |
|---|---|
| Pressure, E | 145 |
| Stark, E | 76,135 |
| Stark, T | 1764 |
| Van der Waals, E | 781,1451 by Ar |
| | 531 by $N_2$ |
| Van der Waals, T | 1764 by Ar |

## D (Deuterium)

D I

| | |
|---|---|
| Van der Waals, E | 643,696,1742 by Ar |
| | 1669 by He |
| | 643,696 by Ne |

## Eu (Europium)

Eu II

| | |
|---|---|
| Van der Waals, T | 1750 by Ar |
| | 1750 by $H_2$ |
| | 1750 by He |

| Description | Reference No.* |
|---|---|

## F (Fluorine)

F I

| | |
|---|---|
| Stark, T | 1706 |
| Van der Waals, E | 1831 by Ar |
| | 1831 by $F_2$ |
| | 1831 by He |

F II

| | |
|---|---|
| Stark, E | 734 |

F III

| | |
|---|---|
| Stark, E | 734 |

## Fe (Iron)

Fe I

| | |
|---|---|
| Line, T | 1743 |
| Pressure, C | 281 |
| Pressure, E | 106 |
| Van der Waals, E | 714,781,1450 by Ar |
| | 573,1411 by H |
| | 573 by $H_2$ |
| | 703,1450 by He |
| | 531 by $N_2$ |
| Van der Waals, T | 1750 by Ar |
| | 1590,1715 by H |
| | 1750 by $H_2$ |
| | 1750 by He |
| Zeeman, T | 1743 |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|

## Ga (Gallium)

Ga I

| | |
|---|---|
| Resonance, E | 1207 |
| Stark, E | 1613 |
| Van der Waals, E | 1207 by Ar<br>1207 by He<br>1207 by Ne |

## Ge (Germanium)

Ge I

| | |
|---|---|
| Stark, C | 925 |
| Stark, E | 1612 |

## H (Hydrogen)

H I

| | |
|---|---|
| Doppler, T,E | 989 |
| Pressure, E | 26,55 |
| Resonance, E | 1655 |
| Resonance, T | 699,1474,1503 |
| Stark, C | 886,1099,1552,<br>1595,1596,1712 |
| Stark, E | 62,97,135,261,<br>332,383,407,450,<br>475,476,479,481,<br>499,507,518,529,<br>575,591,642,675,<br>700,705,720,761,<br>776,777,778,798,<br>799,830,833,865,<br>892,902,913,920,<br>940,964,992,1013,<br>1047,1063,1075, |
| Stark, E (cont.) | 1104,1105,1146,<br>1181,1223,1310,<br>1318,1319,1322,<br>1331,1336,1388,<br>1393,1446,1528,<br>1560,1614,1660,<br>1700,1798,1833,<br>1835 |
| Stark, T | 47,48,69,249,268<br>269,283,309,406,<br>478,524,525,526,<br>568,577,596,615,<br>619,651,653,655,<br>659,660,661,667,<br>726,736,768,771,<br>843,852,912,928,<br>932,981,1060,<br>1082,1087,1096,<br>1166,1170,1176,<br>1177,1180,1189,<br>1217,1218,1250,<br>1282,1295,1296,<br>1311,1312,1313,<br>1338,1339,1377,<br>1379,1380,1381,<br>1509,1511,1518,<br>1519,1557,1561,<br>1603,1636,1665,<br>1697,1711,1721,<br>1748,1753,1799,<br>1800,1819,1832,<br>1877 |
| Stark, T,C | 1759 |
| Stark, T,E | 429,448,566,712,<br>1095,1205,1600 |
| Van der Waals, E | 643,696,789,<br>1258,1742 by Ar |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|
| Van der Waals, E (cont.) | 1521 by Ar-$H_2$ |
| | 643,696,789,1521 by $H_2$ |
| | 643,696,789 by He |
| | 1270 by Kr |
| | 643,696,789 by Ne |
| | 1270 by Xe |
| Van der Waals, T | 1415 by Ar |
| | 1474 by H |
| | 763,1415,1493, 1495,1510,1580, 1586,1776 by He |
| | 1415 by Kr |
| | 1415,1586 by Ne |
| | 1415 by Xe |
| Stark-Doppler, T | 717,1468 |
| Stark-Zeeman, E | 1165,1423 |
| Stark-Zeeman, T | 1073,1085 |
| Stark-Zeeman, T,E | 1091 |
| Stark-Zeeman-Doppler, T | 1591 |
| Stark-Doppler-Natural-Van der Waals, T | 1303 |

## H (Hydrogen) Sequence

| | |
|---|---|
| Stark, T | 651 |

## He (Helium)

### He I

| | |
|---|---|
| Doppler, T,E | 989 |
| Resonance, E | 140,918,930,1111, 1112,1162 |
| Resonance, T | 1196,1628 |
| Resonance, T,E,C | 1466 |
| Stark, C | 1795 |
| Stark, E | 86,96,261,479, 581,608,733,761, 785,827,855,856, 920,935,940,1280, 1301,1382,1571, 1593,1599,1643, 1651,1672,1702, 1708,1719,1767, 1777,1791 |
| Stark, T | 47,95,310,317, 336,477,652,770, 893,999,1097, 1098,1175,1197, 1206,1281,1282, 1383,1384,1408, 1420,1439,1501, 1553,1569,1654, 1706,1711 |
| Stark, T,C | 1873 |
| Stark, T,E | 601,857,1095, 1600,1701 |
| Stark-Resonance, E | 856 |
| Stark-Zeeman, E | 1651 |
| Stark-Zeeman, T | 1267,1417,1419, 1583,1736 |
| Stark-Zeeman, T,E | 1266,1869 |

### He II

| | |
|---|---|
| Natural, E | 1807 |
| Stark, C | 1595,1756 |
| Stark, E | 581,700,761,1043, 1137,1179,1445, 1563,1587,1592, 1767,1768 |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|
| Stark, T | 711,768,853,1620, 1661,1769 |
| Stark, T,E | 601,1600 |

# Hg (Mercury)

## Hg I

| Description | Reference No.* |
|---|---|
| Pressure, E | 49,78,87,253,255, 302,367 |
| Resonance, C | 779 |
| Resonance, E | 61,98,136,203,225, 226,227,232,251, 252,291,355,447, 527,578,723,991, 1200,1422 |
| Resonance, T | 270,896,1321,1865 |
| Stark, E | 758 |
| Van der Waals, C | 919 by Ar |
| Van der Waals, E | 16 by Air |
| | 61,125,129,138, 231,237,252,389, 410,504,528,539, 541,542,578,616, 673,909,1009,1012, by Ar |
| | 129 by $CH_4$ |
| | 129 by $C_3H_8$ |
| | 1227 by $C_6H_{14}$ |
| | 129 by CO |
| | 54,61,252 by $CO_2$ |
| | 1357 by Cd |
| | 710,838,1067, 1156 by $D_2$ |
| | 941,1838 by Hydrocarbons |
| Van der Waals, E (cont.) | 16,54,61,125,129 389,410,453,528, 541,578,616,710, 728,838,967,1067 |
| | 1156 by $H_2$ |
| | 61,344 by $H_2O$ |
| | 125,129,138,237, 244,265,453,502, 528,542,578,616, 967,968,978,979, 1009,1067,1168 by He |
| | 99 by He-Ne |
| | 136,344,800,801 by Hg |
| | 542,609,909,1009, 1447 by Kr |
| | 1357 by Mg |
| | 54,61,125,129, 252,315,344,389, 410,504,528,541, 578,616 by $N_2$ |
| | 129,941 by $NH_3$ |
| | 138,539,542,967, 1009,1168 by Ne |
| | 61,252,315 by $O_2$ |
| | 541,542,578,674, 909,1009 by Xe |
| | 1357 by Zn |
| Van der Waals, T | 94,114,151,725, 794,896,1109, 1516,1808 by Ar |
| | 114 by CO |
| | 151 by $CO_2$ |
| | 114,151 by $H_2$ |
| | 114 by $H_2O$ |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|
| Van der Waals, T (cont.) | 94,114,794,896, 1220,1516,1517, 1657 by He<br>896,1808 by Kr<br>94,114,151,794 by $N_2$<br>896,1808 by Ne<br>151,794 by $O_2$<br>896,1808 by Xe |
| Van der Waals, T,E | 503,610 by Ar<br>1443 by $D_2$<br>1443 by $H_2$<br>503,1443 by He<br>610 by Kr<br>503 by $N_2$ |

Hg II

| | |
|---|---|
| Pressure, E | 147 |
| Stark, E | 1089 |

# I (Iodine)

I I

| | |
|---|---|
| Pressure, E | 92 |
| Van der Waals, E | 1831 by Ar<br>1831 by He<br>1831 by $I_2$ |

# In (Indium)

In I

| | |
|---|---|
| Resonance, E | 1207 |
| Stark, E | 1613 |
| Van der Waals, E | 647,702,1207 by Ar |

| Description | Reference No.* |
|---|---|
| Van der Waals, E (cont.) | 647,1207 by He<br>1207 by Ne<br>702 by Xe |

# K (Potassium)

K I

| | |
|---|---|
| Resonance, E | 228,458,1471, 1784,1785 |
| Resonance, T | 324,1003,1515, 1642,1663 |
| Resonance, T,E,C | 1466 |
| Stark, E | 1613 |
| Stark, T | 1706 |
| Van der Waals, E | 180,183,184,186, 200,215,390,410, 504,540,616,644, 704,781,988,1083, 1084 by Ar<br>180,308,410,644, 791 by $H_2$<br>180,183,184,186, 263,644,704,988 by He<br>191 by Hg<br>988 by Hydrocarbons<br>644,704,988, 1479 by Kr<br>174,215,229,308, 410,531,716,988 by $N_2$<br>180,183,184,186, 644,704,988 by Ne<br>341 by Rb |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|
| Van der Waals, E (cont.) | 704,988 by Xe |
| Van der Waals, T | 602,794 by Ar |
| | 1881 by H |
| | 602 by He |
| | 1297,1872 by Kr |
| | 794 by $N_2$ |
| | 602,1297,1872 by Xe |
| K IX | |
| Stark, E | 1154 |
| Stark, T | 1265 |

## Kr (Krypton)

Kr I

| | |
|---|---|
| Pressure, C | 234 |
| Resonance, E | 1348,1349 |
| Resonance, T | 1196,1628 |
| Resonance, T,E,C | 1466 |
| Van der Waals, C | 233 by Kr |
| Van der Waals, E | 1349,1399 by Ar |
| | 1399 by $H_2$ |
| | 1349,1399 by He |
| | 216,826,1349 by Kr |
| | 1349,1399 by Ne |
| | 1399 by Xe |
| Van der Waals, T | 1808 by Ar |
| | 1880 by He |
| | 1604 by Kr |
| | 1808 by Ne |
| Van der Waals, T,E,C | 1466 by Ar |
| | 1466 by Kr |

| Description | Reference No.* |
|---|---|
| Kr II | |
| Stark, E | 784,786 |
| Stark, T,E | 857 |

## Li (Lithium)

Li I

| | |
|---|---|
| Doppler, E | 546 |
| Pressure, E | 49,546 |
| Resonance, E | 1114,1523 |
| Resonance, T | 1515 |
| Stark, E | 76,333,724,1288, 1353,1354,1523, 1524,1525,1613 |
| Stark, T | 767,980,1648, 1706,1882 |
| Van der Waals, E | 392 |
| Van der Waals, E | 704,780,781,1522 by Ar |
| | 704,780,781,1522 by He |
| | 704 by Kr |
| | 353 by Li |
| | 531,716 by $N_2$ |
| | 1522 by Ne |
| | 704 by Xe |
| Van der Waals, T | 602,1506 by Ar |
| | 1881 by H |
| | 602,1645 by He |
| | 1297,1872 by Kr |
| | 602,1297,1872 by Xe |
| Stark-Zeeman, T | 1882 |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|

## Mg (Magnesium)

### Mg I

| | |
|---|---|
| Resonance, E | 136 |
| Stark, E | 557,758 |
| Stark, T | 218,1350,1706 |
| Van der Waals, E | 136 by Mg |
| Van der Waals, T | 1750 by Ar<br>1750 by $H_2$<br>1750 by He<br>1350 by Mg |

### Mg II

| | |
|---|---|
| Stark, E | 557,1573,1879 |
| Stark, T | 1058,1330,1501,<br>1558,1699 |
| Stark, T,E | 1871 |
| Van der Waals, T | 1750 by Ar<br>1750 by $H_2$<br>1750 by He |

## Mn (Manganese)

### Mn I

| | |
|---|---|
| Van der Waals, E | 646,1451 by Ar<br>646 by He<br>531 by $N_2$ |

## Mo (Molybdenum)

### Mo I

| | |
|---|---|
| Van der Waals, E | 1451 by Ar |

| Description | Reference No.* |
|---|---|

## N (Nitrogen)

### N I

| | |
|---|---|
| Resonance, E | 1622 |
| Stark, E | 862,1319,1482,<br>1485 |
| Stark, T | 1225,1706 |
| Van der Waals, E | 834,854,1622<br>by Ar<br>834,854,1622,<br>1667 by He<br>592,775,834,854,<br>1667 by $N_2$<br>834,854,1667<br>by Ne |
| Van der Waals, T | 1477,1493,1494<br>by He |

### N II

| | |
|---|---|
| Stark, E | 116,122,971,972,<br>1102,1142,1143,<br>1589,1606,1616 |
| Stark, T | 1069,1150,1160,<br>1265,1435,1501,<br>1646,1771,1815 |
| Stark-Natural, T | 1878 |

### N III

| | |
|---|---|
| Stark, E | 122,1341 |
| Stark, T | 1771,1815 |

### N V

| | |
|---|---|
| Doppler, E | 975 |
| Stark, E | 1072 |
| Stark, T | 1581,1815 |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|

# Na (Sodium)

## Na I

| | |
|---|---|
| Doppler, E | 546 |
| Natural, E | 100 |
| Pressure, E | 164,546,766 |
| Pressure, T,E | 74 |
| Resonance, E | 79,149,292,427, 433,456 |
| Resonance, T | 75,324,1003,1515, 1663 |
| Resonance, T,E | 1052 |
| Stark, E | 485,501,507,530, 906,1486,1613 |
| Stark, T | 218,432,767,828, 893,894,980,1706, 1734,1760 |
| Van der Waals, C | 468 by Ar |
| Van der Waals, E | 392 |
| Van der Waals, E | 84,100,115,172, 180,183,184,186, 202,205,326,391, 410,704,781,887, 888,1002,1451 by Ar |
| | 887,888 by $CO_2$ |
| | 243 by Cs |
| | 84,100,115,149, 172,180,181,202, 247,308,410,791, 1002 by $H_2$ |
| | 100,115,149,180, 183,184,186,202, 704,887,888,1002, 1107,1453,1572 by He |
| Van der Waals, E (cont.) | 191 by Hg |
| | 115 by Hydrocarbons |
| | 704,1002 by Kr |
| | 56,100,115,172, 181,202,247,308 391,410,451,507 531,716,887,888 |
| | 1002 by $N_2$ |
| | 100,115,180,183 184,186,202,704 1002,1107,1453 by Ne |
| | 704 by Xe |
| Van der Waals, T | 563,602,794,103 1507,1590,1750 by Ar |
| | 1760,1783,1881 by H |
| | 1750 by $H_2$ |
| | 354,602,794, 1590,1645,1647, 1750 by He |
| | 1297,1872 by Kr |
| | 794 by $N_2$ |
| | 602,1297,1872 by Xe |
| Van der Waals, T,E | 503 by Ar |
| Natural-Resonance, E | 85 |
| Resonance-Zeeman, T | 1332 |
| Stark-Doppler-Resonance-Van der Waals, E | 906 by N |

# Ne (Neon)

## Ne I

| | |
|---|---|
| Line, E | 408 |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|
| Natural, E | 190,1828 |
| Pressure, E | 428,1284,1789 |
| Pressure, T | 1458 |
| Resonance, E | 387,1141,1188, 1398,1828 |
| Resonance, T | 1196,1628 |
| Resonance, T,E,C | 1466 |
| Stark, E | 538,1310,1633, 1635,1638 |
| Stark, T | 1706,1775 |
| Van der Waals, E | 1106,1141,1300, 1335,1398,1478 by He<br>1481 by He-Ne<br>1224,1465,1631, 1787 by Ne |
| Van der Waals, T | 1775 by Ne |
| Stark-Resonance, E | 1787 |
| Doppler-Van der Waals,E | 1287,1448 by He |
| Ne II | |
| Pressure, E | 1774 |
| Stark, E | 139,603,784,786 |
| Stark, T,E | 857 |

## Ni (Nickel)

| Description | Reference No.* |
|---|---|
| Ni I | |
| Resonance, E | 1469 |
| Stark, E | 76 |
| Van der Waals, E | 1452,1469,1778 by Ar<br>1452,1469 by He<br>531 by $N_2$ |

## O (Oxygen)

| Description | Reference No.* |
|---|---|
| O I | |
| Stark, E | 846,864,1310, 1319,1482,1550, 1627,1633 |
| Stark, T | 1225,1501,1706 |
| Van der Waals, E | 565,1762 by Ar<br>565 by $N_2$<br>1521 by $O_2$ |
| Van der Waals, T | 1320 by O |
| O II | |
| Stark, E | 139 |
| O III | |
| Stark, E | 139,1341 |
| O VI | |
| Doppler, E | 975 |
| Stark, E | 1154 |
| Stark, T | 1265,1815 |

## P (Phosphorus)

| Description | Reference No.* |
|---|---|
| P I | |
| Stark, E | 1310,1633 |
| Stark, T | 1706 |
| Van der Waals, E | 782 by He<br>782 by Ne |
| P II | |
| Stark, E | 1310 |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|

## Pb (Lead)

### Pb I

| | |
|---|---|
| Resonance, E | 1178 |
| Stark, E | 1612 |

## Rb (Rubidium)

### Rb I

| | |
|---|---|
| Line, T,E | 1307 |
| Resonance, E | 277,341,457 |
| Resonance, T | 324,1003,1515, 1663 |
| Stark, E | 1613 |
| Van der Waals, C | 939 by Xe |
| Van der Waals, E | 235,236,248,276, 390,424,497,540, 562,616,697,704, 781,837,1066,1067, 1387,1390,1428, 1429 by Ar<br>1387 by $CH_4$<br>562,836,1067 by $D_2$<br>247,248,276,278, 497,562,791,836, 1067 by $H_2$<br>235,236,248,276, 390,424,497,562, 616,704,781,1387, 1390 by He<br>522,562,569 by Hydrocarbons<br>497,534,562,704, 1065,1067,1390, 1601 by Kr |
| Van der Waals, E (cont.) | 247,248,278,390, 497,562,616,716, 1387 by $N_2$<br>235,236,248,262, 279,280,497,562, 704,1064,1067, 1387,1390 by Ne<br>206,277 by Rb<br>497,534,704,898, 1390 by Xe |
| Van der Waals, T | 602,606,670,713, 987 by Ar<br>602,606,670,713 by He<br>606,670,713,987, 1297,1872 by Kr<br>606,670,713 by $N_2$<br>606,670,713 by Ne<br>602,606,713,987, 1297,1872 by Xe |
| Van der Waals, T,E | 503,1443 by Ar<br>1443 by $D_2$<br>1443 by $H_2$<br>503,1716 by He<br>1443 by Kr<br>503 by $N_2$<br>1443 by Ne |

### Rb II

| | |
|---|---|
| Van der Waals, T,E | 1443 by Kr |

## S (Sulfur)

### S I

| | |
|---|---|
| Resonance, E | 117 |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|
| Stark, E | 1038,1153,1310, 1633 |
| Stark, T | 1706 |
| S II | |
| Stark, E | 1153,1310 |
| Stark, T | 1069,1160,1164, 1328,1330,1501 |
| S III | |
| Stark, T | 1330,1501,1815 |
| S IV | |
| Stark, T | 1815 |
| S VI | |
| Stark, T | 1815 |

## Sb (Antimony)

| | |
|---|---|
| Sb I | |
| Pressure, E | 195 |
| Stark, E | 1613 |
| Sb II | |
| Pressure, E | 195 |
| Sb III | |
| Pressure, E | 195 |

## Sc (Scandium)

| | |
|---|---|
| Sc II | |
| Van der Waals, T | 1750 by Ar<br>1750 by $H_2$<br>1750 by He |

| Description | Reference No.* |
|---|---|

## Si (Silicon)

| | |
|---|---|
| Si I | |
| Line, T | 1743 |
| Stark, E | 734,1310,1612, 1630,1633 |
| Stark, T | 1350,1706,1889 |
| Van der Waals, E | 1171,1416,1866 by Ar<br>1630 by H |
| Van der Waals, T | 1750 by Ar<br>1750 by $H_2$<br>1750 by He<br>1350 by Si |
| Si II | |
| Stark, E | 734,1310,1618 |
| Stark, T | 1283,1330,1501, 1815,1889 |
| Stark-Natural, T | 1878 |
| Si III | |
| Stark, E | 734,784,922 |
| Stark, T | 1330,1501,1815, 1889 |
| Stark, T,E | 857 |
| Stark-Natural, T | 1878 |
| Si IV | |
| Stark, E | 734,922 |
| Stark, T | 1815 |
| Stark, T,E | 857 |
| Stark-Natural, T | 1878 |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|

## Sn (Tin)

| | |
|---|---|
| **Sn I** | |
| Pressure, E | 208 |
| Stark, E | 1612 |
| **Sn II** | |
| Pressure, E | 208 |
| **Sn III** | |
| Pressure, E | 208 |
| **Sn IV** | |
| Stark, E | 784,922 |

## Sr (Strontium)

| | |
|---|---|
| **Sr I** | |
| Resonance, E | 1487 |
| Van der Waals, E | 888,1488,1746 by Ar<br>888 by $CO_2$<br>888,1488,1746 by He<br>1488 by Kr<br>531,716,888,1605 by $N_2$<br>1488 by Ne |
| **Sr II** | |
| Stark, E | 543,614,1805,1879 |
| Van der Waals, T | 1750 by Ar<br>1750 by $H_2$<br>1750 by He |
| **Sr IV** | |
| Stark, T,E | 857 |

| Description | Reference No.* |
|---|---|

## T (Tritium)

| | |
|---|---|
| **T I** | |
| Van der Waals, E | 643,696,789, 1742 by Ar<br>643,696,789 by Ne |

## Te (Tellurium)

| | |
|---|---|
| **Te I** | |
| Stark, E | 1613 |

## Ti (Titanium)

| | |
|---|---|
| **Ti I** | |
| Stark, E | 924 |
| Van der Waals, E | 1191,1263 by Ar<br>924 by H |
| Van der Waals, T | 1750 by Ar<br>1750 by $H_2$<br>1750 by He |
| **Ti II** | |
| Van der Waals, E | 1191 by Ar<br>924 by H |

## Tl (Thallium)

| | |
|---|---|
| **Tl I** | |
| Doppler, E | 546 |
| Pressure, E | 546 |
| Resonance, E | 136 |
| Stark, E | 1613 |
| Van der Waals, C | 1172 by Hg |

*The numbers refer to paper identification numbers of Part 3.

| Description | Reference No.* |
|---|---|
| Van der Waals, E | 392 |
| Van der Waals, E | 237,616,622,702 by Ar<br>622,974 by $H_2$<br>237,702 by He<br>21 by Hg<br>702 by Kr<br>531 by $N_2$<br>702 by Ne<br>136 by Tl<br>702 by Xe |

## Xe (Xenon)

### Xe I

| | |
|---|---|
| Resonance, E | 173,936,982,1568 |
| Resonance, T | 1196 |
| Van der Waals, E | 372,410,936,1174, 1399 by Ar<br>410,1174,1399 by $H_2$<br>936,1174,1399, 1568 by He<br>936,1399 by Kr<br>410 by $N_2$<br>936,1174,1399, 1568 by Ne |
| Van der Waals, T | 1808 by Ar<br>1808 by Kr<br>1808 by Ne |
| Van der Waals, T,E | 1443 by Ne |

| Description | Reference No.* |
|---|---|

## Zn (Zinc)

### Zn I

| | |
|---|---|
| Pressure, E | 49 |
| Resonance, E | 136 |
| Resonance, T | 896 |
| Stark, E | 669,758,1193 |
| Van der Waals, E | 1199,1406 by Ar<br>1199,1406 by He<br>1483 by Hg<br>1199,1406 by Kr<br>1199,1406 by Ne<br>1199,1406 by Xe<br>136 by Zn |

### Zn II

| | |
|---|---|
| Stark, E | 1193 |

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16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)

This is the first general, annotated bibliography on atomic line shapes and shifts. It covers exhaustively the atomic spectral line broadening literature in about 1400 separate references extending from 1889 through March 1972. The bibliography contains four major parts: (1) All general interest papers are catalogued according to the broadening mechanisms (and, further, according to special topics under several of the mechanisms), and as to whether the work is a general theory, a general review, a table of profiles or parameters, a comment on existing work, a study of general experimental measurement techniques, or an experimental effort of general importance. Also included are selected papers on important applications of line broadening and on miscellaneous topics relating to atomic spectral line shapes and shifts. (2) In Part 2, all papers containing numerical data are ordered as to element, ionization stage, broadening mechanism (in the case of foreign gas broadening the perturbing species are listed), and it is indicated whether the data are experimentally or theoretically derived. (3) While in the two preceding parts of the bibliography the references are listed for brevity by identification numbers only, in Part 3 all references are listed completely by journal, authors, and title and are arranged chronologically and alphabetically within each year according to the principal authors. (4) A final section contains a list of all authors and their papers.

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215