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The First Spectrum of Copper (Cu I)

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THE FIRST SPECTRUM OF COPPER (Cu I)

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An analysis of the first spectrum of copper is given which identifies in some detail all the predictable types of electron structure. The spectrum is unique in having many more identified levels above the point of easiest ionization than below. Auto-ionization is therefore the rule rather than the exception. There are a great many series converging to complex limits and showing various degrees of perturbation. The peculiar behaviour of some groups of series is described in detail.

Introduction

The main features of the copper arc spectrum have been known since 1926 when several papers were published on its analysis (Beals 1926; Shenstone 1926; Sommer 1926). Since that time further papers on the subject have appeared (Menzies 1927; Selwyn 1929; Sambursky 1931; Allen 1932), and a more complete though somewhat inaccurate term table has been given in Bacher & Goudsmit's *Atomic energy levels*, from unpublished material supplied by this laboratory. The present paper gives a more critical and exhaustive analysis of all the data which have been accumulated during the past twenty years. From it, it appears that the copper spectrum gives possibly the best examples of most of the peculiarities which can be met with in atomic spectra. For instance, it exhibits a radically perturbed series; more examples of auto-ionization than all other known spectra; the only example of a complex series converging toward a limit more complex than a doublet. Of the 174 identified levels, 110 lie above the point of easiest ionization.

Observations

The observational data are the result of many measurements by many people of the spectra emitted by a variety of sources. Amongst these sources are the ordinary arc, the low-voltage arc in copper vapour, the hollow-cathode tube, and the globule arc, the last mentioned being by far the best source of copper arc lines that has come to my knowledge. The usual copper arc produces a spectrum filled with innumerable molecular lines in addition to large numbers of spark lines. The globule arc exhibits practically no spark lines except those of the very lowest excitation, and the band lines are reduced to an insignificant number throughout the greater part of the spectrum.

The globule arc has been used by a number of workers interested in spectro-chemical analysis (Milbourn 1934), but apparently it has not been used before as a tool in spectrum analysis. Its main feature is a cathode consisting of a graphite rod on which rests a bead of copper oxide. The anode may be copper or graphite or indeed any other conducting material of high melting-point, since it takes scarcely any part in the process of emission. The current required to keep the copper oxide molten is about 5 amp., and when the length of the arc is 4 mm. the potential is close to 40 V. Ordinarily the globule arc will burn for only a few minutes before the oxide bead has evaporated, but it is possible to prolong its life indefinitely by feeding fine copper wire into the bead. Also there is a continuous transfer of oxide from the cathode to the anode, and the material may be re-used by simply transferring it back to the cathode by closing the arc momentarily. The migration of oxide to the anode occurs even when the arc is run in pure nitrogen, and the repeated return of the bead to the cathode makes possible exposures up to half an hour without replenishment. The spectra in the Schumann region were made in this way.

The wave-length list (table 3) has been compiled from all available information and should be very nearly complete. The whole spectrum has been rephotographed from $\lambda 1250$ to $\lambda 11,000$ using the globule arc as source, and the reality of every line reported has been examined critically before inclusion in the table. The instruments used have been as follows: a 30,000 line/in. grating of radius 21 ft. for all but the weakest lines between $\lambda 2100$ and $\lambda 7000$; a 15,000 line/in. grating of radius 21 ft. in a Wadsworth mounting from $\lambda 7000$ to $\lambda 11,000$; a Hilger E.I. quartz spectrograph for faint lines, and a 30,000 line/in. grating of 2 m. radius from $\lambda 1250$ to $\lambda 2150$. For the exposures with the last-named instrument, the globule arc was run in pure nitrogen at atmospheric pressure and was focused on the slit by a fluorite lens in the manner previously described (Shenstone 1936). The oxide beads had to be prepared in air, and they are sufficiently poor conductors when cold to make the starting of the arc impossible without the initial high potential supplied by the constant-current circuit (Shenstone 1938; Green & Kuper 1940). The spectra photographed in the Schumann region are free of spark lines except for a few of lowest excitation, and even the nitrogen and carbon lines are faint. Obviously the arc stream must be carried almost entirely in copper or copper-oxide vapour. The plates used in this region were Ilford QII or Hilger Schumann, the latter of which unfortunately appear to be no longer available.

Unlike most arc spectra which consist of lines all of much the same character, the copper spectrum is a mixture of a relatively small number of sharp lines in a mass of diffuse lines of all sorts of widths and shapes. Most of the diffuse lines cannot be sharpened by the usual device of using a low pressure and field-free source. In such a source they simply disappear while retaining their width. These characteristics have been described in detail by Allen (1932), and the explanation is, of course, that the line-widths are inherent in the levels which give rise to them, due to auto-ionization.

Accurate measurements of diffuse lines cannot be expected. Moreover, in a spectrum as dense as that of copper, there must be much overlapping of wide lines which no device can resolve. Such observational difficulties impose definite restrictions on the analysis of the spectrum, and they are hardly counterbalanced by the fact that the line widths are a guide in judging the reality of a level. In a spectrum of sharp lines accurately measured, like iron, the numerical accuracy of the combinations is of primary importance, but in copper a much more detailed study of the characteristics of the spectrum is necessary.

The wave-lengths used are derived from several sources. The most accurate measures are those made by Burns & Walters (1929) with the interferometer. They are the basis of the numerical analysis of most of the sharp levels. Next in accuracy are some of the values given by Hetzler, Boreman & Burns (1935) and the measures made at M.I.T., and included in the *M.I.T. wave-length tables*. In the infra-red, measures made by Kiess (1935) have been used. The remaining lines, of which there are a great many, are the result of my own measurements, though the majority of them have been previously observed. Especially valuable has been the list of faint lines given by Milbourn (1943), very few of which have been rejected.

It has been remarked above that the wave-length measurements are not very satisfactory because of diffuseness and asymmetry of the lines. A special example of the latter difficulty is the following. The combination $m\,{}^2D_{1\frac{1}{2}}$–$6p\,{}^2P^\circ_{\frac{1}{2}}$ is the line at $\lambda 2392$, which has a strong reversal that can be used to obtain an accurate value for the level $6p\,{}^2P^\circ_{\frac{1}{2}}$. The combination $4s\,{}^2S$–$6p\,{}^2P^\circ_{\frac{1}{2}}$ at $\lambda 1817$ can then be calculated, and it is found that the observed wave-number is too large by about 2 cm.$^{-1}$. The explanation lies in the fact that the centre of gravity of $\lambda 2392$ is this same amount longer than the reversal. Probably there is a reversal in $\lambda 1817$ at the correct position at one side of the emission, but it is not observable with the means available. Both measured and calculated wave-lengths of $\lambda 1817$ are given in the table.

The wave-lengths of a number of lines in the ultra-violet are marked with a C to indicate that they have been computed. They are quite accurately calculable from easily observed and accurately measured combinations, and they form an excellent set of standards down to $\lambda 1703$. They were so used in the present work, together with the copper spark lines at $\lambda 1472$ and $\lambda 1358$. In no case should the error in wave-length of the computed lines exceed $\pm 0{\cdot}002$, and most of them can be trusted to $\pm 0{\cdot}001$.

The line intensities have, as a primary basis, the measures of Allen (1932). These are supplemented by visual estimates of plates on which ten exposures of 1, 2, 4, 8, etc. sec. of the globule arc were made with the 21 ft. grating. They cannot be anything more than rough estimates because this method necessarily favours sharp lines over diffuse ones; and as has been pointed out, there are a great many of the latter of varying widths in the copper spectrum.

Analysis

The outer electron structure of the copper atom consists of eleven electrons which in the lowest state are arranged in the structure $3d^{10}\,4s$. There is a more or less regular doublet spectrum produced by changes in the state of the outermost electron only. In addition there are the structures $3d^9\,4snx$. The term tables (tables 1 and 2) show that levels representative of the following structures have been found: $3d^{10}\,4s$ to $3d^{10}\,9s$; $3d^{10}\,4p$ to $3d^{10}\,11p$; $3d^{10}\,4d$ to $3d^{10}\,11d$; $3d^{10}\,4f$, $3d^{10}\,5f$; $3d^9\,4s^2$; $3d^9\,4s\,5s$ to $3d^9\,4s\,8s$; $3d^9\,4s\,4p$ and $3d^9\,4s\,5p$; $3d^9\,4s\,4d$ to $3d^9\,4s\,6d$. Of the structures $3d^9\,4snx$ all but $3d^9\,4s^2$ and $3d^9\,4s\,4p$ are above the ionization level $3d^{10}$ and are therefore subject to auto-ionization.

The notation used to distinguish the various levels requires some explanation. It is in general agreement with the recommendations made by Russell, Shenstone & Turner (1929) with one exception. The name $m\,{}^2D$ for the metastable term has been retained, chiefly because it is well known by that designation to a considerable number of spectroscopists; but partly, perhaps, because, in the course of years, I have acquired a sentimental attachment for it. The rest of the notation is obvious. Whenever an electron number and letter appear before the type designation, the level is a part of the ordinary doublet spectrum based on the d^{10} ion. For all other levels, the distinguishing mark is an arbitrary small letter, the order being *e*, *f*, *g*, *h*, etc., for even levels and *z*, *y*, *x*, etc., for odd levels, in accordance with the recommendations of Russell *et al.* (1929).

Of the ordinary doublet series both the ^{2}S and ^{2}D series have been fitted to an extended Ritz formula of the form $T = R/(n+\mu+\alpha T+\beta T^2)^2$ (Shenstone 1936). The calculated limits differ by less than 0·4 cm.$^{-1}$ and the mean value 62317·2 has been adopted. The higher series limits $3d^9\,4s\,{}^3\mathrm{D}{}^1\mathrm{D}$ are then also accurately determined, because the difference

$$3d^{10}\,{}^1\mathrm{S}_0 - 3d^9\,4s\,{}^3\mathrm{D}_3 = 21928{\cdot}6$$

is known from the analysis of the spark spectrum. Of the other series, both the ^{2}P° and ^{2}F° are perturbed by the levels of the structure $3d^9\,4s\,4p$ (Shenstone & Russell 1932). The perturbations are, however, of a vastly different magnitude in the two series. The ^{2}P° series

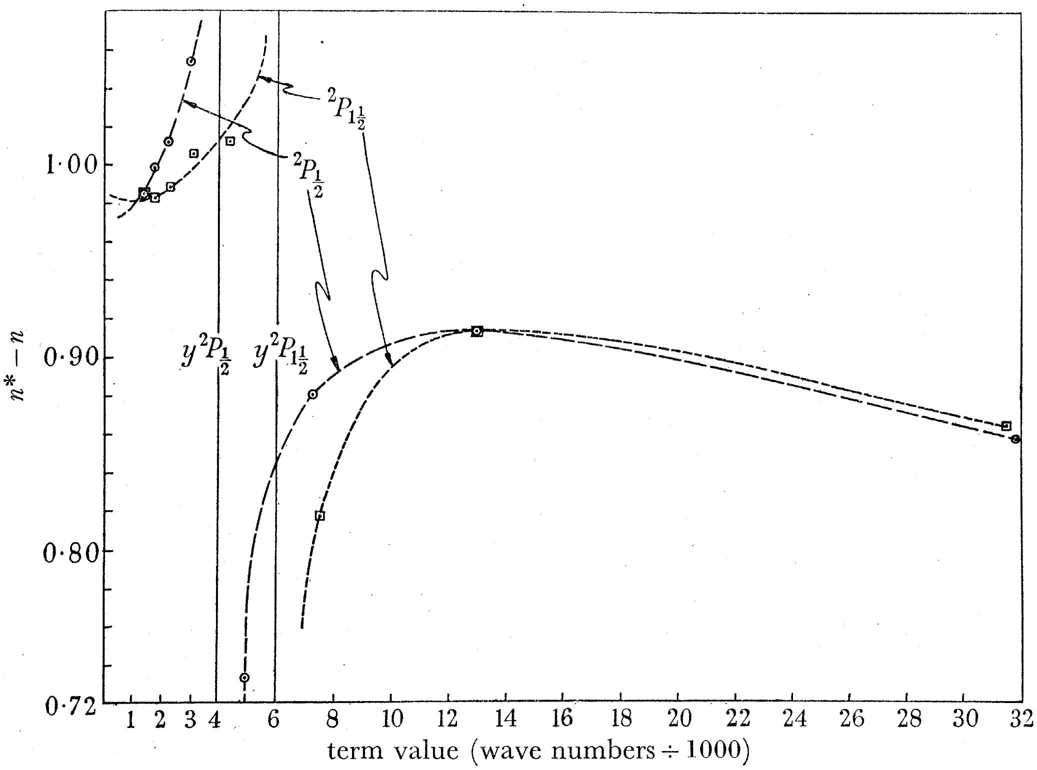

FIGURE 1. The perturbed ^{2}P° series.

was for long unknown because its members are so displaced that they were not recognized as a series. However, the correct assignment of the levels of $3d^9\,4s\,4p$ made it possible to follow the series, and it has been extended to $11p\,{}^2$P° by recent observations with the globule arc. The plot of the series given in figure 1, makes the perturbations evident and shows how the two component series are differently affected by the very wide inverted term $y\,{}^2$P°. Unexplained is the apparent lack of perturbation due to the lower $z\,{}^2$P° of the same structure. When the constants of the formula for perturbed series, in which $n^* = n+\mu+\alpha T+\dfrac{\beta'}{T-T_0}$ are calculated for the ^{2}P series, the following approximate values are obtained:

$$^2\mathrm{P}^\circ_{\frac{1}{2}} \quad \mu = 0{\cdot}944, \quad \alpha = 0, \quad \beta' = -145; \qquad {}^2\mathrm{P}^\circ_{1\frac{1}{2}} \quad \mu = 0{\cdot}930, \quad \alpha = 0, \quad \beta' = -185.$$

The values of β' are of the same order as those given in Shenstone (1936) for series in other spectra. They differ from the values formerly given because of the new data and the revised series limit.

The perturbation of the $^2F^\circ$ series is quite different. Two members only are known, but they are very near their correct hydrogenic positions. The inversion of the levels is attributable to a perturbation, as is also their ability to combine strongly with the metastable $m\,^2D$, a transition involving $\Delta l_1 = 2$, $\Delta l_2 = 3$. Since $y\,^2F^\circ_{3\frac{1}{2}}$ is near $4f\,^2F^\circ$, the $4f\,^2F^\circ_{3\frac{1}{2}}$ level acquires some of the combining properties of $y\,^2F^\circ$, whereas $4f\,^2F^\circ_{2\frac{1}{2}}$ does not. At the next series member $y\,^2F^\circ_{2\frac{1}{2}}$ is nearby, so $5f\,^2F^\circ_{2\frac{1}{2}}$ is the level which is chiefly affected. Such small perturbations can hardly, however, be compared with the great disruption of the $^2P^\circ$ series. There has been no published attempt at a theoretical explanation of this radical difference.

It is usually considered that the structure $3d^9\,4s\,4p$ should give rise to a set of terms $^4P^\circ$, $^4D^\circ$, $^4F^\circ$, $^2P^\circ$, $^2D^\circ$, $^2F^\circ$ based on ^3D, and a second set $^2P^\circ$, $^2D^\circ$, $^2F^\circ$ based on ^1D. The levels are all present in the copper spectrum, but their arrangement indicates that another point of view should be taken regarding the coupling of the electrons. The upper group of doublets is not narrow as one would expect if it were built on ^1D, but shows a definite separation into two narrow groups whose centres of gravity are 2043 cm.$^{-1}$ apart, a value close to the separations of $3d^9\,4s^2\,^2D$ of Cu I and $3d^9\,^2D$ of Cu III. It therefore appears more reasonable to describe the electron coupling as $3d^9\,^2D + 4s\,4p\,^3P$, ^1P. The lower and upper groups of levels then arise from the addition of ^3P and ^1P respectively to ^2D. On that basis one would expect to find that the lowest level is the result of adding $^3P^\circ_0$ to $^2D_{2\frac{1}{2}}$, which gives a level of $J = 2\frac{1}{2}$ as observed. The usual view would lead to a lowest level of $J = 3\frac{1}{2}$ resulting from the addition of $^2P_{\frac{1}{2}}$ to $^3D_3$. The arrangement of levels in the next series member $3d^9\,4s\,5p$ should approach much more closely to a grouping which can be correlated to $3d^9\,4s\,^3D$, $^1D + p$, i.e. there should be four groups of levels with roughly the separations of the limit levels. The approximate position of this series member and of its combinations with $m\,^2D$ can be easily calculated. In the predicted position there is observed a group of strong lines having the correct characteristics and containing amongst them five pairs with the $m\,^2D$ difference. There are no other levels except $4s\,^2S$ with which this group of levels can combine, and the position of the ^2S combinations is in the region where the observations are most difficult. Accordingly, it is not possible to assign the lines to levels unambiguously. In spite of this, it has seemed worth while to make tentative assignments based on analogy with other spectra and on series relationships. The levels so assigned are given in the term table as questionable, except for the five which are based on the $m\,^2D$ difference. They are at least numerically correct even if named incorrectly.

The odd levels just discussed, and all the remaining even levels of copper, lie above the first ionization point $3d^{10}\,^1S$, and they considerably outnumber the levels below that point. They are all, to a greater or less degree, subject to auto-ionization (Shenstone 1931), an effect closely allied to the perturbation of series. The effect may occur whenever a discrete level above ionization can find a continuum which has the same parity and angular momenta as itself. In strict Russell-Saunders coupling this means that levels of Cu I of character ^2S, $^2P^\circ$, ^2D, $^2F^\circ$, ^2G, etc., are subject to auto-ionization. In reality the coupling is far from Russell-Saunders, and levels may be considered as mixtures of various types. Auto-ionization may, therefore, affect, to a greater or less degree, almost any discrete level which is above ionization. The best known examples are the levels ^4D, ^2D, ^2D due to $3d^9\,4s\,5s$. Of the eight levels, all those having J-values characteristic of ^2D levels produce broad lines which retain their widths under any method of excitation. The remaining two levels $^4D_{3\frac{1}{2}}$ and $^4D_{\frac{1}{2}}$ produce sharp lines having normal characteristics. The resulting quartet multiplets are unique in exhibiting both sharp and diffuse lines. In a low-pressure source, the diffuse lines disappear leaving multiplets with sides but no centre. The variation of relative intensity of these lines with pressure and with exciting current constitutes the only detailed experimental evidence of auto-ionization (Allen 1932).

The $3d^9\,4sns$ series is of special interest because it is the only known complex series in which individual series can be unambiguously assigned to the components of a limit of greater complexity than a doublet. The convergence is exhibited in figure 2, from which it is obvious that ${}^4D_{3\frac{1}{2}}$ and ${}^4D_{2\frac{1}{2}}$ converge to ${}^3D_3$; ${}^4D_{1\frac{1}{2}}$ and ${}^2D_{2\frac{1}{2}}$ to ${}^3D_2$; ${}^4D_{\frac{1}{2}}$ and ${}^2D_{1\frac{1}{2}}$ to ${}^3D_1$; and both components of the upper ${}^2D$ to ${}^1D_2$. Some of these individual series follow a Ritz formula rather closely; but others, notably ${}^4D_{2\frac{1}{2}}$, depart markedly from such an expression.

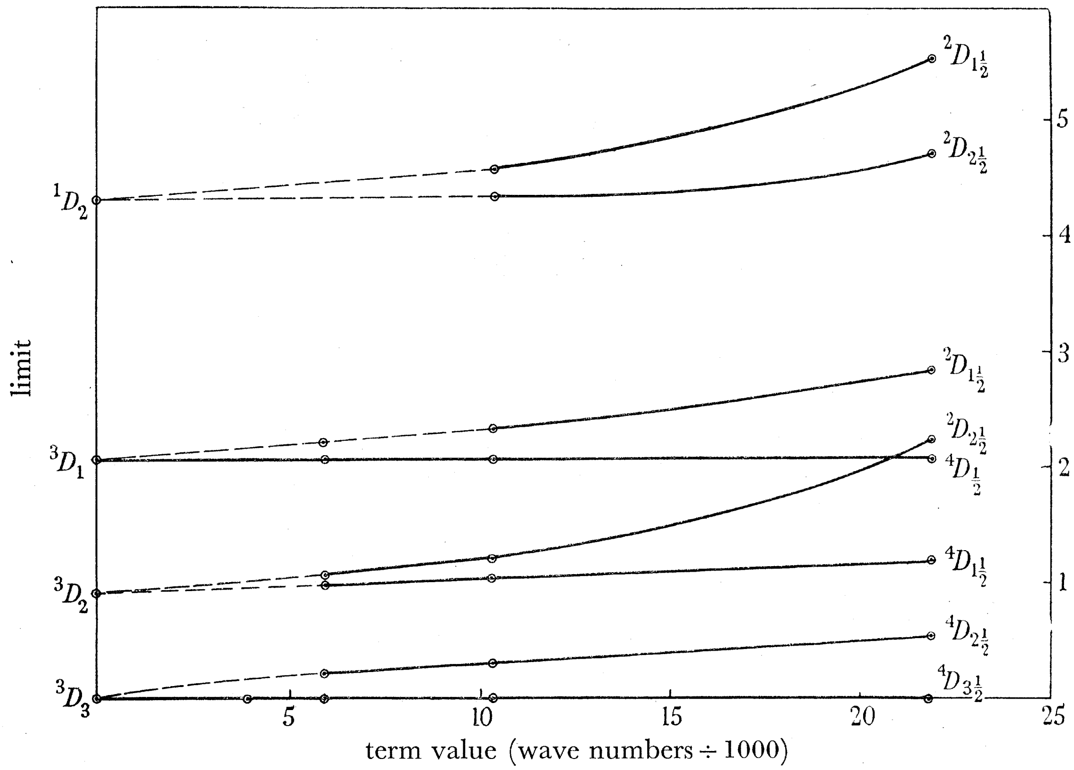

FIGURE 2. The series $3d^9 4sns\,{}^4D$, ${}^2D$, ${}^2D$. The vertical scale is three times the horizontal scale. The levels for any 'n' are plotted directly above the position of ${}^4D_{3\frac{1}{2}}$ of that 'n'. ($n = 5, 6, 7, 8$.)

The remaining even levels are all due to structures $3d^9\,4snd$, and they were found from their combinations with the levels of $3d^9\,4s\,4p$. This is a one-electron transition and is the complex counterpart of an ordinary diffuse series doublet. The structure theoretically gives rise to the 34 levels which make up the terms ${}^{4\text{ and }2\text{ and }2}$S, P, D, F, G. Since the whole group is built on the four levels of ${}^{3\text{ and }1}$D, the levels arrange themselves in four distinct subgroups which reveal their origin. The coupling is therefore close to J–j coupling. Nevertheless, it has seemed worth while to give the levels Russell-Saunders names to indicate the chief constituent in their composition. This has been done chiefly on the basis of the intensities of the combinations of the lowest $4d$ group. The higher groups have been named partly from intensities and partly to satisfy series relationships. There is a considerable correspondence between the strong combinations of the $4d$ group and the higher groups. The levels appear to be arranged as follows: on $^3D_3$ there are built the leading members of each quartet and each doublet; on $^3D_2$, the next quartet levels and the remaining doublets; on $^3D_1$ the remaining quartet levels. The limit $^1D_2$ has its own complete set of doublets.

The $4d$ group of levels lacks only one of $J = \frac{1}{2}$, but the higher groups are progressively less complete. There are unidentified lines in parts of the spectrum where we would expect higher series terms, but they are too few to fix further levels with any certainty.

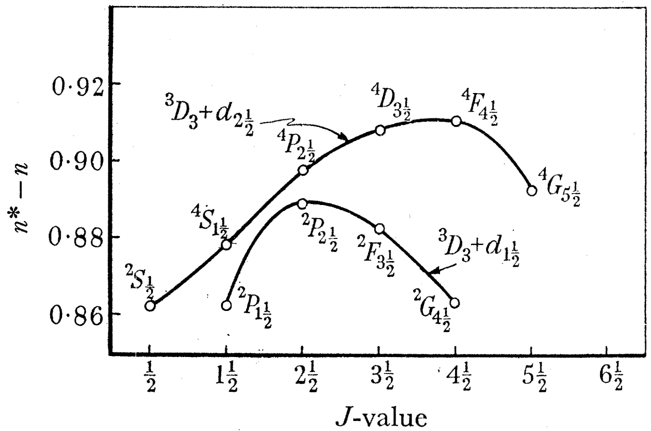

FIGURE 3. The levels $3d^9\,4s(^3D_3)\,4d$ showing division into two groups.

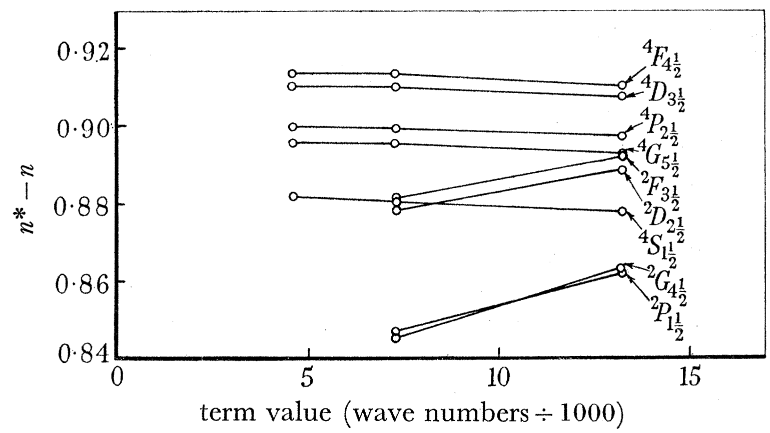

FIGURE 4. The series $3d^9\,4s(^3D_3)\,nd$ ($n = 4, 5, 6$).

A closer examination of the $3d^9\,4snd$ groups reveals a further subdivision which has not previously been noted. If the fractional part, n^*-n of the Rydberg denominator of the levels is plotted against J-value, there results the regular arrangement shown in figure 3. It will be noticed that the levels naturally divide themselves into two groups which have the proper J-values resulting respectively from the additions of a $d_{2\frac{1}{2}}$ and a $d_{1\frac{1}{2}}$ electron to a $^3D_3$ term. The first of these two groups includes all the quartets, and the second one the doublets except the $^2S_{\frac{1}{2}}$ which must be attached to the first group. This division is made more noteworthy by an additional differentiation of the two subgroups which is illustrated in figure 4 and is discussed below.

The most striking way to exhibit the characteristics of a spectral series is to plot n^*-n against the term value, as is done in figure 1. On such a plot, a series obeying a Ritz formula

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$n^* = n+\mu+\alpha T$, appears as a straight line with slope α and intercept μ. When ordinary doublet series are plotted in this way, there appears a characteristic which apparently has not been mentioned in the literature, the component series plot as nearly parallel lines. This means that the difference in the coupling of l and s affects the value of μ but not of α. In the present case of a d-electron coupled to a $^3D_3$ core it is evident from figure 4 that quite the reverse effect is present. In fact, all the series which arise from $d_{2\frac{1}{2}}$ are parallel to each other as are those arising from $d_{1\frac{1}{2}}$. Between the two groups, however, there is a large difference in slope. In other words, in this case the spin-orbit coupling of the d-electron produces a large difference in α rather than in μ. The same effect is present in the other groups built on ^3D and ^1D but it is less obvious because the analysis is less complete and less certain.

Term tables

Most of the essential information about the copper atom deducible from the spectrum is given in tables 1 and 2. In addition to the energy levels of Cu I there are included the chief levels of Cu II to which the Cu I series converge. The Rydberg denominators are, of course, calculated from the distance of each level from its proper limit in Cu II.

Column 4 of table 1 gives the available information regarding the intrinsic width of all the levels which lie above the first ionization point. Allen (1932) determined some of the widths with considerable accuracy, and he sent me several years ago in a letter a number of less certain determinations. One further width was measured here by comparison with Allen's results. For the remaining levels, rough indication of the width is given by the notation s (sharp), h (wide), $h(2)$, $h(3)$ for increasing widths. 'h' is used for widths of about 0·3 to 2 cm.$^{-1}$, $h(2)$ for 2 to 5 cm.$^{-1}$ and $h(3)$ for 5 to 10 cm.$^{-1}$.

Forbidden lines

Certain so-called forbidden combinations have been observed in Cu I. Of these, the $4p\,^2P$–$4f\,^2F$ are well known and have been the subject of experimental and theoretical work by Sambursky (1931). He attributes their presence to forced dipole radiation. In the new observations two forbidden lines have been found in the Schumann region. They are the combinations $4s\,^2S$–$7s\,^2S$ and $4s\,^2S$–$8s\,^2S$. The lines are strong and of the same character, and their positions are sufficiently exact to dispose of any doubt of their correct assignment. No other $4s\,^2S$–$ns\,^2S$ lines have been found in spite of the fact that most of them would fall in spectral regions much more easily observed.

Zeeman effect

The Zeeman effect in Cu I was used in the early papers to assist in the identification of the terms. No further observations appear to have been made since that time, and the old observations with one exception are not sufficiently consistent to warrant a calculation of g-factors. The exception is the $4p\,^2P$–$4d\,^2D$ multiplet which has been shown by Green (1930) to fit exceptionally well the formulae for the partial Paschen-Beck effect developed by Darwin (1927).

Hyperfine structure

The hyperfine structure of copper has been the subject of several papers, the most important being those of Ritschl (1932), Fermi & Segre (1933) and Schuler & Schmidt (1936). Many of the lines have a very narrow and complex structure which in no case is completely resolved. However, a consistent structural scheme can be deduced from the observations and gives the following values for the copper nucleus. Both isotopes 63 and 65 have nuclear spins $I = \frac{3}{2}$ and the magnetic moments are 2·5 nuclear magnetons for isotope 63 and 2·6 for 65. It is probable that both isotopes have a quadrupole moment of very roughly $-0{\cdot}1 \times 10^{-24}$ cm.^{2}. They have energy levels which are coincident except in the case of $3d^9 4s^2\,{}^2D$. In that term there is a separation of the levels, due to the two isotopes, of 0·085 cm.$^{-1}$ in ${}^2D_{2\frac{1}{2}}$ and 0·072 cm.$^{-1}$ in ${}^2D_{1\frac{1}{2}}$, the levels due to isotope 65 being lower in energy. One level $e\,{}^4D_{3\frac{1}{2}}$ has a sufficiently wide hyperfine structure for all of its combinations to appear as broadened lines under the dispersion of a large grating. This width should not be confused with the diffuseness of the majority of the lines.

The analysis of the first spectrum of copper here presented is the sum of contributions from a considerable number of students who have been my research assistants during the past twenty years. It is now as complete an analysis as that of any complex spectrum, and little more can be added to it unless radically new methods of excitation and observation are found. It should be of practical use in spectro-chemical analysis and of theoretical value when it becomes profitable to study atomic structure in more detail than has yet been done.

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TABLE 1. EVEN LEVELS OF Cu I

Conventions used in col. 4: A number indicates breadth in cm.$^{-1}$.
s = sharp.
h, h(2), h(3) = increasing degrees of diffuseness.
A. = Allen (1932).
A.l. = Allen's letter.
S. = author.

1 electron structure	2 designation	3 numerical value	4 term breadth	5 term connexions								6 Rydberg denominator
$3d^{10}\,(^1S)\,4s$	$4s\,^2S_{\frac12}$	000·000										1·3270
$3d^9\,4s^2$	$m\,^2D_{2\frac12}$	11202·565		*								
,,	$m\,^2D_{1\frac12}$	13245·423		*								
$(^1S)\,5s$	$5s\,^2S_{\frac12}$	43137·209										2·3920
,, $4d$	$4d\,^2D_{1\frac12}$	49935·200		*								2·9770
,, $4d$	$4d\,^2D_{2\frac12}$	49942·057		*								2·9779
,, $6s$	$6s\,^2S_{\frac12}$	52848·749										3·4044
,, $5d$	$5d\,^2D_{1\frac12}$	55387·668		*								3·9795
,, $5d$	$5d\,^2D_{2\frac12}$	55391·292		*								3·9808
,, $7s$	$7s\,^2S_{\frac12}$	56671·387										4·4087
,, $6d$	$6d\,^2D_{1\frac12}$	57893·05		*								4·9804
,, $6d$	$6d\,^2D_{2\frac12}$	57895·10		*								4·9815
,, $8s$	$8s\,^2S_{\frac12}$	58568·92										5·4108
,, $7d$	$7d\,^2D_{1\frac12}$	59249·46		*								5·9811
,, $7d$	$7d\,^2D_{2\frac12}$	59250·72		*								5·9821
,, $9s$	$9s\,^2S_{\frac12}$	59647·88										6·4118
,, $8d$	$8d\,^2D_{1\frac12}$	60065·51		*								6·9810
,, $8d$	$8d\,^2D_{2\frac12}$	60066·33		*								6·9823
,, $9d$	$9d\,^2D_{1\frac12}$	60594·53			*							7·9813
,, $9d$	$9d\,^2D_{2\frac12}$	60595·05			*							7·9825
,, $10d$	$10d\,^2D_{1\frac12}$	60956·92		*								8·9817
,, $10d$	$10d\,^2D_{2\frac12}$	60957·35		*								8·9833
,, $11d$	$11d\,^2D_{2\frac12}$	61215·59										9·9810
$3d^{10}$	$^1S_0$ (Cu II)	62317·2										
$3d^9\,4s\,(^3D_3)\,5s$	$e\,^4D_{3\frac12}$	62403·320	s A.	*								2·2415
,,	$e\,^4D_{2\frac12}$	62948·29	2·50 A.	*								2·2699
$(^3D_2)\,5s$	$e\,^4D_{1\frac12}$	63584·57	4·48 A.	*								2·2550
$(^3D_1)\,5s$	$e\,^4D_{\frac12}$	64472·300	0·37 A.	*								2·2415
$(^3D_2)\,5s$	$e\,^2D_{2\frac12}$	64657·8	3·51 A.		*							2·3133
$(^3D_1)\,5s$	$e\,^2D_{1\frac12}$	65260·1	6·5 S.		*							2·2830
$(^1D_2)\,5s$	$f\,^2D_{2\frac12}$	67142·7	8·7 A.			*						2·2624
,,	$f\,^2D_{1\frac12}$	67971·94	1·86 A.			*						2·3075
$(^3D_3)\,4d$	$g\,^2P_{1\frac12}$	70853·39	0·61 A.	*								2·8625
,,	$g\,^2S_{\frac12}$	70853·9 ?	h(2)	|								2·8625
,,	$g\,^2G_{4\frac12}$	70859·53	0·3 A.l.	|	*							2·8632
,,	$g\,^4S_{1\frac12}$	70998·12	h	|	|							2·8781
,,	$g\,^2D_{2\frac12}$	71098·17	1·41 A.	|	|	*						2·8890
,,	$g\,^2F_{3\frac12}$	71127·81	0·25 A.	|	|	|	*					2·8923
,,	$g\,^4G_{5\frac12}$	71130·69	s	|	|	|	|	*				2·8926
,,	$g\,^4P_{2\frac12}$	71178·19	0·43 A.l.	|	|	|	|	|	*			2·8978
,,	$g\,^4D_{3\frac12}$	71268·21	0·2 A.l.	|	|	|	|	|	|	*		2·9079
,,	$g\,^4F_{4\frac12}$	71290·54	0·3 A.l.	|	|	|	|	|	|	|	*	2·9103
$(^3D_2)\,4d$	$g\,^4P_{\frac12}$	71882·96	h	|	|	|	|	|	*	|	|	2·8745
,,	$g\,^4P_{1\frac12}$	71927·22	h	|	|	|	|	|	*	|	|	2·8797
,,	$g\,^4G_{4\frac12}$	71978·70	h	|	|	|	|	*		|		2·8849
,,	$g\,^2G_{3\frac12}$	72016·76	0·9 A.l.	|	*	|	|	|		|	|	2·8891
,,	$g\,^4D_{2\frac12}$	72066·97	0·7 A.l.	|		|	|	|		*	|	2·8946
,,	$g\,^4F_{3\frac12}$	72093·08	0·5 A.l.	|		|	|	|		|	*	2·8975
,,	$g\,^2D_{1\frac12}$	72104·8	h(2)	|		*	|	|		|	|	2·8988
,,	$g\,^2F_{2\frac12}$	72151·18	0·8 A.l.	|			*	|		|	|	2·9039
,,	$g\,^2P_{\frac12}$	72151·49 ?	h	*				|		|	|	2·9039
$(^3D_1)\,4d$	$g\,^4G_{3\frac12}$	73102·74	0·6 A.l.					*		|	|	2·8819
,,	$g\,^4D_{1\frac12}$	73104·88	h					|		*	|	2·8820
,,	$g\,^4G_{2\frac12}$	73198·71	h					*			|	2·8924
,,	$g\,^4F_{2\frac12}$	73304·67	0·5 A.l.								*	2·9042
,,	$g\,^4F_{1\frac12}$	73316·46	0·5 A.l.								*	2·9056
$(^3D_3)\,6s$	$i\,^4D_{3\frac12}$	73995·15	s	*								3·2719
,,	$i\,^4D_{2\frac12}$	74312·91	h	*								3·3240

TABLE 1 (*cont.*)

1 electron structure	2 designation	3 numerical value	4 term breadth	5 term connexions	6 Rydberg denominator
$(^3D_2)\,6s$	$i\,^4D_{1\frac12}$	75043·61	*h*(2)	*	3·2929
$(^1D_2)\,4d$	$h\,^2P_{\frac12}$	75109·46	*s*	*	2·8540
$(^3D_2)\,6s$	$i\,^2D_{2\frac12}$	75170·25	*h*	*	3·3147
$(^1D_2)\,4d$	$h\,^2G_{3\frac12}$	75206·4	*h*(3)	*	2·8644
,,	$h\,^2P_{1\frac12}$	75263·45	*s*	*	2·8705
,,	$h\,^2G_{4\frac12}$	75346·1 ?	*h*	*	2·8795
,,	$h\,^2S_{\frac12}$	75386·7	*h*(3)		2·8838
,,	$h\,^2D_{1\frac12}$	75440·1	*h*(2)	*	2·8898
,,	$h\,^2D_{2\frac12}$	75446·5	*h*(2)	*	2·8904
,,	$h\,^2F_{2\frac12}$	75536·2	*h*(2)	*	2·9003
,,	$h\,^2F_{3\frac12}$	75572·85	0·6 A.l.	*	2·9044
$(^3D_1)\,6s$	$i\,^4D_{\frac12}$	76064·37	*s*	*	3·2719
,,	$i\,^2D_{1\frac12}$	76332·3	*h*	*	3·3155
$(^3D_3)\,5d$	$j\,^2G_{4\frac12}$	76824·3	*h*	*	3·8453
,,	$j\,^2P_{1\frac12}$	76831·31	*h*		3·8471
,,	$j\,^2D_{2\frac12}$	76949·2	*h*(2)	*	3·8781
,,	$j\,^4S_{1\frac12}$	76959·0	*h*		3·8807
,,	$j\,^2F_{3\frac12}$	76960·2	*h*	*	3·8810
,,	$j\,^4G_{5\frac12}$	77014·1	*h*	*	3·8954
,,	$j\,^4P_{2\frac12}$	77030·59	*h*	*	3·8999
,,	$j\,^4D_{3\frac12}$	77068·2	*h*	*	3·9101
$(^3D_3)\,5d$	$j\,^4F_{4\frac12}$	77080·5	*h*	*	3·9135
$(^3D_2)\,5d$	$j\,^4P_{\frac12}$	77814·5	*h*	*	3·8640
,,	$j\,^4P_{1\frac12}$	77840·9	*h*(2)	*	3·8710
,,	$j\,^4G_{4\frac12}$	77854·0	*h*	*	3·8745
,,	$j\,^2G_{3\frac12}$	77898·9	*h*	*	3·8864
,,	$j\,^4D_{2\frac12}$	77905·5	*h*	*	3·8882
,,	$j\,^4F_{3\frac12}$	77919·4	*h*	*	3·8919
,,	$j\,^2D_{1\frac12}$	77933·3	*h*(2)	*	3·8957
,,	$j\,^2F_{2\frac12}$	77959·3	*h*	*	3·9027
$(^3D_3)\,7s$	$k\,^4D_{3\frac12}$	78261·2	*s*	*	4·2821
$(^1D_2)\,6s$	$p\,^2D_{2\frac12}$	78349·6	*h*(2)		3·2749
$(^3D_3)\,7s$	$k\,^4D_{2\frac12}$	78486·5	*h*	*	4·3651
$(^1D_2)\,6s$	$p\,^2D_{1\frac12}$	78578·0	*h*		3·3120
$(^3D_1)\,5d$	$j\,^4G_{3\frac12}$	78988·3	*h*	*	3·8700
,,	$j\,^4D_{1\frac12}$	79003·1	*h*(2)	*	3·8739
,,	$j\,^4G_{2\frac12}$	79053·4	*h*	*	3·8873
,,	$j\,^4F_{2\frac12}$	79116·5	*h*	*	3·9043
,,	$j\,^4F_{1\frac12}$	79119·3	*h*	*	3·9051
$(^3D_2)\,7s$	$k\,^4D_{1\frac12}$	79257·8	*h*	*	4·3104
,,	$k\,^2D_{2\frac12}$	79268·0	*h*(2)	*	4·3141
$(^3D_3)\,6d$	$l\,^4S_{1\frac12}$	79641·4	*h*(2)		4·8819
,,	$l\,^4G_{5\frac12}$	79667·9	*h*(2)	*	4·8960
,,	$l\,^4P_{2\frac12}$	79675·1	*h*(2)		4·8999
,,	$l\,^4D_{3\frac12}$	79694·5	*h*(2)	*	4·9103
,,	$l\,^4F_{4\frac12}$	79700·5	*h*(3)	*	4·9135
$(^3D_3)\,8s$	$n\,^4D_{3\frac12}$	80318·4	*h*		5·2860
$(^3D_1)\,7s$	$k\,^4D_{\frac12}$	80330·4	*h*	*	4·2819
,,	$k\,^2D_{1\frac12}$	80456·4 ?	*h*(2)	*	4·2913
$(^3D_2)\,6d$	$1\,^4G_{4\frac12}$	80505·5	*h*(2)	*	4·8533
,,	$1\,^4D_{2\frac12}$	80542·2	*h*(2)	*	4·8726
,,	$1\,^2G_{3\frac12}$	80553·8	*h*		4·8787
,,	$1\,^4F_{3\frac12}$	80560·0	*h*	*	4·8820
,,	$1\,^2F_{2\frac12}$	80574	*h*(3)		4·8895
,,	$1\,^2D_{1\frac12}$	80586·7 ?	*h* (3)		4·8963
$(^1D_2)\,5d$	$o\,^2D_{2\frac12}$	81292·5	*h*	*	3·8801
,,	$o\,^2D_{1\frac12}$	81313·7	*h*	*	3·8857
,,	$o\,^2F_{2\frac12}$	81362·7	*h*(2)	*	3·8987
,,	$o\,^2F_{3\frac12}$	81376·2	*h*	*	3·9025
$3d^9\,4s$	$^3D_3$ (Cu II)	84245·8			
	$^3D_2$,,	85164·2			
	$^3D_1$,,	86315·5			
	$^1D_2$,,	88581·7			

Table 2. Odd levels of Cu I

1 electron structure	2 designation	3 numerical value	4 term connexions	5 Rydberg denominator
$3d^{10}4p$	$4p\ {}^2P^{\circ}_{1/2}$	30535·302	*	1·8582
,,	$4p\ {}^2P^{\circ}_{1\frac12}$	30783·686	*	1·8655
$3d^9 4s 4p$	$z\ {}^4P^{\circ}_{2\frac12}$	39018·652	*	
,,	$z\ {}^4P^{\circ}_{1\frac12}$	40113·99	*	
,,	$z\ {}^4F^{\circ}_{4\frac12}$	40909·138	* |	
,,	$z\ {}^4P^{\circ}_{1/2}$	40943·73	| *	
,,	$z\ {}^4F^{\circ}_{3\frac12}$	41153·433	*	
,,	$z\ {}^4F^{\circ}_{2\frac12}$	41562·895	*	
,,	$z\ {}^4F^{\circ}_{1\frac12}$	42302·47	*	
,,	$z\ {}^4D^{\circ}_{3\frac12}$	43513·95	*	
,,	$z\ {}^2F^{\circ}_{2\frac12}$	43726·191	* |	
,,	$z\ {}^4D^{\circ}_{2\frac12}$	44406·268	| *	
,,	$z\ {}^4D^{\circ}_{1\frac12}$	44544·153	| *	
,,	$z\ {}^4D^{\circ}_{1/2}$	44915·61	| *	
,,	$z\ {}^2F^{\circ}_{3\frac12}$	44963·223	*	
,,	$z\ {}^2P^{\circ}_{1/2}$	45821·00	*	
,,	$z\ {}^2P^{\circ}_{1\frac12}$	45879·311	*	
,,	$z\ {}^2D^{\circ}_{1\frac12}$	46172·842	*	
,,	$z\ {}^2D^{\circ}_{2\frac12}$	46598·34	*	
$3d^{10}5p$	$5p\ {}^2P^{\circ}_{1\frac12}$	49382·95	*	2·9128
,, $5p$	$5p\ {}^2P^{\circ}_{1/2}$	49383·26	*	2·9128
,, $6p$	$6p\ {}^2P^{\circ}_{1\frac12}$	54784·06	*	3·8167
,, $6p$	$6p\ {}^2P^{\circ}_{1/2}$	55027·74	*	3·8800
,, $4f$	$4f\ {}^2F^{\circ}_{3\frac12}$	55426·3	*	3·9906
,, $4f$	$4f\ {}^2F^{\circ}_{2\frac12}$	55429·8	*	3·9916
$3d^9 4s 4p$	$y\ {}^2F^{\circ}_{3\frac12}$	56029·95	*	
,,	$y\ {}^2P^{\circ}_{1\frac12}$	56343·74	| *	
,,	$y\ {}^2D^{\circ}_{2\frac12}$	56651·48	| | *	
$3d^{10}7p$	$7p\ {}^2P^{\circ}_{1/2}$	57419·31	| | | *	4·7334
,, $5f$	$5f\ {}^2F^{\circ}_{2\frac12}$	57905·2	| | | | *	4·9872
,, $5f$	$5f\ {}^2F^{\circ}_{3\frac12}$	57908·7	| | | | *	4·9892
,, $7p$	$7p\ {}^2P^{\circ}_{1\frac12}$	57948·71	| | | *	5·0120
$3d^9 4s 4p$	$y\ {}^2F^{\circ}_{2\frac12}$	58119·28	* | |	
,,	$y\ {}^2P^{\circ}_{1/2}$	58364·73	* |	
,,	$y\ {}^2D^{\circ}_{1\frac12}$	58690·86	*	
$3d^{10}8p$	$8p\ {}^2P^{\circ}_{1\frac12}$	59275·33	*	6·0063
,, $8p$	$8p\ {}^2P^{\circ}_{1/2}$	59323·17	*	6·0541
,, $9p$	$9p\ {}^2P^{\circ}_{1\frac12}$	60070·6	*	6·9890
,, $9p$	$9p\ {}^2P^{\circ}_{1/2}$	60085·2	*	7·0118
,, $10p$	$10p\ {}^2P^{\circ}_{1\frac12}$	60595·0	*	7·9825
,, $10p$	$10p\ {}^2P^{\circ}_{1/2}$	60601·9	*	7·9985
,, $11p$	$11p\ {}^2P^{\circ}$	60958·0		
$3d^{10}$	${}^1S_0$ (Cu II)	62317·2		
$3d^9 4s 5p$	$x\ {}^4P^{\circ}_{1\frac12}$?	70281 ?	*	
,,	$x\ {}^4F^{\circ}_{3\frac12}$?	70336·5 ?	| *	
,,	$x\ {}^4F^{\circ}_{2\frac12}$?	70414·1	| *	
,,	$x\ {}^4D^{\circ}_{3\frac12}$?	70441·0 ?	| *	
,,	$x\ {}^4D^{\circ}_{2\frac12}$?	70561·2 ?	| *	
,,	$x\ {}^2F^{\circ}_{2\frac12}$?	70959·7	| * |	
,,	$x\ {}^4P^{\circ}_{1/2}$?	71004 ?	* | |	
,,	$x\ {}^4D^{\circ}_{1\frac12}$?	71029·6	| *	
,,	$x\ {}^2F^{\circ}_{3\frac12}$?	71613·9 ?	*	
,,	$x\ {}^2D^{\circ}_{2\frac12}$?	71745·5	*	
,,	$x\ {}^2P^{\circ}_{1\frac12}$?	71917 ?	|	
,,	$x\ {}^2D^{\circ}_{1\frac12}$?	72024·2 ?	*	
,,	$w\ {}^2P^{\circ}_{1\frac12}$?	74259·5 ?	*	
,,	$w\ {}^2F^{\circ}_{3\frac12}$?	74341·9 ?	| *	
,,	$w\ {}^2D^{\circ}$?	74507·6	| |	
,,	$w\ {}^2F^{\circ}_{2\frac12}$?	74923·7 ?	| *	
,,	$w\ {}^2P^{\circ}_{1/2}$?	75090·6 ?	*	
$3d^9 4s$	${}^3D_3$ (Cu II)	84245·8		
,,	${}^3D_3$,,	85164·2		
,,	${}^3D_2$,,	86315·5		
,,	${}^1D_2$,,	88581·7		

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Table 3. List of observed lines of Cu I

I wave-length	II authority and intensity	III intensity	IV wave-number	V identification
18229	Ra 5		5484·1	$4d\,^2D_{2\frac{1}{2}}-4f\,^2F^{\circ}_{3\frac{1}{2}}$
18194	Ra 7		5494·6	$4d\,^2D_{1\frac{1}{2}}-4f\,^2F^{\circ}_{2\frac{1}{2}}$
16653	Ra 4		6003·2	$5p\,^2P^{\circ}-5d\,^2D_{1\frac{1}{2}}$?
16008	Ra 5		6245·0	$5s\,^2S_{\frac{1}{2}}-5p\,^2P^{\circ}$
11118·2	K 1*h*		8991·8	$z\,^4P^{\circ}_{\frac{1}{2}}-4d\,^2D_{1\frac{1}{2}}$
10883·3	K 1		9185·8	$5p\,^2P^{\circ}-8s\,^2S_{\frac{1}{2}}$
10771·7	K 2*h*(2)		9281·0	$y\,^2D^{\circ}_{1\frac{1}{2}}-f\,^2D_{1\frac{1}{2}}$
10179·2	K 1		9821·2	$z\,^4P^{\circ}_{1\frac{1}{2}}-4d\,^2D_{1\frac{1}{2}}$
10172·00	K 30	2	9828·23	$z\,^4P^{\circ}_{1\frac{1}{2}}-4d\,^2D_{2\frac{1}{2}}$
10146·78	K 50	10	9852·64	$y\,^2F^{\circ}_{2\frac{1}{2}}-f\,^2D_{1\frac{1}{2}}$
10124·5	K 5*h*(2)		9874·3	$6p\,^2P^{\circ}_{1\frac{1}{2}}-e\,^2D_{2\frac{1}{2}}$
9739·6	K 4*h*(2)		10264·6	$5p\,^2P^{\circ}-9s\,^2S_{\frac{1}{2}}$
9688·5	K 2*h*(2)		10318·7	
9530·3	K 10*h*(2)	5*h*(2)	10490·0	$y\,^2D^{\circ}_{2\frac{1}{2}}-f\,^2D_{2\frac{1}{2}}$
9472·4	K 2*h*(2)	2*h*	10554·1	$7p\,^2P^{\circ}_{\frac{1}{2}}-f\,^2D_{1\frac{1}{2}}$?
9263·54		3	10792·1	$z\,^2P^{\circ}_{1\frac{1}{2}}-7s\,^2S_{\frac{1}{2}}$
9255·53		0	10801·4	$y\,^2P^{\circ}_{1\frac{1}{2}}-f\,^2D_{2\frac{1}{2}}$
9256·8	K 1*h*(2)		10799·9	
9213·75		0	10850·4	$z\,^2P^{\circ}_{\frac{1}{2}}-7s\,^2S_{\frac{1}{2}}$
8996·2		20*h*(2)	11112·7	$y\,^2F^{\circ}_{3\frac{1}{2}}-f\,^2D_{2\frac{1}{2}}$
8831·3		1	11320·3	$y\,^2D^{\circ}_{2\frac{1}{2}}-f\,^2D_{1\frac{1}{2}}$
8584·0	K	10	11646·4	$5s\,^2S_{\frac{1}{2}}-6p\,^2P^{\circ}_{1\frac{1}{2}}$
8408·15	K	20	11889·96	$5s\,^2S_{\frac{1}{2}}-6p\,^2P^{\circ}_{\frac{1}{2}}$
8092·634	IBu	2000	12353·524	$4p\,^2P^{\circ}_{1\frac{1}{2}}-5s\,^2S_{\frac{1}{2}}$
7933·130	IBu	1500	12601·904	$4p\,^2P^{\circ}_{\frac{1}{2}}-5s\,^2S_{\frac{1}{2}}$
7570·09		200*h*	13206·24	$5s\,^2S_{\frac{1}{2}}-y\,^2P^{\circ}_{1\frac{1}{2}}$
7452·5		2*h*(2)	13414·6	$y\,^2D^{\circ}_{1\frac{1}{2}}-g\,^2D_{1\frac{1}{2}}$
7427·2		5*h*	13460·3	$y\,^2D^{\circ}_{1\frac{1}{2}}-g\,^2F_{2\frac{1}{2}}$
7349·0		0*h*(2)	13603·6	
7193·56		50*h*	13897·49	$y\,^2F^{\circ}_{2\frac{1}{2}}-g\,^2G_{3\frac{1}{2}}$
7154·29		5	13973·78	$y\,^2F^{\circ}_{2\frac{1}{2}}-g\,^4F_{3\frac{1}{2}}$
7124·66		5*h*	14031·89	$y\,^2F^{\circ}_{2\frac{1}{2}}-g\,^2F_{2\frac{1}{2}}$
7039·37	M	25	14201·90	$5p\,^2P^{\circ}-e\,^4D_{1\frac{1}{2}}$ $y\,^2D^{\circ}_{2\frac{1}{2}}-g\,^2S_{\frac{1}{2}}$
7000·05		2*h*(2)	14281·68	$5s\,^2S_{\frac{1}{2}}-7p\,^2P^{\circ}_{\frac{1}{2}}$
6968·34		5	14346·67	$y\,^2D^{\circ}_{2\frac{1}{2}}-g\,^4S_{1\frac{1}{2}}$
6935·82	M	5*h*	14413·94	$y\,^2D^{\circ}_{1\frac{1}{2}}-g\,^4D_{1\frac{1}{2}}$
6920·06	M	50*h*	14446·76	$y\,^2D^{\circ}_{2\frac{1}{2}}-g\,^2D_{2\frac{1}{2}}$
6905·94	M	100	14476·30	$y\,^2D^{\circ}_{2\frac{1}{2}}-g\,^2F_{3\frac{1}{2}}$
6890·90		10	14507·9	$7p\,^2P^{\circ}_{\frac{1}{2}}-g\,^4P_{1\frac{1}{2}}$ $y\,^2D^{\circ}_{1\frac{1}{2}}-g\,^4G_{2\frac{1}{2}}$
6889·92		10*h*(2)	14510·0	$y\,^2P^{\circ}_{1\frac{1}{2}}-g\,^2S_{\frac{1}{2}}$
6881·94		10	14526·8	$y\,^2D^{\circ}_{2\frac{1}{2}}-g\,^4P_{2\frac{1}{2}}$
6840·99		3*h*	14613·7	$y\,^2D^{\circ}_{1\frac{1}{2}}-g\,^4F_{2\frac{1}{2}}$
6835·46		1*h*	14625·6	$y\,^2D^{\circ}_{1\frac{1}{2}}-g\,^4F_{1\frac{1}{2}}$
6821·86		2*h*	14654·7	$y\,^2P^{\circ}_{1\frac{1}{2}}-g\,^4S_{1\frac{1}{2}}$
6775·64		2*h*(2)	14754·7	$y\,^2P^{\circ}_{1\frac{1}{2}}-g\,^2D_{2\frac{1}{2}}$
6749·29	Me 2*h*		14812·3	$5s\,^2S_{\frac{1}{2}}-7p\,^2P^{\circ}_{1\frac{1}{2}}$
6741·42		100	14829·0	$y\,^2F^{\circ}_{3\frac{1}{2}}-g\,^2G_{4\frac{1}{2}}$
6672·23		10	14983·4	$y\,^2F^{\circ}_{2\frac{1}{2}}-g\,^4G_{3\frac{1}{2}}$
6634·7		2*h*	15068·1	$y\,^2F^{\circ}_{3\frac{1}{2}}-g\,^2D_{2\frac{1}{2}}$
6629·67		5*h*	15079·5	$y\,^2F^{\circ}_{2\frac{1}{2}}-g\,^4G_{2\frac{1}{2}}$
6621·61		30*h*	15097·9	$y\,^2F^{\circ}_{3\frac{1}{2}}-g\,^2F_{3\frac{1}{2}}$
6599·68		0*h*	15148·1	$y\,^2F^{\circ}_{3\frac{1}{2}}-g\,^4P_{2\frac{1}{2}}$
6583·54		0*h*	15185·2	$y\,^2F^{\circ}_{2\frac{1}{2}}-g\,^4F_{2\frac{1}{2}}$
6565·54		1*h*(2)	15226·8	$5s\,^2S_{\frac{1}{2}}-y\,^2P^{\circ}_{\frac{1}{2}}$
6550·98		1	15260·7	$y\,^2F^{\circ}_{3\frac{1}{2}}-g\,^4F_{4\frac{1}{2}}$
6544·51		1	15275·8	$y\,^2D^{\circ}_{2\frac{1}{2}}-g\,^4P_{1\frac{1}{2}}$
6506·14		0	15365·9	$y\,^2D^{\circ}_{2\frac{1}{2}}-g\,^2G_{3\frac{1}{2}}$
6485·18		5	15415·5	$y\,^2D^{\circ}_{2\frac{1}{2}}-g\,^4D_{2\frac{1}{2}}$

TABLE 3 (*cont.*)

I wave-length	II authority and intensity	III intensity	IV wave-number	V identification
6474·20		10	15441·7	$y\,^2\mathrm{D}^\circ_{2\frac12}-g\,^4\mathrm{F}_{3\frac12}$
6433·35	K 1		15539·72	$y\,^2\mathrm{P}^\circ_{1\frac12}-g\,^4\mathrm{P}_{\frac12}$
6427·57		1*h*	15553·7	$5s\,^2\mathrm{S}_{\frac12}-y\,^2\mathrm{D}^\circ_{1\frac12}$
6415·18		0*h*	15583·7	$y\,^2\mathrm{P}^\circ_{1\frac12}-g\,^4\mathrm{P}_{1\frac12}$
6373·3	K 1		15686·1	$7p\,^2\mathrm{P}^\circ_{\frac12}-g\,^4\mathrm{D}_{1\frac12}$
6358·09		0*h*	15723·7	$y\,^2\mathrm{P}^\circ_{1\frac12}-g\,^4\mathrm{D}_{2\frac12}$
6325·45		5	15804·8	$z\,^2\mathrm{D}^\circ_{1\frac12}-e\,^4\mathrm{D}_{3\frac12}$
6268·30		20*h*	15948·9	$y\,^2\mathrm{F}^\circ_{3\frac12}-g\,^4\mathrm{G}_{4\frac12}$
6253·37		1*h*	15987·0	$y\,^2\mathrm{F}^\circ_{3\frac12}-g\,^2\mathrm{G}_{3\frac12}$
6233·79		1*h*	16037·2	$y\,^2\mathrm{F}^\circ_{3\frac12}-g\,^4\mathrm{D}_{2\frac12}$
6223·66		4	16063·3	$y\,^2\mathrm{F}^\circ_{3\frac12}-g\,^4\mathrm{F}_{3\frac12}$
6221·11		2*h*(2)	16069·9	$6p\,^2\mathrm{P}^\circ_{1\frac12}-g\,^2\mathrm{S}_{\frac12}$
6165·7	K 1*h*		16214·3	$6p\,^2\mathrm{P}^\circ_{1\frac12}-g\,^4\mathrm{S}_{1\frac12}$
6127·73		1*h* ?	16314·8	$6p\,^2\mathrm{P}^\circ_{1\frac12}-g\,^2\mathrm{D}_{2\frac12}$
6032·33		2*h*	16572·8	$y\,^2\mathrm{D}^\circ_{1\frac12}-h\,^2\mathrm{P}_{1\frac12}$
5966·59		3*h*	16755·2	$y\,^2\mathrm{D}^\circ_{1\frac12}-h\,^2\mathrm{D}_{2\frac12}$
5934·75		1*h*	16845·3	$y\,^2\mathrm{D}^\circ_{1\frac12}-h\,^2\mathrm{F}_{2\frac12}$
5856·94		5*h*	17069·0	$z\,^2\mathrm{P}^\circ_{1\frac12}-e\,^4\mathrm{D}_{2\frac12}$
5851·1		2*h*(2)	17086·1	$y\,^2\mathrm{F}^\circ_{2\frac12}-h\,^2\mathrm{G}_{3\frac12}$
5831·26		1*h*	17144·2	$y\,^2\mathrm{F}^\circ_{2\frac12}-h\,^2\mathrm{P}_{1\frac12}$
5782·132	IBu	1500	17289·877	$m\,^2\mathrm{D}_{1\frac12}-4p\,^2\mathrm{P}^\circ_{\frac12}$
5769·75		0*h*(2)	17327·0	$y\,^2\mathrm{F}^\circ_{2\frac12}-h\,^2\mathrm{D}_{2\frac12}$
5732·325	Hz	75	17440·10	$z\,^2\mathrm{F}^\circ_{3\frac12}-e\,^4\mathrm{D}_{3\frac12}$
5727·96		5	17453·4	$y\,^2\mathrm{F}^\circ_{2\frac12}-h\,^2\mathrm{F}_{3\frac12}$
5700·240	IBu	1500	17538·268	$m\,^2\mathrm{D}^\circ_{1\frac12}-4p\,^2\mathrm{P}^\circ_{1\frac12}$
5646·5		2*h*(2)	17705·2	$z\,^2\mathrm{P}^\circ_{1\frac12}-e\,^4\mathrm{D}_{1\frac12}$
5629·2		1*h*(3)	17759·6	$5p\,^2\mathrm{P}^\circ-f\,^2\mathrm{D}_{2\frac12}$
5554·935	Hz	100	17997·03	$z\,^4\mathrm{D}^\circ_{2\frac12}-e\,^4\mathrm{D}_{3\frac12}$
5535·78		50	18059·3	$z\,^2\mathrm{D}^\circ_{2\frac12}-e\,^2\mathrm{D}_{2\frac12}$
5530·02		1*h* ?	18078·1	$6p\,^2\mathrm{P}^\circ_{\frac12}-g\,^4\mathrm{D}^\circ_{1\frac12}$
5463·138		150	18299·43	$z\,^2\mathrm{D}^\circ_{1\frac12}-e\,^4\mathrm{D}_{\frac12}$
5432·05		250*h*(2)	18404·2	$z\,^4\mathrm{D}^\circ_{1\frac12}-e\,^4\mathrm{D}_{2\frac12}$
5408·34		100*h*(2)	18484·8	$z\,^2\mathrm{D}^\circ_{1\frac12}-e\,^2\mathrm{D}_{2\frac12}$
5398·408		0*h*	18518·84	$y\,^2\mathrm{D}^\circ_{2\frac12}-i\,^2\mathrm{D}_{2\frac12}$
5391·62		450*h*(2)	18542·2	$z\,^4\mathrm{D}^\circ_{2\frac12}-e\,^4\mathrm{D}_{2\frac12}$
5378·16		0*h*	18588·6	$5p\,^2\mathrm{P}^\circ-f\,^2\mathrm{D}_{1\frac12}$
5376·867		5	18593·04	$z\,^2\mathrm{P}^\circ_{1\frac12}-e\,^4\mathrm{D}_{\frac12}$
5375·20		0*h*	18598·8	$4p\,^2\mathrm{P}^\circ_{1\frac12}-5p\,^2\mathrm{P}^\circ$
5371·28		0*h*	18612·4	$y\,^2\mathrm{D}^\circ_{2\frac12}-h\,^2\mathrm{P}_{1\frac12}$
5360·030	Hz	200	18651·44	$z\,^2\mathrm{P}^\circ_{1\frac12}-e\,^4\mathrm{D}_{\frac12}$
5357·33		3*h*(3)	18660·8	$z\,^2\mathrm{D}^\circ_{2\frac12}-e\,^2\mathrm{D}_{1\frac12}$
5354·95		250*h*(2)	18669·1	$z\,^4\mathrm{D}^\circ_{\frac12}-e\,^4\mathrm{D}_{1\frac12}$
5352·666	Hz	300	18677·10	$z\,^2\mathrm{F}^\circ_{2\frac12}-e\,^4\mathrm{D}_{3\frac12}$
5323·78		3*h*(2)	18778·4	$z\,^2\mathrm{P}^\circ_{1\frac12}-e\,^2\mathrm{D}_{2\frac12}$
5320·80		0*h*	18789·0	$y\,^2\mathrm{D}^\circ_{2\frac12}-h\,^2\mathrm{D}_{1\frac12}$
5304·17		0*h*	18847·9	$4p\,^2\mathrm{P}^\circ_{\frac12}-5p\,^2\mathrm{P}^\circ$
5292·517	IBu	1650	18889·360	$z\,^4\mathrm{D}^\circ_{3\frac12}-e\,^4\mathrm{D}_{3\frac12}$
5283·530		5	18921·49	$y\,^2\mathrm{D}^\circ_{2\frac12}-h\,^2\mathrm{F}_{3\frac12}$
5250·52		500*h*(2)	19040·4	$z\,^4\mathrm{D}^\circ_{1\frac12}-e\,^4\mathrm{D}_{1\frac12}$
5237·65		10*h*(3)	19087·2	$z\,^2\mathrm{D}^\circ_{1\frac12}-e\,^2\mathrm{D}_{1\frac12}$
5220·070	IBu	500	19151·515	$4p\,^2\mathrm{P}^\circ_{1\frac12}-4d\,^2\mathrm{D}_{1\frac12}$
5218·202	IBu	2500	19158·371	$4p\,^2\mathrm{P}^\circ_{1\frac12}-4d\,^2\mathrm{D}_{2\frac12}$
5212·780	Hz	140*h*	19178·30	$z\,^4\mathrm{D}^\circ_{2\frac12}-e\,^4\mathrm{D}_{1\frac12}$
5200·87		500*h*	19222·2	$z\,^2\mathrm{F}^\circ_{2\frac12}-e\,^4\mathrm{D}_{2\frac12}$
5175·60		1*h*(2)	19316·1	$y\,^2\mathrm{F}^\circ_{3\frac12}-h\,^2\mathrm{G}_{4\frac12}$
5158·36		50*h*(3)	19380·6	$z\,^2\mathrm{P}^\circ_{1\frac12}-e\,^2\mathrm{D}_{1\frac12}$
5153·235	IBu	2000	19399·897	$4p\,^2\mathrm{P}^\circ_{\frac12}-4d\,^2\mathrm{D}_{1\frac12}$
5144·120		550*h*	19434·27	$z\,^4\mathrm{D}^\circ_{3\frac12}-e\,^4\mathrm{D}_{2\frac12}$
5142·7		10*h*(3)	19439·6	$z\,^2\mathrm{P}^\circ_{\frac12}-e\,^2\mathrm{D}_{1\frac12}$
5115·49		10	19543·0	$y\,^2\mathrm{F}^\circ_{3\frac12}-h\,^2\mathrm{F}_{3\frac12}$

Table 3 (*cont.*)

I wave-length	II authority and intensity	III intensity	IV wave-number	V identification
5111·913	IBu	300	19556·714	$z\,^4D^\circ_{\frac{1}{2}}-e\,^4D_{\frac{1}{2}}$
5105·541	IBu	1500	19581·121	$m\,^2D_{2\frac{1}{2}}-4p\,^2P^\circ_{1\frac{1}{2}}$
5076·173	IBu	100h(2)	19694·40	$z\,^2F^\circ_{3\frac{1}{2}}-e\,^2D_{2\frac{1}{2}}$
5034·36		100h(2)	19858·0	$z\,^2F^\circ_{2\frac{1}{2}}-e\,^4D_{1\frac{1}{2}}$
5016·611	IBu	400	19928·236	$z\,^4D^\circ_{1\frac{1}{2}}-e\,^4D_{\frac{1}{2}}$
4936·69		0h(2)	20250·9	$z\,^4D^\circ_{2\frac{1}{2}}-e\,^2D_{2\frac{1}{2}}$
4866·10		75h(3)	20544·6	$z\,^2D^\circ_{2\frac{1}{2}}-f\,^2D_{2\frac{1}{2}}$
4842·290		25h	20645·63	$z\,^4F^\circ_{1\frac{1}{2}}-e\,^4D_{2\frac{1}{2}}$
4828·733		0	20703·60	
4797·042		20	20840·37	$z\,^4F^\circ_{2\frac{1}{2}}-e\,^4D_{3\frac{1}{2}}$
4794·00		150h(3)	20853·6	$z\,^4D^\circ_{2\frac{1}{2}}-e\,^2D_{1\frac{1}{2}}$
4776·22		20h(2)	20931·2	$z\,^2F^\circ_{2\frac{1}{2}}-e\,^2D_{2\frac{1}{2}}$
4767·49		75h(3)	20969·6	$z\,^2D^\circ_{1\frac{1}{2}}-f\,^2D_{2\frac{1}{2}}$
4704·594	IBu	450	21249·892	$z\,^4F^\circ_{3\frac{1}{2}}-e\,^4D_{3\frac{1}{2}}$
4701·71		10h(2)	21262·9	$z\,^2P^\circ_{1\frac{1}{2}}-f\,^2D_{2\frac{1}{2}}$
4697·490	M	350h(2)	21282·03	$z\,^4F^\circ_{1\frac{1}{2}}-e\,^4D_{1\frac{1}{2}}$
4677·340		3h	21373·71	$z\,^2D^\circ_{2\frac{1}{2}}-f\,^2D_{1\frac{1}{2}}$
4674·72		500h(2)	21385·7	$z\,^4F^\circ_{2\frac{1}{2}}-e\,^4D_{2\frac{1}{2}}$
4651·124	IBu	2000	21494·182	$z\,^4F^\circ_{4\frac{1}{2}}-e\,^4D_{3\frac{1}{2}}$
4642·58		150h(3)	21533·7	$z\,^2F^\circ_{2\frac{1}{2}}-e\,^2D_{1\frac{1}{2}}$
4586·97		1300h(2)	21794·8	$z\,^4F^\circ_{3\frac{1}{2}}-e\,^4D_{2\frac{1}{2}}$
4539·695	M	800h(2)	22021·76	$z\,^4F^\circ_{2\frac{1}{2}}-e\,^4D_{1\frac{1}{2}}$
4530·785	IBu	800	22065·063	$4p\,^2P^\circ_{1\frac{1}{2}}-6s\,^2S_{\frac{1}{2}}$
4525·112		40h	22092·73	$z\,^2P^\circ_{1\frac{1}{2}}-f\,^2D_{1\frac{1}{2}}$
4513·192		50h	22151·07	$z\,^2P^\circ_{\frac{1}{2}}-f\,^2D_{1\frac{1}{2}}$
4509·374	IBu	400	22169·828	$z\,^4F^\circ_{1\frac{1}{2}}-e\,^4D_{\frac{1}{2}}$
4507·35		200h(3)	22179·8	$z\,^2F^\circ_{3\frac{1}{2}}-f\,^2D_{2\frac{1}{2}}$
4480·350	IBu	500	22313·447	$4p\,^2P^\circ_{\frac{1}{2}}-6s\,^2S_{\frac{1}{2}}$
4423·81		0h(2)	22598·6	$z\,^4D^\circ_{1\frac{1}{2}}-f\,^2D_{2\frac{1}{2}}$
4415·54		200h(2)	22641·0	$z\,^4P^\circ_{\frac{1}{2}}-e\,^4D_{1\frac{1}{2}}$
4397·0		10h(3)	22736·4	$z\,^4D^\circ_{2\frac{1}{2}}-f\,^2D_{2\frac{1}{2}}$
4378·20	M	550h(2)	22834·0	$z\,^4P^\circ_{1\frac{1}{2}}-e\,^4D_{2\frac{1}{2}}$
4354·74		10h(3)	22957·0	$z\,^4F^\circ_{1\frac{1}{2}}-e\,^2D_{1\frac{1}{2}}$
4336·00	M	10h	23056·3	$z\,^4D^\circ_{\frac{1}{2}}-f\,^2D_{1\frac{1}{2}}$
4328·68	M	20h(2)	23095·3	$z\,^4F^\circ_{2\frac{1}{2}}-e\,^2D_{2\frac{1}{2}}$
4275·107	IBu	950	23384·668	$z\,^4P^\circ_{2\frac{1}{2}}-e\,^4D_{3\frac{1}{2}}$
4267·204		2h	23427·98	$z\,^4D^\circ_{1\frac{1}{2}}-f\,^2D_{1\frac{1}{2}}$
4259·401		150h(3)	23470·90	$z\,^4P^\circ_{1\frac{1}{2}}-e\,^4D_{1\frac{1}{2}}$
4253·390		20h(2)	23505·0	$z\,^2F^\circ_{3\frac{1}{2}}-e\,^2D_{2\frac{1}{2}}$
4248·956	IBu	150	23528·593	$z\,^4P^\circ_{\frac{1}{2}}-e\,^4D_{\frac{1}{2}}$
4242·26	M	30h	23565·7	$z\,^4D^\circ_{2\frac{1}{2}}-f\,^2D_{1\frac{1}{2}}$
4230·9		5h(3)	23629·0	$z\,^4D^\circ_{3\frac{1}{2}}-f\,^2D_{2\frac{1}{2}}$
4218·8		2h(3)	23696·8	$z\,^4F^\circ_{2\frac{1}{2}}-e\,^2D_{1\frac{1}{2}}$
4177·758		100h(2)	23929·56	$z\,^4P^\circ_{2\frac{1}{2}}-e\,^4D_{2\frac{1}{2}}$
4165·8		0h(3)	23998·3	
4123·287	M	30h	24245·68	$z\,^2F^\circ_{2\frac{1}{2}}-f\,^2D_{1\frac{1}{2}}$
4121·74	M	10	24254·8	$z\,^2D^\circ_{2\frac{1}{2}}-g\,^2P_{1\frac{1}{2}}$
4111·4		3h(3)	24317·8	$z\,^4P^\circ_{\frac{1}{2}}-e\,^2D_{1\frac{1}{2}}$
4104·218	IBu	25	24358·328	$z\,^4P^\circ_{1\frac{1}{2}}-e\,^4D_{\frac{1}{2}}$
4097·215		0h	24399·96	$z\,^2D^\circ_{2\frac{1}{2}}-g\,^4S_{1\frac{1}{2}}$
4080·534		15h	24499·70	$z\,^2D^\circ_{2\frac{1}{2}}-g\,^2D_{2\frac{1}{2}}$
4075·572	IBu	50	24529·534	$z\,^2D^\circ_{2\frac{1}{2}}-g\,^2F_{3\frac{1}{2}}$
4073·224		20h(3)	24543·67	$z\,^4P^\circ_{1\frac{1}{2}}-e\,^2D_{2\frac{1}{2}}$
4070·814		2h(2)	24558·20	
4069·53		6h(2)	24565·9	$z\,^4P^\circ_{2\frac{1}{2}}-e\,^4D_{1\frac{1}{2}}$
4063·238	IBu	650	24603·990	$4p\,^2P^\circ_{1\frac{1}{2}}-5d\,^2D_{1\frac{1}{2}}$
4062·641	IBu	2000	24607·606	$4p\,^2P^\circ_{1\frac{1}{2}}-5d\,^2D_{2\frac{1}{2}}$
4056·78	S	{ 35h(3)	24643·2	$4p\,^2P^\circ_{1\frac{1}{2}}-4f\,^2F^\circ_{3\frac{1}{2}}$
4056·38	S		24645·6	$4p\,^2P^\circ_{1\frac{1}{2}}-4f\,^2F^\circ_{2\frac{1}{2}}$
4052·380		2	24669·91	$z\,^2D^\circ_{2\frac{1}{2}}-g\,^4D_{3\frac{1}{2}}$

TABLE 3 (*cont.*)

I wave-length	II authority and intensity	III intensity	IV wave-number	V identification
4050·617		20*h*	24680·65	$z\,{}^2D^\circ_{1\frac{1}{2}}-g\,{}^2P_{1\frac{1}{2}}$
4027·026		10	24825·23	$z\,{}^2D^\circ_{1\frac{1}{2}}-g\,{}^4S_{1\frac{1}{2}}$
4022·629	IBu	1250	24852·366	$4p\,{}^2P^\circ_{\frac{1}{2}}-5d\,{}^2D_{1\frac{1}{2}}$
4015·8		10*h*(3)	24894·6	$4p\,{}^2P^\circ_{\frac{1}{2}}-4f\,{}^2F^\circ_{2\frac{1}{2}}$
4010·836		8*h*	24925·44	$z\,{}^2D^\circ_{1\frac{1}{2}}-g\,{}^2D_{2\frac{1}{2}}$
4010·043		0 ?	24930·36	$5p\,{}^2P^\circ-i\,{}^4D_{2\frac{1}{2}}$
4003·028		15	24974·06	$z\,{}^2P^\circ_{1\frac{1}{2}}-g\,{}^2P_{1\frac{1}{2}}$
3998·018		3	25005·35	$z\,{}^2D^\circ_{1\frac{1}{2}}-g\,{}^4P_{2\frac{1}{2}}$
3993·692		0 ?	25032·43	$z\,{}^2P^\circ_{\frac{1}{2}}-g\,{}^2P_{1\frac{1}{2}}$
3979·954		5	25118·84	$z\,{}^2P^\circ_{1\frac{1}{2}}-g\,{}^4S_{1\frac{1}{2}}$
3975·7		5*h*(3)	25145·7	$z\,{}^4P^\circ_{1\frac{1}{2}}-e\,{}^2D_{1\frac{1}{2}}$
3964·16		5*h*	25218·9	$z\,{}^2P^\circ_{1\frac{1}{2}}-g\,{}^2D_{2\frac{1}{2}}$
3951·616		2	25298·97	$z\,{}^2P^\circ_{1\frac{1}{2}}-g\,{}^4P_{2\frac{1}{2}}$
3946·938		3	25328·95	$z\,{}^2D^\circ_{2\frac{1}{2}}-g\,{}^4P_{1\frac{1}{2}}$
3933·027		5	25418·54	$z\,{}^2D^\circ_{2\frac{1}{2}}-g\,{}^2G_{3\frac{1}{2}}$
3925·274	M	8	25468·74	$z\,{}^2D^\circ_{2\frac{1}{2}}-g\,{}^4D_{2\frac{1}{2}}$
3921·267	M	5	25494·77	$z\,{}^2D^\circ_{2\frac{1}{2}}-g\,{}^4F_{3\frac{1}{2}}$
3912·335		1*h*	25552·97	$z\,{}^2D^\circ_{2\frac{1}{2}}-g\,{}^2F_{2\frac{1}{2}}$
3911·419		0*h*	25558·96	
3899·22		8*h*(2)	25638·9	$z\,{}^4P^\circ_{2\frac{1}{2}}-e\,{}^2D_{2\frac{1}{2}}$
3888·40		4*h*	25710·3	$z\,{}^2D^\circ_{1\frac{1}{2}}-g\,{}^4P_{\frac{1}{2}}$
3885·92		3*h*	25726·7	$5p\,{}^2P^\circ-h\,{}^2P_{\frac{1}{2}}$
3881·714		5	25754·54	$z\,{}^2D^\circ_{1\frac{1}{2}}-g\,{}^4P_{1\frac{1}{2}}$
3862·781		5*h*	25880·77	$5p\,{}^2P^\circ-h\,{}^2P_{1\frac{1}{2}}$
3861·747	IBu	250	25887·70	$4p\,{}^2P^\circ_{1\frac{1}{2}}-7s\,{}^2S_{\frac{1}{2}}$
3860·898		5	25894·00	$z\,{}^2D^\circ_{1\frac{1}{2}}-g\,{}^4D_{2\frac{1}{2}}$
3860·472	Hz	600	25896·25	$z\,{}^2F^\circ_{3\frac{1}{2}}-g\,{}^2G_{4\frac{1}{2}}$
3848·256		0*h*	25978·45	$z\,{}^2D^\circ_{1\frac{1}{2}}-g\,{}^2F_{2\frac{1}{2}}$
3844·51		4*h*	26003·8	$z\,{}^2P^\circ_{1\frac{1}{2}}-g\,{}^4P_{\frac{1}{2}}$
3837·976		5	26048·04	$z\,{}^2P^\circ_{1\frac{1}{2}}-g\,{}^4P_{1\frac{1}{2}}$
3836·70		0*h*(2)	26056·7	$5p\,{}^2P^\circ-h\,{}^2D_{1\frac{1}{2}}$
3835·74		0*h*(2)	26063·2	$5p\,{}^2P^\circ-h\,{}^2D_{2\frac{1}{2}}$
3825·047	IBu	100*h*	26136·08	$4p\,{}^2P^\circ_{\frac{1}{2}}-7s\,{}^2S_{\frac{1}{2}}$
3822·48		0*h*(3)	26153·6	$5p\,{}^2P^\circ-h\,{}^2F_{2\frac{1}{2}}$
3820·884	M	60	26164·56	$z\,{}^2F^\circ_{3\frac{1}{2}}-g\,{}^2F_{3\frac{1}{2}}$
3817·490		5	26187·82	$z\,{}^2P^\circ_{1\frac{1}{2}}-g\,{}^4D_{2\frac{1}{2}}$
3813·542	M	10	26214·93	$z\,{}^2F^\circ_{3\frac{1}{2}}-g\,{}^4P_{2\frac{1}{2}}$
3811·95		8*h*(2)	26225·9	$z\,{}^2P^\circ_{1\frac{1}{2}}-g\,{}^2D_{1\frac{1}{2}}$
3805·232		100*h*	26272·18	$z\,{}^2P^\circ_{1\frac{1}{2}}-g\,{}^2P_{\frac{1}{2}}$
3803·49		5*h*(2)	26284·2	$z\,{}^2P^\circ_{\frac{1}{2}}-g\,{}^2D_{1\frac{1}{2}}$
3803·07		0*h*	26287·1	$6p\,{}^2P^\circ_{\frac{1}{2}}-o\,{}^2D_{1\frac{1}{2}}$
3800·502	M	30*h*	26304·87	$z\,{}^2F^\circ_{3\frac{1}{2}}-g\,{}^4D_{3\frac{1}{2}}$
3799·88		10*h*	26309·1	$z\,{}^4D^\circ_{1\frac{1}{2}}-g\,{}^2P_{1\frac{1}{2}}$
3797·245		8	26327·44	$z\,{}^2F^\circ_{3\frac{1}{2}}-g\,{}^4F_{4\frac{1}{2}}$
3785·49		5*h*	26409·2	$z\,{}^4F^\circ_{2\frac{1}{2}}-f\,{}^2D_{1\frac{1}{2}}$
3780·045		5*h*	26447·23	$z\,{}^4D^\circ_{2\frac{1}{2}}-g\,{}^2P_{1\frac{1}{2}}$
3779·067		2*h*	26454·07	$z\,{}^4D^\circ_{1\frac{1}{2}}-g\,{}^4S_{1\frac{1}{2}}$
3771·904	M	100*h*	26504·31	$z\,{}^2D^\circ_{2\frac{1}{2}}-g\,{}^4G_{3\frac{1}{2}}$
3764·837	M	5*h*	26554·06	$z\,{}^4D^\circ_{1\frac{1}{2}}-g\,{}^2D_{2\frac{1}{2}}$
3759·492	M	60	26591·81	$z\,{}^4D^\circ_{2\frac{1}{2}}-g\,{}^4S_{1\frac{1}{2}}$
3758·296		5	26600·26	$z\,{}^2D^\circ_{2\frac{1}{2}}-g\,{}^4G_{2\frac{1}{2}}$
3753·519		8	26634·12	$z\,{}^4D^\circ_{1\frac{1}{2}}-g\,{}^4P_{2\frac{1}{2}}$
3745·356		20*h*	26692·17	$z\,{}^4D^\circ_{2\frac{1}{2}}-g\,{}^2D_{2\frac{1}{2}}$
3743·363	M	3*h*	26706·48	$z\,{}^2D^\circ_{2\frac{1}{2}}-g\,{}^4F_{2\frac{1}{2}}$
3741·242	M	450*h*	26721·52	$z\,{}^4D^\circ_{2\frac{1}{2}}-g\,{}^2F_{3\frac{1}{2}}$
3734·180		200*h*	26772·06	$z\,{}^4D^\circ_{2\frac{1}{2}}-g\,{}^4P_{2\frac{1}{2}}$
3721·666		8*h*	26862·08	$z\,{}^4D^\circ_{2\frac{1}{2}}-g\,{}^4D_{3\frac{1}{2}}$
3720·771	M	150	26868·54	$m\,{}^2D_{1\frac{1}{2}}-z\,{}^4P^\circ_{1\frac{1}{2}}$
3712·009	M	30*h*	26931·96	$z\,{}^2D^\circ_{1\frac{1}{2}}-g\,{}^4D_{1\frac{1}{2}}$
3707·12		4*h*(2)	26967·5	$z\,{}^4D^\circ_{\frac{1}{2}}-g\,{}^4P_{\frac{1}{2}}$

TABLE 3 (*cont.*)

I wave-length	II authority and intensity	III intensity	IV wave-number	V identification
3701·070		5*h*	27011·56	$z\,{}^4D^{\circ}_{\frac{1}{2}}-g\,{}^4P_{1\frac{1}{2}}$
3700·536	M	250*h*	27015·45	$z\,{}^2F^{\circ}_{3\frac{1}{2}}-g\,{}^4G_{4\frac{1}{2}}$
3699·097		10*h*	27025·96	$z\,{}^2D^{\circ}_{1\frac{1}{2}}-g\,{}^4G_{2\frac{1}{2}}$
3695·358	M	8*h*	27053·30	$z\,{}^2F^{\circ}_{3\frac{1}{2}}-g\,{}^2G_{3\frac{1}{2}}$
3687·708		S.T. 40	27109·43	$4p\,{}^2P^{\circ}_{1\frac{1}{2}}-6d\,{}^2D_{1\frac{1}{2}}$
3687·438		S.T. 400	27111·41	$4p\,{}^2P^{\circ}_{1\frac{1}{2}}-6d\,{}^2D_{2\frac{1}{2}}$
3684·930	M	200	27129·86	$z\,{}^2F^{\circ}_{3\frac{1}{2}}-g\,{}^4F_{3\frac{1}{2}}$
3684·672	M	450	27131·76	$z\,{}^2D^{\circ}_{1\frac{1}{2}}-g\,{}^4F_{2\frac{1}{2}}$
3683·000		1*h*	27144·08	$z\,{}^2D^{\circ}_{1\frac{1}{2}}-g\,{}^4F_{1\frac{1}{2}}$
3676·878	M	50*h*(2)	27189·27	$z\,{}^4D^{\circ}_{\frac{1}{2}}-g\,{}^2D_{1\frac{1}{2}}$
3671·953	M	100*h*	27225·74	$z\,{}^2P^{\circ}_{1\frac{1}{2}}-g\,{}^4D_{1\frac{1}{2}}$
3665·735	M	125*h*	27271·92	$z\,{}^2F^{\circ}_{2\frac{1}{2}}-g\,{}^4S_{1\frac{1}{2}}$
3664·08		5*h*	27284·2	$z\,{}^2P^{\circ}_{\frac{1}{2}}-g\,{}^4D_{1\frac{1}{2}}$
3659·353	M	125*h*	27319·48	$z\,{}^2P^{\circ}_{1\frac{1}{2}}-g\,{}^4G_{2\frac{1}{2}}$
3656·785	M	125*h*	27338·67	$z\,{}^4D^{\circ}_{1\frac{1}{2}}-g\,{}^4P_{\frac{1}{2}}$
3655·859	M	600*h*	27345·59	$z\,{}^4D^{\circ}_{3\frac{1}{2}}-g\,{}^2G_{4\frac{1}{2}}$
3654·243	Hz	200	27357·68	$4p\,{}^2P^{\circ}_{\frac{1}{2}}-6d\,{}^2D_{1\frac{1}{2}}$
3652·34		100*h*	27371·9	$z\,{}^2F^{\circ}_{2\frac{1}{2}}-g\,{}^2D_{2\frac{1}{2}}$
3650·855	M	5	27383·07	$z\,{}^4D^{\circ}_{1\frac{1}{2}}-g\,{}^4P_{1\frac{1}{2}}$
3648·383	M	125	27401·63	$z\,{}^2F^{\circ}_{2\frac{1}{2}}-g\,{}^2F_{3\frac{1}{2}}$
3645·232	M	250	27425·31	$z\,{}^2P^{\circ}_{1\frac{1}{2}}-g\,{}^4F_{2\frac{1}{2}}$
3643·632		5	27437·35	$z\,{}^2P^{\circ}_{1\frac{1}{2}}-g\,{}^4F_{1\frac{1}{2}}$
3643·182		0	27440·75	
3641·693	M	50	27451·95	$z\,{}^2F^{\circ}_{2\frac{1}{2}}-g\,{}^4P_{2\frac{1}{2}}$
3635·916	M	250	27495·58	$z\,{}^2P^{\circ}_{\frac{1}{2}}-g\,{}^4F_{1\frac{1}{2}}$
3632·558	M	50	27521·00	$z\,{}^4D^{\circ}_{2\frac{1}{2}}-g\,{}^4P_{1\frac{1}{2}}$
3632·308		5	27522·89	$z\,{}^4D^{\circ}_{1\frac{1}{2}}-g\,{}^4D_{2\frac{1}{2}}$
3629·771		10	27542·13	$z\,{}^2F^{\circ}_{2\frac{1}{2}}-g\,{}^4D_{3\frac{1}{2}}$
3627·32		125*h*(2)	27560·7	$z\,{}^4D^{\circ}_{1\frac{1}{2}}-g\,{}^2D_{1\frac{1}{2}}$
3624·236		100	27584·19	$z\,{}^4D^{\circ}_{3\frac{1}{2}}-g\,{}^2D_{2\frac{1}{2}}$
3621·245	M	600	27606·97	$z\,{}^4D^{\circ}_{1\frac{1}{2}}-g\,{}^2F_{2\frac{1}{2}}$
3620·352	M	225	27613·78	$z\,{}^4D^{\circ}_{3\frac{1}{2}}-g\,{}^2F_{3\frac{1}{2}}$
3614·218	M	200	27660·64	$z\,{}^4D^{\circ}_{2\frac{1}{2}}-g\,{}^4D_{2\frac{1}{2}}$
3613·761	M	600	27664·14	$z\,{}^4D^{\circ}_{3\frac{1}{2}}-g\,{}^4P_{2\frac{1}{2}}$
3610·809	M	200	27686·76	$z\,{}^4D^{\circ}_{2\frac{1}{2}}-g\,{}^4F_{3\frac{1}{2}}$
3609·295	IBu	200	27698·37	$m\,{}^2D_{1\frac{1}{2}}-z\,{}^4P^{\circ}_{\frac{1}{2}}$
3607·20		0*h*	27714·5	$z\,{}^2D^{\circ}_{2\frac{1}{2}}-i\,{}^4D_{2\frac{1}{2}}$
3602·032	IBu	1400	27754·22	$z\,{}^4D^{\circ}_{3\frac{1}{2}}-g\,{}^4D_{3\frac{1}{2}}$
3599·132	IBu	1400	27776·58	$z\,{}^4D^{\circ}_{3\frac{1}{2}}-g\,{}^4F_{4\frac{1}{2}}$
3598·011	IBu	10*h*	27785·24	$4p\,{}^2P^{\circ}_{1\frac{1}{2}}-8s\,{}^2S_{\frac{1}{2}}$
3594·023	M	30	27816·08	$m\,{}^2D_{2\frac{1}{2}}-z\,{}^4P^{\circ}_{2\frac{1}{2}}$
3566·131		5*h*(2)	28033·62	$4p\,{}^2P^{\circ}_{\frac{1}{2}}-8s\,{}^2S_{\frac{1}{2}}$
3552·695		0*h*	28139·64	$z\,{}^2F^{\circ}_{3\frac{1}{2}}-g\,{}^4G_{3\frac{1}{2}}$ $z\,{}^2D^{\circ}_{1\frac{1}{2}}-i\,{}^4D_{2\frac{1}{2}}$
3546·433		15*h*	28189·32	$z\,{}^4D^{\circ}_{\frac{1}{2}}-g\,{}^4D_{1\frac{1}{2}}$
3544·963	M	125*h*	28201·01	$z\,{}^2F^{\circ}_{2\frac{1}{2}}-g\,{}^4P_{1\frac{1}{2}}$
3533·746	M	500	28290·53	$z\,{}^2F^{\circ}_{2\frac{1}{2}}-g\,{}^2G_{3\frac{1}{2}}$
3530·383	IBu	2000	28317·474	$m\,{}^2D_{1\frac{1}{2}}-z\,{}^4F^{\circ}_{2\frac{1}{2}}$
3527·482	M	500	28340·76	$z\,{}^2F^{\circ}_{2\frac{1}{2}}-g\,{}^4D_{2\frac{1}{2}}$
3524·231	IBu	1250	28366·90	$z\,{}^2F^{\circ}_{2\frac{1}{2}}-g\,{}^4F_{3\frac{1}{2}}$
3520·031	M	500	28400·75	$z\,{}^4D^{\circ}_{\frac{1}{2}}-g\,{}^4F_{1\frac{1}{2}}$
3517·039	M	100*h*	28424·91	$z\,{}^2F^{\circ}_{2\frac{1}{2}}-g\,{}^2F_{2\frac{1}{2}}$
3512·121	M	650*h*	28464·71	$z\,{}^4D^{\circ}_{3\frac{1}{2}}-g\,{}^4G_{4\frac{1}{2}}$
3511·985		S.T. 10	28465·81	$4p\,{}^2P^{\circ}_{1\frac{1}{2}}-7d\,{}^2D_{1\frac{1}{2}}$
3511·835		S.T. 50	28467·03	$4p\,{}^2P^{\circ}_{1\frac{1}{2}}-7d\,{}^2D_{2\frac{1}{2}}$
3507·407		5*h*	28502·97	$z\,{}^4D^{\circ}_{3\frac{1}{2}}-g\,{}^2G_{3\frac{1}{2}}$
3505·058		0*h*	28522·07	$5p\,{}^2P^{\circ}-j\,{}^4D_{2\frac{1}{2}}$
3501·529	M	3*h*	28550·81	$z\,{}^4F^{\circ}_{1\frac{1}{2}}-g\,{}^2P_{1\frac{1}{2}}$
3501·251		5*h*	28553·08	$z\,{}^4D^{\circ}_{3\frac{1}{2}}-g\,{}^4D_{2\frac{1}{2}}$
3500·324	M	50*h*	28560·64	$z\,{}^4D^{\circ}_{1\frac{1}{2}}-g\,{}^4D_{1\frac{1}{2}}$

TABLE 3 (*cont.*)

I wave-length	II authority and intensity	III intensity	IV wave-number	V identification
3498·938		3*h*	28571·96	$z\,^{2}D^{\circ}_{2\frac{1}{2}}-i\,^{2}D_{2\frac{1}{2}}$
3498·063	M	125*h*	28579·10	$z\,^{4}D^{\circ}_{3\frac{1}{2}}-g\,^{4}F_{3\frac{1}{2}}$
3494·50		1*h*(3)	28608·2	$z\,^{2}D^{\circ}_{2\frac{1}{2}}-h\,^{2}G_{3\frac{1}{2}}$
3490·958		1*h*	28637·27	$z\,^{4}D^{\circ}_{3\frac{1}{2}}-g\,^{2}F_{2\frac{1}{2}}$
3488·858	M	100*h*	28654·50	$z\,^{4}D^{\circ}_{1\frac{1}{2}}-g\,^{4}G_{2\frac{1}{2}}$
3487·566	M	60*h*	28665·12	$z\,^{2}D^{\circ}_{2\frac{1}{2}}-h\,^{2}P_{1\frac{1}{2}}$
3483·761	M	1250*h*	28696·43	$z\,^{4}D^{\circ}_{2\frac{1}{2}}-g\,^{4}G_{3\frac{1}{2}}$
3481·614		S.T. 5	28714·12	$4p\,^{2}P^{\circ}_{\frac{1}{2}}-7d\,^{2}D_{1\frac{1}{2}}$
3475·999	M	750*h*	28760·50	$z\,^{4}D^{\circ}_{1\frac{1}{2}}-g\,^{4}F_{2\frac{1}{2}}$
3474·578	M	5	28772·26	$z\,^{4}D^{\circ}_{1\frac{1}{2}}-g\,^{4}F_{1\frac{1}{2}}$
3472·141	M	200*h*	28792·46	$z\,^{4}D^{\circ}_{2\frac{1}{2}}-g\,^{4}G_{2\frac{1}{2}}$
3471·748		2*h*	28795·72	$z\,^{4}F^{\circ}_{1\frac{1}{2}}-g\,^{2}D_{2\frac{1}{2}}$
3466·24		25*h*(2)	28841·5	$z\,^{2}D^{\circ}_{2\frac{1}{2}}-h\,^{2}D_{1\frac{1}{2}}$
3465·401	M	50*h*(2)	28848·5	$z\,^{2}D^{\circ}_{2\frac{1}{2}}-h\,^{2}D_{2\frac{1}{2}}$
3463·499	M	5*h*(2)	28864·3	$4p\,^{2}P^{\circ}_{1\frac{1}{2}}-9s\,^{2}S_{\frac{1}{2}}$
3462·137		1*h*	28875·66	$z\,^{4}F^{\circ}_{1\frac{1}{2}}-g\,^{4}P_{2\frac{1}{2}}$
3459·428	M	25*h*	28898·27	$z\,^{4}D^{\circ}_{2\frac{1}{2}}-g\,^{4}F_{2\frac{1}{2}}$
3457·850	IBu	750	28911·45	$m\,^{2}D_{2\frac{1}{2}}-z\,^{4}P^{\circ}_{1\frac{1}{2}}$
3454·686	M	200*h*(2)	28937·94	$z\,^{2}D^{\circ}_{2\frac{1}{2}}-h\,^{2}F_{2\frac{1}{2}}$
3450·332	M	750	28974·45	$z\,^{2}D^{\circ}_{2\frac{1}{2}}-h\,^{2}F_{3\frac{1}{2}}$
3447·590		3*h*	28997·49	$z\,^{2}D^{\circ}_{1\frac{1}{2}}-i\,^{2}D_{2\frac{1}{2}}$
3440·507	IBu	250	29057·19	$m\,^{2}D_{1\frac{1}{2}}-z\,^{4}F^{\circ}_{1\frac{1}{2}}$
3436·543	M	5*h*	29090·69	$z\,^{2}D^{\circ}_{1\frac{1}{2}}-h\,^{2}P_{1\frac{1}{2}}$
3433·972	M	3*h*	29112·48	$4p\,^{2}P^{\circ}_{\frac{1}{2}}-9s\,^{2}S_{\frac{1}{2}}$
3427·87		1*h*(2)	29164·3	$z\,^{2}P^{\circ}_{1\frac{1}{2}}-i\,^{4}D_{1\frac{1}{2}}$
3422·10		15*h*(2)	29213·5	$z\,^{2}D^{\circ}_{1\frac{1}{2}}-h\,^{2}S_{\frac{1}{2}}$
3420·166	M	8*h*	29230·00	$z\,^{2}P^{\circ}_{1\frac{1}{2}}-h\,^{2}P_{\frac{1}{2}}$
3415·80		200*h*(3)	29267·4	$z\,^{2}D^{\circ}_{1\frac{1}{2}}-h\,^{2}D_{1\frac{1}{2}}$
3414·017		S.T. 5	29282·64	$4p\,^{2}P^{\circ}_{1\frac{1}{2}}-8d\,^{2}D_{2\frac{1}{2}}$
3413·343	M	200*h*	29288·42	$z\,^{2}P^{\circ}_{\frac{1}{2}}-h\,^{2}P_{\frac{1}{2}}$
3413·107		10*h*	29290·44	$z\,^{4}F^{\circ}_{2\frac{1}{2}}-g\,^{2}P_{1\frac{1}{2}}$
3404·66		125*h*(2)	29363·1	$z\,^{2}D^{\circ}_{1\frac{1}{2}}-h\,^{2}F_{2\frac{1}{2}}$
3403·107		5	29376·51	$z\,^{2}F^{\circ}_{2\frac{1}{2}}-g\,^{4}G_{3\frac{1}{2}}$
3402·244	M	225*h*	29383·96	$z\,^{2}P^{\circ}_{1\frac{1}{2}}-h\,^{2}P_{1\frac{1}{2}}$
3396·324	M	10*h*	29435·18	$z\,^{4}F^{\circ}_{2\frac{1}{2}}-g\,^{4}S_{1\frac{1}{2}}$
3395·476	M	60*h*	29442·53	$z\,^{2}P^{\circ}_{\frac{1}{2}}-h\,^{2}P_{1\frac{1}{2}}$
3392·016	M	8*h*	29472·56	$z\,^{2}F^{\circ}_{2\frac{1}{2}}-g\,^{4}G_{2\frac{1}{2}}$
3388·07		8*h*(3)	29506·9	$z\,^{2}P^{\circ}_{1\frac{1}{2}}-h\,^{2}S_{\frac{1}{2}}$
3385·394		S.T. 2	29530·21	$4p\,^{2}P^{\circ}_{\frac{1}{2}}-8d\,^{2}D_{1\frac{1}{2}}$
3384·80		15*h*	29535·4	$z\,^{4}F^{\circ}_{2\frac{1}{2}}-g\,^{2}D_{2\frac{1}{2}}$
3381·421	M	200*h*	29564·91	$z\,^{4}F^{\circ}_{2\frac{1}{2}}-g\,^{2}F_{3\frac{1}{2}}$
3381·124	M	60*h*(2)	29567·50	$z\,^{2}P^{\circ}_{1\frac{1}{2}}-h\,^{2}D_{2\frac{1}{2}}$
3379·864		3	29578·53	$z\,^{2}F^{\circ}_{2\frac{1}{2}}-g\,^{4}F_{2\frac{1}{2}}$
3379·653		5*h*	29580·37	$z\,^{4}F^{\circ}_{1\frac{1}{2}}-g\,^{4}P_{\frac{1}{2}}$
3378·707		2	29588·65	$z\,^{4}D^{\circ}_{3\frac{1}{2}}-g\,^{4}G_{3\frac{1}{2}}$
				$z\,^{4}D^{\circ}_{2\frac{1}{2}}-i\,^{4}D_{3\frac{1}{2}}$
3375·672		30*h*	29615·26	$z\,^{4}F^{\circ}_{2\frac{1}{2}}-g\,^{4}P_{2\frac{1}{2}}$
3375·18		8*h*(2)	29619·6	$z\,^{2}P^{\circ}_{\frac{1}{2}}-h\,^{2}D_{1\frac{1}{2}}$
3365·342	IBu	750*h*	29706·16	$z\,^{4}F^{\circ}_{3\frac{1}{2}}-g\,^{2}G_{4\frac{1}{2}}$
3362·12		2*h*	29734·6	$z\,^{2}D^{\circ}_{2\frac{1}{2}}-i\,^{2}D_{1\frac{1}{2}}$
3358·74		2*h*	29764·6	$z\,^{4}F^{\circ}_{1\frac{1}{2}}-g\,^{4}D_{2\frac{1}{2}}$
3358·27		2*h*	29768·7	$z\,^{4}D^{\circ}_{1\frac{1}{2}}-i\,^{4}D_{2\frac{1}{2}}$
3354·474	M	60*h*(2)	29802·40	$z\,^{4}F^{\circ}_{1\frac{1}{2}}-g\,^{2}D_{1\frac{1}{2}}$
3353·466		S.T. 10	29811·36	$4p\,^{2}P^{\circ}_{1\frac{1}{2}}-9d\,^{2}D_{2\frac{1}{2}}$
3349·279		450*h*	29848·62	$z\,^{4}F^{\circ}_{1\frac{1}{2}}-g\,^{2}F_{2\frac{1}{2}}$
3342·77		5*h*	29906·7	$z\,^{4}D^{\circ}_{2\frac{1}{2}}-i\,^{4}D_{2\frac{1}{2}}$
3342·454		5*h*	29909·57	$z\,^{4}P^{\circ}_{\frac{1}{2}}-g\,^{2}P_{1\frac{1}{2}}$
3337·845	IBu	1500	29950·868	$m\,^{2}D_{2\frac{1}{2}}-z\,^{4}F^{\circ}_{3\frac{1}{2}}$
3335·215	IBu	400	29974·48	$z\,^{4}F^{\circ}_{3\frac{1}{2}}-g\,^{2}F_{3\frac{1}{2}}$
3329·636	M	225	30024·71	$z\,^{4}F^{\circ}_{3\frac{1}{2}}-g\,^{4}P_{2\frac{1}{2}}$

TABLE 3 (*cont.*)

I wave-length	II authority and intensity	III intensity	IV wave-number	V identification
3325·328		3	30054·57	$z\,^4P^\circ_{\frac{1}{2}}-g\,^4S_{1\frac{1}{2}}$
3325·812		S.T. 3	30059·23	$4p\,^2P^\circ_{\frac{1}{2}}-9d\,^2D_{1\frac{1}{2}}$
3319·682	IBu	150	30114·73	$z\,^4F^\circ_{3\frac{1}{2}}-g\,^4D_{3\frac{1}{2}}$
3317·218	IBu	750	30137·10	$z\,^4F^\circ_{3\frac{1}{2}}-g\,^4F_{4\frac{1}{2}}$
3314·82		1	30158·8	$z\,^2D^\circ_{1\frac{1}{2}}-i\,^2D_{1\frac{1}{2}}$
3313·199		0*h*	30173·66	$4p\,^2P^\circ_{1\frac{1}{2}}-10d\,^2D_{2\frac{1}{2}}$
3310·987		8	30193·83	$z\,^4D^\circ_{\frac{1}{2}}-h\,^2P_{\frac{1}{2}}$
3309·558		4	30206·85	$z\,^2F^\circ_{3\frac{1}{2}}-i\,^2D_{2\frac{1}{2}}$
3307·948	IBu	2500*h*	30221·552	$z\,^4F^\circ_{4\frac{1}{2}}-g\,^4G_{5\frac{1}{2}}$
3305·530		4	30243·66	$z\,^2P^\circ_{\frac{1}{2}}-i\,^4D_{\frac{1}{2}}$
3302·787		4	30268·78	$z\,^2F^\circ_{2\frac{1}{2}}-i\,^4D_{3\frac{1}{2}}$
3297·093		0*h*	30321·07	
3294·168		5*h*	30347·97	$z\,^4D^\circ_{\frac{1}{2}}-h\,^2P_{1\frac{1}{2}}$
3293·815		2*h*	30351·22	$z\,^2D^\circ_{2\frac{1}{2}}-j\,^2D_{2\frac{1}{2}}$
3292·965		450*h*	30359·06	$z\,^4F^\circ_{4\frac{1}{2}}-g\,^4D_{3\frac{1}{2}}$
3292·827	IBu	650	30360·33	$m\,^2D_{2\frac{1}{2}}-z\,^4F^\circ_{2\frac{1}{2}}$
3292·393	M	125*h*	30364·33	$z\,^4F^\circ_{2\frac{1}{2}}-g\,^4P_{1\frac{1}{2}}$
3290·541	IBu	1500*h*	30381·42	$z\,^4F^\circ_{4\frac{1}{2}}-g\,^4F_{4\frac{1}{2}}$
3286·193		S.T. 2	30421·62	$4p\,^2P^\circ_{\frac{1}{2}}-10d\,^2D_{1\frac{1}{2}}$
3285·017		S.T. 1	30432·50	$4p\,^2P^\circ_{1\frac{1}{2}}-11d\,^2D_{2\frac{1}{2}}$
3282·716	M	1400*h*	30453·84	$z\,^4F^\circ_{2\frac{1}{2}}-g\,^2G_{3\frac{1}{2}}$
3279·815	IBu	2000	30480·772	$m\,^2D_{1\frac{1}{2}}-z\,^2F^\circ_{2\frac{1}{2}}$
3277·310	M	650	30504·07	$z\,^4F^\circ_{2\frac{1}{2}}-g\,^4D_{2\frac{1}{2}}$
3273·957	IBu	10000R	30535·305	$4s\,^2S_{\frac{1}{2}}-4p\,^2P^\circ_{\frac{1}{2}}$
3268·278	M	650*h*	30588·36	$z\,^4F^\circ_{2\frac{1}{2}}-g\,^2F_{2\frac{1}{2}}$
3266·023	M	650*h*	30609·49	$z\,^2F^\circ_{3\frac{1}{2}}-h\,^2F_{3\frac{1}{2}}$
3252·220	M	650	30739·39	$z\,^4P^\circ_{1\frac{1}{2}}-g\,^2P_{1\frac{1}{2}}$
3247·540	IBu	10000R	30783·684	$4s\,^2S_{\frac{1}{2}}-4p\,^2P^\circ_{1\frac{1}{2}}$
3243·164	M	1500*h*	30825·22	$z\,^4F^\circ_{3\frac{1}{2}}-g\,^4G_{4\frac{1}{2}}$
3239·16		150*h*	30863·3	$z\,^4F^\circ_{3\frac{1}{2}}-g\,^2G_{3\frac{1}{2}}$
3235·713	M	650*h*	30896·20	$z\,^4F^\circ_{1\frac{1}{2}}-g\,^4G_{2\frac{1}{2}}$
3233·899		450*h*	30913·53	$z\,^4F^\circ_{3\frac{1}{2}}-g\,^4D_{2\frac{1}{2}}$
3231·178	IBu	650*h*	30939·56	$z\,^4F^\circ_{3\frac{1}{2}}-g\,^4F_{3\frac{1}{2}}$
3226·602	M	150*h*	30983·44	$z\,^4P^\circ_{\frac{1}{2}}-g\,^4P_{1\frac{1}{2}}$
3226·541		50*h*	30984·03	$z\,^4P^\circ_{1\frac{1}{2}}-g\,^2D_{2\frac{1}{2}}$
3225·698		5*h*(2)	30992·12	$z\,^4D^\circ_{1\frac{1}{2}}-h\,^2F_{2\frac{1}{2}}$
3225·088		2*h*	30998·00	$z\,^4F^\circ_{3\frac{1}{2}}-g\,^2F_{2\frac{1}{2}}$
3224·664	M	450*h*	31002·06	$z\,^4F^\circ_{1\frac{1}{2}}-g\,^4F_{2\frac{1}{2}}$
3223·435	M	400*h*	31013·88	$z\,^4F^\circ_{1\frac{1}{2}}-g\,^4F_{1\frac{1}{2}}$
3221·35		8*h*(2)	31033·9	$z\,^4D^\circ_{2\frac{1}{2}}-h\,^2D_{1\frac{1}{2}}$
3220·65		8*h*(2)	31040·7	$z\,^4D^\circ_{2\frac{1}{2}}-h\,^2D_{2\frac{1}{2}}$
3218·204		5*h*	31064·29	$z\,^4P^\circ_{1\frac{1}{2}}-g\,^4P_{2\frac{1}{2}}$
3217·64		10*h*	31069·7	$z\,^4F^\circ_{4\frac{1}{2}}-g\,^4G_{4\frac{1}{2}}$
3211·43		30*h*(2)	31129·8	$z\,^4D^\circ_{2\frac{1}{2}}-h\,^2F_{2\frac{1}{2}}$
3209·498		4*h*	31148·55	$z\,^4D^\circ_{\frac{1}{2}}-i\,^4D_{\frac{1}{2}}$
3208·231	IBu	1400	31160·853	$m\,^2D_{1\frac{1}{2}}-z\,^4D^\circ_{2\frac{1}{2}}$
3194·099	IBu	1500	31298·716	$m\,^2D_{1\frac{1}{2}}-z\,^4D^\circ_{1\frac{1}{2}}$
3192·22		2*h*(2)	31317·1	$z\,^2F^\circ_{2\frac{1}{2}}-i\,^4D_{1\frac{1}{2}}$
3179·343		2*h*	31443·97	$z\,^2F^\circ_{2\frac{1}{2}}-i\,^2D_{2\frac{1}{2}}$
3175·67		60*h*(3)	31480·3	$z\,^2F^\circ_{2\frac{1}{2}}-h\,^2G_{3\frac{1}{2}}$
3171·663	M	5*h*	31520·11	$z\,^4D^\circ_{1\frac{1}{2}}-i\,^4D_{\frac{1}{2}}$
3169·681	M	500*h*	31539·81	$z\,^4F^\circ_{2\frac{1}{2}}-g\,^4G_{3\frac{1}{2}}$
3160·047		25	31636·0	$z\,^4F^\circ_{2\frac{1}{2}}-g\,^4G_{2\frac{1}{2}}$
3158·02		1*h*	31656·2	$z\,^4D^\circ_{3\frac{1}{2}}-i\,^2D_{2\frac{1}{2}}$
3156·629	IBu	450	31670·22	$m\,^2D_{1\frac{1}{2}}-z\,^4D^\circ_{\frac{1}{2}}$
3152·29		1*h*(3)	31713·8	$z\,^2F^\circ_{2\frac{1}{2}}-h\,^2D_{1\frac{1}{2}}$
3151·62	M	8*h*(3)	31720·6	$z\,^2F^\circ_{2\frac{1}{2}}-h\,^2D_{2\frac{1}{2}}$
3149·508	M	30	31741·83	$z\,^4F^\circ_{2\frac{1}{2}}-g\,^4F_{2\frac{1}{2}}$
3148·57		2*h*(3)	31751·3	$z\,^2D^\circ_{2\frac{1}{2}}-p\,^2D_{2\frac{1}{2}}$
3148·333		3	31753·67	$z\,^4F^\circ_{2\frac{1}{2}}-g\,^4F_{1\frac{1}{2}}$

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Table 3 (*cont.*)

I wave-length	II authority and intensity	III intensity	IV wave-number	V identification
3146·821	M	450*h*	31768·93	$z\,^4P^\circ_{1\frac{1}{2}}-g\,^4P_{\frac{1}{2}}$
3142·797		8*h*(2)	31809·62	$z\,^2F^\circ_{2\frac{1}{2}}-h\,^2F_{2\frac{1}{2}}$
3142·444	M	750*h*	31813·18	$z\,^4P^\circ_{1\frac{1}{2}}-g\,^4P_{1\frac{1}{2}}$
3140·312	M	400*h*	31834·78	$z\,^4P^\circ_{2\frac{1}{2}}-g\,^2P_{1\frac{1}{2}}$
3139·17		0	31846·3	$z\,^2F^\circ_{2\frac{1}{2}}-h\,^2F_{3\frac{1}{2}}$
3137·72		5*h*	31861·1	$z\,^2F^\circ_{3\frac{1}{2}}-j\,^2G_{4\frac{1}{2}}$
3135·01		1*h*	31888·6	$z\,^2D^\circ_{2\frac{1}{2}}-k\,^4D_{2\frac{1}{2}}$
3131·33		5*h*	31926·1	$z\,^4D^\circ_{2\frac{1}{2}}-i\,^2D_{1\frac{1}{2}}$
3128·701	M	650*h*	31952·91	$z\,^4P^\circ_{1\frac{1}{2}}-g\,^4D_{2\frac{1}{2}}$
3126·109	IBu	1400*h*	31979·41	$z\,^4P^\circ_{2\frac{1}{2}}-g\,^4S_{1\frac{1}{2}}$
3124·373		1*h*	31997·17	$z\,^2F^\circ_{3\frac{1}{2}}-j\,^2F_{3\frac{1}{2}}$
3123·00		1*h* ?	32011·2	$z\,^4F^\circ_{1\frac{1}{2}}-i\,^4D_{2\frac{1}{2}}$
3121·93		0*h*(2)	32022·2	$z\,^4D^\circ_{3\frac{1}{2}}-h\,^2F_{2\frac{1}{2}}$
3120·435	M	50*h*	32037·56	$z\,^4P^\circ_{1\frac{1}{2}}-g\,^2P_{\frac{1}{2}}$
3118·355	M	5	32058·92	$z\,^4D^\circ_{3\frac{1}{2}}-h\,^2F_{3\frac{1}{2}}$
3116·348	M	400	32079·57	$z\,^4P^\circ_{2\frac{1}{2}}-g\,^2D_{2\frac{1}{2}}$
3114·778		3	32095·74	
3113·482	M	50	32109·10	$z\,^4P^\circ_{2\frac{1}{2}}-g\,^2F_{3\frac{1}{2}}$
3108·605	M	2000	32159·47	$z\,^4P^\circ_{2\frac{1}{2}}-g\,^4P_{2\frac{1}{2}}$
3108·452	M	600	32161·07	$z\,^4P^\circ_{\frac{1}{2}}-g\,^4D_{1\frac{1}{2}}$
3106·912		1*h*	32176·99	$z\,^2D^\circ_{1\frac{1}{2}}-p\,^2D_{2\frac{1}{2}}$
3099·928	IBu	1250	32249·48	$z\,^4P^\circ_{2\frac{1}{2}}-g\,^4D_{3\frac{1}{2}}$
3093·989	IBu	1500	32311·39	$m\,^2D_{2\frac{1}{2}}-z\,^4D^\circ_{3\frac{1}{2}}$
3088·132	M	125	32372·67	$z\,^4P^\circ_{\frac{1}{2}}-g\,^4F_{1\frac{1}{2}}$
3086·47		2*h*(2)	32390·1	$z\,^2D^\circ_{2\frac{1}{2}}-j\,^4G_{3\frac{1}{2}}$
3084·96		2*h*(2)	32405·9	$z\,^2D^\circ_{1\frac{1}{2}}-p\,^2D_{1\frac{1}{2}}$ $z\,^4D^\circ_{1\frac{1}{2}}-j\,^2D_{2\frac{1}{2}}$ $z\,^2D^\circ_{2\frac{1}{2}}-j\,^4D_{1\frac{1}{2}}$
3082·53		1*h*	32431·4	$z\,^4F^\circ_{2\frac{1}{2}}-i\,^4D_{3\frac{1}{2}}$
3073·798	IBu	1400	32523·62	$m\,^2D_{2\frac{1}{2}}-z\,^2F^\circ_{2\frac{1}{2}}$
3071·96		2*h*(2)	32543·1	$z\,^4D^\circ_{2\frac{1}{2}}-j\,^2D_{2\frac{1}{2}}$
3070·97		5*h*(2)	32553·6	$z\,^4D^\circ_{2\frac{1}{2}}-j\,^2F_{3\frac{1}{2}}$
3068·906	M	15	32575·46	$m\,^2D_{1\frac{1}{2}}-z\,^2P^\circ_{\frac{1}{2}}$
3066·011		3*h*	32606·22	$z\,^2F^\circ_{2\frac{1}{2}}-i\,^2D_{1\frac{1}{2}}$
3063·411	IBu	2500	32633·894	$m\,^2D_{1\frac{1}{2}}-z\,^2P^\circ_{1\frac{1}{2}}$
3060·84		2*h*	32661·3	$z\,^4D^\circ_{2\frac{1}{2}}-j\,^4D_{3\frac{1}{2}}$
3057·36		8*h*	32698·4	$z\,^2P^\circ_{1\frac{1}{2}}-p\,^2D_{1\frac{1}{2}}$
3053·38		10*h*(2)	32741·0	$z\,^4F^\circ_{1\frac{1}{2}}-i\,^4D_{1\frac{1}{2}}$
3052·554		15*h*	32749·96	$z\,^4F^\circ_{2\frac{1}{2}}-i\,^4D_{2\frac{1}{2}}$
3051·901		2*h*	32756·96	$z\,^2P^\circ_{\frac{1}{2}}-p\,^2D_{1\frac{1}{2}}$
3047·795		1*h*	32801·10	$4p\,^2P^\circ_{1\frac{1}{2}}-e\,^4D_{1\frac{1}{2}}$
3045·025		1*h*	32830·93	$z\,^2D^\circ_{1\frac{1}{2}}-j\,^4D_{1\frac{1}{2}}$
3044·028	M	20*h*	32841·68	$z\,^4F^\circ_{3\frac{1}{2}}-i\,^4D_{3\frac{1}{2}}$
3041·62		0*h*	32867·6	$z\,^4F^\circ_{1\frac{1}{2}}-i\,^2D_{2\frac{1}{2}}$
3040·467		1*h*	32880·14	$z\,^2D^\circ_{1\frac{1}{2}}-j\,^4G_{2\frac{1}{2}}$
3039·488		10*h*	32890·13	$z\,^2F^\circ_{3\frac{1}{2}}-j\,^4G_{4\frac{1}{2}}$
3036·101	IBu	2500	32927·426	$m\,^2D_{1\frac{1}{2}}-z\,^2D^\circ_{1\frac{1}{2}}$
3034·555		3*h*	32944·20	$z\,^2D^\circ_{1\frac{1}{2}}-j\,^4F_{2\frac{1}{2}}$
3033·480		2*h*	32955·87	$z\,^2F^\circ_{3\frac{1}{2}}-j\,^4F_{3\frac{1}{2}}$
3030·258	M	10*h*	32990·91	$z\,^4P^\circ_{1\frac{1}{2}}-g\,^4D_{1\frac{1}{2}}$
3029·60		2	32998·1	$z\,^4P^\circ_{2\frac{1}{2}}-g\,^2G_{3\frac{1}{2}}$
3027·82		5*h*(2)	33017·5	$z\,^4D^\circ_{\frac{1}{2}}-j\,^2D_{1\frac{1}{2}}$
3024·994	M	100*h*	33048·33	$4p\,^2P^\circ_{\frac{1}{2}}-e\,^4D_{1\frac{1}{2}}$ $z\,^4P^\circ_{2\frac{1}{2}}-g\,^4D_{2\frac{1}{2}}$
3022·608	IBu	300*h*	33074·41	$z\,^4P^\circ_{2\frac{1}{2}}-g\,^4F_{3\frac{1}{2}}$
3021·544	IBu	300*h*	33086·06	$z\,^4F^\circ_{4\frac{1}{2}}-i\,^4D_{3\frac{1}{2}}$
3018·09		2*h*(2)	33123·9	$z\,^2P^\circ_{1\frac{1}{2}}-j\,^4D_{1\frac{1}{2}}$
3016·24		0*h*(2)	33144·2	$z\,^4F^\circ_{1\frac{1}{2}}-h\,^2D_{2\frac{1}{2}}$
3014·848		30*h*	33159·54	$z\,^4F^\circ_{3\frac{1}{2}}-i\,^4D_{2\frac{1}{2}}$
3013·510		2*h*	33174·26	$z\,^2P^\circ_{1\frac{1}{2}}-j\,^4G_{2\frac{1}{2}}$

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TABLE 3 (*cont.*)

I wave-length	II authority and intensity	III intensity	IV wave-number	V identification
3012·775		1*h*	33181·35	$z\,{}^{2}\mathrm{P}^{\circ}_{\frac{1}{2}}-j\,{}^{4}\mathrm{D}_{1\frac{1}{2}}$
3012·005	M	250	33190·83	$z\,{}^{4}\mathrm{P}^{\circ}_{1\frac{1}{2}}-g\,{}^{4}\mathrm{F}_{2\frac{1}{2}}$
3010·838	IBu	2000	33203·698	$m\,{}^{2}\mathrm{D}_{2\frac{1}{2}}-z\,{}^{4}\mathrm{D}^{\circ}_{2\frac{1}{2}}$
3008·12		5*h*(2)	33233·7	$z\,{}^{4}\mathrm{F}^{\circ}_{1\frac{1}{2}}-h\,{}^{2}\mathrm{F}_{2\frac{1}{2}}$
				$z\,{}^{2}\mathrm{F}^{\circ}_{2\frac{1}{2}}-j\,{}^{2}\mathrm{F}_{3\frac{1}{2}}$
3007·80		1*h*	33237·2	$z\,{}^{2}\mathrm{P}^{\circ}_{1\frac{1}{2}}-j\,{}^{4}\mathrm{F}_{2\frac{1}{2}}$
3004·73		1*h*	33270·5	$z\,{}^{4}\mathrm{D}^{\circ}_{1\frac{1}{2}}-j\,{}^{4}\mathrm{P}_{\frac{1}{2}}$
3002·281		10*h*	33298·33	$z\,{}^{4}\mathrm{P}^{\circ}_{\frac{1}{2}}-j\,{}^{4}\mathrm{F}_{1\frac{1}{2}}$
3001·774		2*h*	33303·95	$z\,{}^{2}\mathrm{F}^{\circ}_{2\frac{1}{2}}-j\,{}^{4}\mathrm{P}_{2\frac{1}{2}}$
3001·24		5*h*	33309·9	$z\,{}^{4}\mathrm{D}^{\circ}_{3\frac{1}{2}}-j\,{}^{2}\mathrm{G}_{4\frac{1}{2}}$
2998·384	IBu	150	33341·61	$m\,{}^{2}\mathrm{D}_{2\frac{1}{2}}-z\,{}^{4}\mathrm{D}^{\circ}_{1\frac{1}{2}}$
2997·364	IBu	2000	33352·96	$m\,{}^{2}\mathrm{D}_{1\frac{1}{2}}-z\,{}^{2}\mathrm{D}^{\circ}_{2\frac{1}{2}}$
2994·13		5*h*(2)	33389·0	$z\,{}^{2}\mathrm{P}^{\circ}_{1\frac{1}{2}}-k\,{}^{2}\mathrm{D}_{2\frac{1}{2}}$
				$z\,{}^{4}\mathrm{D}^{\circ}_{1\frac{1}{2}}-j\,{}^{2}\mathrm{D}_{1\frac{1}{2}}$
2991·780		15*h*	33415·20	$z\,{}^{4}\mathrm{D}^{\circ}_{1\frac{1}{2}}-j\,{}^{2}\mathrm{F}_{2\frac{1}{2}}$
2990·002		1*h*	33435·07	$z\,{}^{4}\mathrm{D}^{\circ}_{2\frac{1}{2}}-j\,{}^{4}\mathrm{P}_{1\frac{1}{2}}$
				$z\,{}^{4}\mathrm{D}^{\circ}_{3\frac{1}{2}}-j\,{}^{2}\mathrm{D}_{2\frac{1}{2}}$
2989·010		2*h*	33446·16	$z\,{}^{4}\mathrm{D}^{\circ}_{3\frac{1}{2}}-j\,{}^{2}\mathrm{F}_{3\frac{1}{2}}$
2985·926		10*h*	33480·71	$z\,{}^{4}\mathrm{F}^{\circ}_{2\frac{1}{2}}-i\,{}^{4}\mathrm{D}_{1\frac{1}{2}}$
2984·267		5*h*	33499·32	$z\,{}^{4}\mathrm{D}^{\circ}_{2\frac{1}{2}}-j\,{}^{4}\mathrm{D}_{2\frac{1}{2}}$
2983·038		3*h*	33513·12	$z\,{}^{4}\mathrm{D}^{\circ}_{2\frac{1}{2}}-j\,{}^{4}\mathrm{F}_{3\frac{1}{2}}$
2982·765	M	8*h*	33516·19	$z\,{}^{4}\mathrm{D}^{\circ}_{3\frac{1}{2}}-j\,{}^{4}\mathrm{P}_{2\frac{1}{2}}$
2982·123		3*h*	33523·39	$z\,{}^{2}\mathrm{F}^{\circ}_{3\frac{1}{2}}-k\,{}^{4}\mathrm{D}_{2\frac{1}{2}}$
2979·380		25*h*	33554·27	$z\,{}^{4}\mathrm{D}^{\circ}_{3\frac{1}{2}}-j\,{}^{4}\mathrm{D}_{3\frac{1}{2}}$
2978·295		30*h*	33566·49	$z\,{}^{4}\mathrm{D}^{\circ}_{3\frac{1}{2}}-j\,{}^{4}\mathrm{F}_{4\frac{1}{2}}$
2974·675		10	33607·34	$z\,{}^{4}\mathrm{F}^{\circ}_{2\frac{1}{2}}-i\,{}^{2}\mathrm{D}_{2\frac{1}{2}}$
2971·50		1*h*(3)	33643·2	$z\,{}^{4}\mathrm{F}^{\circ}_{2\frac{1}{2}}-h\,{}^{2}\mathrm{G}_{3\frac{1}{2}}$
2969·80		0*h*	33662·5	$z\,{}^{4}\mathrm{D}^{\circ}_{\frac{1}{2}}-p\,{}^{2}\mathrm{D}_{1\frac{1}{2}}$
2961·165	IBu	2500R	33760·658	$m\,{}^{2}\mathrm{D}_{2\frac{1}{2}}-z\,{}^{2}\mathrm{F}^{\circ}_{3\frac{1}{2}}$
2951·21		5*h*(3)	33874·5	$4p\,{}^{2}\mathrm{P}^{\circ}_{1\frac{1}{2}}-e\,{}^{2}\mathrm{D}_{2\frac{1}{2}}$
2950·407		1*h*	33883·75	$z\,{}^{4}\mathrm{F}^{\circ}_{2\frac{1}{2}}-h\,{}^{2}\mathrm{D}_{2\frac{1}{2}}$
2945·23		3*h*(3)	33943·3	$z\,{}^{4}\mathrm{D}^{\circ}_{2\frac{1}{2}}-p\,{}^{2}\mathrm{D}_{2\frac{1}{2}}$
				$z\,{}^{2}\mathrm{D}^{\circ}_{2\frac{1}{2}}-\mathrm{l}\,{}^{4}\mathrm{D}_{2\frac{1}{2}}$
2942·44		0*h*(2)	33975·5	$z\,{}^{2}\mathrm{D}^{\circ}_{2\frac{1}{2}}-\mathrm{l}\,{}^{2}\mathrm{F}_{2\frac{1}{2}}$
2939·453		2	34010·02	$z\,{}^{4}\mathrm{F}^{\circ}_{2\frac{1}{2}}-h\,{}^{2}\mathrm{F}_{3\frac{1}{2}}$
2938·868		15*h*	34016·79	$z\,{}^{4}\mathrm{F}^{\circ}_{3\frac{1}{2}}-i\,{}^{2}\mathrm{D}_{2\frac{1}{2}}$
2937·766		2*h*	34029·55	$z\,{}^{4}\mathrm{F}^{\circ}_{1\frac{1}{2}}-i\,{}^{2}\mathrm{D}_{1\frac{1}{2}}$
2933·060		20	34084·15	$z\,{}^{4}\mathrm{P}^{\circ}_{2\frac{1}{2}}-g\,{}^{4}\mathrm{G}_{3\frac{1}{2}}$
2931·699		10*h*	34099·98	$z\,{}^{4}\mathrm{P}^{\circ}_{\frac{1}{2}}-i\,{}^{4}\mathrm{D}_{1\frac{1}{2}}$
2930·416		5*h*	34114·89	$z\,{}^{2}\mathrm{F}^{\circ}_{2\frac{1}{2}}-j\,{}^{4}\mathrm{P}_{1\frac{1}{2}}$
2926·057		10	34165·76	$z\,{}^{4}\mathrm{P}^{\circ}_{\frac{1}{2}}-h\,{}^{2}\mathrm{P}_{\frac{1}{2}}$
2925·439	M	30*h*	34172·93	$z\,{}^{2}\mathrm{F}^{\circ}_{2\frac{1}{2}}-j\,{}^{2}\mathrm{G}_{3\frac{1}{2}}$
2924·882	M	10*h*	34179·44	$z\,{}^{2}\mathrm{F}^{\circ}_{2\frac{1}{2}}-j\,{}^{4}\mathrm{D}_{2\frac{1}{2}}$
2923·704	M	80*h*	34193·21	$z\,{}^{2}\mathrm{F}^{\circ}_{2\frac{1}{2}}-j\,{}^{4}\mathrm{F}_{3\frac{1}{2}}$
2923·212	M	20*h*	34198·96	$z\,{}^{4}\mathrm{P}^{\circ}_{1\frac{1}{2}}-i\,{}^{4}\mathrm{D}_{2\frac{1}{2}}$
2922·830		10*h*	34203·43	$z\,{}^{4}\mathrm{D}^{\circ}_{\frac{1}{2}}-j\,{}^{4}\mathrm{F}_{1\frac{1}{2}}$
2920·296		10*h*	34233·11	$z\,{}^{2}\mathrm{F}^{\circ}_{2\frac{1}{2}}-j\,{}^{2}\mathrm{F}_{2\frac{1}{2}}$
2912·916		2	34319·84	$z\,{}^{4}\mathrm{P}^{\circ}_{\frac{1}{2}}-h\,{}^{2}\mathrm{P}_{1\frac{1}{2}}$
2911·215		30*h*	34339·89	$z\,{}^{4}\mathrm{D}^{\circ}_{3\frac{1}{2}}-j\,{}^{4}\mathrm{G}_{4\frac{1}{2}}$
2905·662		5*h*	34405·52	$z\,{}^{4}\mathrm{D}^{\circ}_{3\frac{1}{2}}-j\,{}^{4}\mathrm{F}_{3\frac{1}{2}}$
2904·46		0*h*	34419·7	$z\,{}^{4}\mathrm{F}^{\circ}_{3\frac{1}{2}}-h\,{}^{2}\mathrm{F}_{3\frac{1}{2}}$
2901·18		1*h*(2)	34458·7	$z\,{}^{4}\mathrm{D}^{\circ}_{1\frac{1}{2}}-j\,{}^{4}\mathrm{D}_{1\frac{1}{2}}$
2899·63		1*h*(3)	34477·1	$4p\,{}^{2}\mathrm{P}^{\circ}_{1\frac{1}{2}}-e\,{}^{2}\mathrm{D}_{1\frac{1}{2}}$
2898·05		0*h*(2)	34495·9	$z\,{}^{4}\mathrm{P}^{\circ}_{\frac{1}{2}}-h\,{}^{2}\mathrm{D}_{1\frac{1}{2}}$
2896·83		0*h*(2)	34510·4	$z\,{}^{4}\mathrm{D}^{\circ}_{1\frac{1}{2}}-j\,{}^{4}\mathrm{G}_{2\frac{1}{2}}$
2891·64		30*h*	34572·3	$z\,{}^{4}\mathrm{D}^{\circ}_{1\frac{1}{2}}-j\,{}^{4}\mathrm{F}_{2\frac{1}{2}}$
2890·84		50*h*	34581·9	$z\,{}^{4}\mathrm{D}^{\circ}_{2\frac{1}{2}}-j\,{}^{4}\mathrm{G}_{3\frac{1}{2}}$
2885·408		5*h*	34647·01	$z\,{}^{4}\mathrm{D}^{\circ}_{2\frac{1}{2}}-j\,{}^{4}\mathrm{G}_{2\frac{1}{2}}$
				$z\,{}^{4}\mathrm{F}^{\circ}_{1\frac{1}{2}}-j\,{}^{2}\mathrm{D}_{2\frac{1}{2}}$
2882·934	IBu	1500	34676·74	$m\,{}^{2}\mathrm{D}_{2\frac{1}{2}}-z\,{}^{2}\mathrm{P}^{\circ}_{1\frac{1}{2}}$

TABLE 3 (*cont.*)

I wave-length	II authority and intensity	III intensity	IV wave-number	V identification
2879·743		2*h*	34715·16	$z\,{}^2\mathrm{D}^\circ_{2\frac{1}{2}}-o\,{}^2\mathrm{D}_{1\frac{1}{2}}$
2878·86		5*h*(3)	34725·8	$4p\,{}^2\mathrm{P}^\circ_{\frac{1}{2}}-e\,{}^2\mathrm{D}_{1\frac{1}{2}}$ $z\,{}^4\mathrm{D}^\circ_{\frac{1}{2}}-l\,{}^4\mathrm{S}_{1\frac{1}{2}}$
2877·101		5	34747·04	$z\,{}^4\mathrm{D}^\circ_{3\frac{1}{2}}-k\,{}^4\mathrm{D}_{3\frac{1}{2}}$
2876·025		2*h*	34760·04	$z\,{}^2\mathrm{F}^\circ_{2\frac{1}{2}}-k\,{}^4\mathrm{D}_{2\frac{1}{2}}$
2875·67		10*h*(2)	34764·3	$z\,{}^2\mathrm{D}^\circ_{2\frac{1}{2}}-o\,{}^2\mathrm{F}_{2\frac{1}{2}}$
2875·240		2*h*	34769·53	$z\,{}^4\mathrm{F}^\circ_{2\frac{1}{2}}-i\,{}^2\mathrm{D}_{1\frac{1}{2}}$
2874·560		20*h*	34777·75	$z\,{}^2\mathrm{D}^\circ_{2\frac{1}{2}}-o\,{}^2\mathrm{F}_{3\frac{1}{2}}$
2869·80		2*h*(2)	34835·4	$z\,{}^4\mathrm{D}^\circ_{3\frac{1}{2}}-p\,{}^2\mathrm{D}_{2\frac{1}{2}}$
2868·470		10*h*	34851·58	$z\,{}^2\mathrm{F}^\circ_{2\frac{1}{2}}-p\,{}^2\mathrm{D}_{1\frac{1}{2}}$ $z\,{}^4\mathrm{D}^\circ_{2\frac{1}{2}}-k\,{}^4\mathrm{D}_{1\frac{1}{2}}$
2867·633		1*h*	34861·76	$z\,{}^4\mathrm{D}^\circ_{2\frac{1}{2}}-k\,{}^2\mathrm{D}_{2\frac{1}{2}}$
2862·07		5*h*(2)	34929·5	$z\,{}^4\mathrm{P}^\circ_{1\frac{1}{2}}-i\,{}^4\mathrm{D}_{1\frac{1}{2}}$
2858·734	IBu	200	34970·27	$m\,{}^2\mathrm{D}_{2\frac{1}{2}}-z\,{}^2\mathrm{D}^\circ_{1\frac{1}{2}}$
2858·225	IBu	50*h*	34976·50	$z\,{}^4\mathrm{P}^\circ_{2\frac{1}{2}}-i\,{}^4\mathrm{D}_{3\frac{1}{2}}$
2856·660		2*h*	34995·66	$z\,{}^4\mathrm{P}^\circ_{1\frac{1}{2}}-h\,{}^2\mathrm{P}_{\frac{1}{2}}$
2851·743		15*h*	35056·00	$z\,{}^4\mathrm{P}^\circ_{1\frac{1}{2}}-i\,{}^2\mathrm{D}_{2\frac{1}{2}}$
2848·15		1*h*(2)	35100·2	
2846·478	M	15	35120·83	$z\,{}^4\mathrm{P}^\circ_{\frac{1}{2}}-i\,{}^4\mathrm{D}_{\frac{1}{2}}$
2844·842		10*h*	35141·03	$z\,{}^2\mathrm{D}^\circ_{1\frac{1}{2}}-o\,{}^2\mathrm{D}_{1\frac{1}{2}}$
2844·160		15	35149·46	$z\,{}^4\mathrm{P}^\circ_{1\frac{1}{2}}-h\,{}^2\mathrm{P}_{1\frac{1}{2}}$
2840·92		10*h*(2)	35189·5	$z\,{}^2\mathrm{D}^\circ_{1\frac{1}{2}}-o\,{}^2\mathrm{F}_{2\frac{1}{2}}$
2837·34		1*h*(2)	35233·9	$z\,{}^4\mathrm{D}^\circ_{2\frac{1}{2}}-l\,{}^4\mathrm{S}_{1\frac{1}{2}}$
2834·30		2*h*(3)	35272	$z\,{}^4\mathrm{P}^\circ_{1\frac{1}{2}}-h\,{}^2\mathrm{S}_{\frac{1}{2}}$
2832·49		5*h*	35294·3	$z\,{}^4\mathrm{P}^\circ_{2\frac{1}{2}}-i\,{}^4\mathrm{D}_{2\frac{1}{2}}$
2830·93		3*h*(2)	35313·7	
2829·88		1*h*	35326·8	$z\,{}^2\mathrm{F}^\circ_{2\frac{1}{2}}-j\,{}^4\mathrm{G}_{2\frac{1}{2}}$ $z\,{}^4\mathrm{P}^\circ_{1\frac{1}{2}}-h\,{}^2\mathrm{D}_{1\frac{1}{2}}$
2829·42		5*h*(2)	35332·6	$z\,{}^4\mathrm{P}^\circ_{1\frac{1}{2}}-h\,{}^2\mathrm{D}_{2\frac{1}{2}}$
2826·50		1*h*	35369·1	
2826·20		1*h*	35372·8	
2824·370	IBu	1250R	35395·732	$m\,{}^2\mathrm{D}_{2\frac{1}{2}}-z\,{}^2\mathrm{D}^\circ_{2\frac{1}{2}}$
2822·86		0*h*	35414·7	$z\,{}^4\mathrm{D}^\circ_{\frac{1}{2}}-k\,{}^4\mathrm{D}_{\frac{1}{2}}$
2821·23		1*h*(2)	35435·1	$z\,{}^2\mathrm{P}^\circ_{1\frac{1}{2}}-o\,{}^2\mathrm{D}_{1\frac{1}{2}}$
2818·68		4*h*	35467·2	$j\,{}^4\mathrm{F}^\circ_{2\frac{1}{2}}-j\,{}^4\mathrm{P}_{2\frac{1}{2}}$
2817·47		1*h*(3)	35482·4	$z\,{}^2\mathrm{P}^\circ_{1\frac{1}{2}}-o\,{}^2\mathrm{F}_{2\frac{1}{2}}$
2815·71		1*h*(3)	35504·6	
2813·558		2*h*	35531·74	$z\,{}^2\mathrm{F}^\circ_{2\frac{1}{2}}-k\,{}^4\mathrm{D}_{1\frac{1}{2}}$
2812·74		2*h*(2)	35542·1	$z\,{}^2\mathrm{F}^\circ_{2\frac{1}{2}}-k\,{}^2\mathrm{D}_{2\frac{1}{2}}$ $z\,{}^2\mathrm{F}^\circ_{3\frac{1}{2}}-k\,{}^2\mathrm{D}_{2\frac{1}{2}}$ $z\,{}^2\mathrm{F}^\circ_{3\frac{1}{2}}-l\,{}^4\mathrm{G}_{4\frac{1}{2}}$
2809·78		1*h*(2)	35579·5	$z\,{}^2\mathrm{F}^\circ_{3\frac{1}{2}}-l\,{}^4\mathrm{D}_{2\frac{1}{2}}$
2805·71		5*h*(2)	35631·1	$z\,{}^4\mathrm{F}^\circ_{1\frac{1}{2}}-j\,{}^2\mathrm{D}_{1\frac{1}{2}}$
2803·686		10*h*	35656·85	$z\,{}^4\mathrm{F}^\circ_{1\frac{1}{2}}-j\,{}^2\mathrm{F}_{2\frac{1}{2}}$
2802·556		10*h*	35671·22	$z\,{}^4\mathrm{F}^\circ_{3\frac{1}{2}}-j\,{}^2\mathrm{G}_{4\frac{1}{2}}$
2796·045		1*h*	35754·29	$z\,{}^4\mathrm{D}^\circ_{3\frac{1}{2}}-k\,{}^2\mathrm{D}_{2\frac{1}{2}}$
2793·485		2*h*	35787·05	$z\,{}^4\mathrm{D}^\circ_{1\frac{1}{2}}-k\,{}^4\mathrm{D}_{\frac{1}{2}}$
2791·951		5*h*	35806·75	$z\,{}^4\mathrm{F}^\circ_{3\frac{1}{2}}-j\,{}^2\mathrm{F}_{3\frac{1}{2}}$
2786·496	M	10*h*	35876·80	$z\,{}^4\mathrm{F}^\circ_{3\frac{1}{2}}-j\,{}^4\mathrm{P}_{2\frac{1}{2}}$
2783·551	M	20*h*	35914·76	$z\,{}^4\mathrm{F}^\circ_{3\frac{1}{2}}-j\,{}^4\mathrm{D}_{3\frac{1}{2}}$
2782·592	M	20*h*	35927·14	$z\,{}^4\mathrm{F}^\circ_{3\frac{1}{2}}-j\,{}^4\mathrm{F}_{4\frac{1}{2}}$
2780·828		1	35949·97	$z\,{}^4\mathrm{P}^\circ_{1\frac{1}{2}}-i\,{}^4\mathrm{D}_{\frac{1}{2}}$
2774·5		*h*(4)	36032	$z\,{}^4\mathrm{D}^\circ_{1\frac{1}{2}}-l\,{}^2\mathrm{F}_{2\frac{1}{2}}$
2773·70		1*h*(2)	36042·3	$z\,{}^4\mathrm{D}^\circ_{1\frac{1}{2}}-l\,{}^2\mathrm{D}_{1\frac{1}{2}}$
2768·878	M	125*h*	36105·07	$z\,{}^4\mathrm{F}^\circ_{4\frac{1}{2}}-j\,{}^4\mathrm{G}_{5\frac{1}{2}}$
2766·371	IBu	2500R	36137·79	$m\,{}^2\mathrm{D}_{1\frac{1}{2}}-5p\,{}^2\mathrm{P}^\circ$
2765·300		1	36151·78	$z\,{}^4\mathrm{P}^\circ_{2\frac{1}{2}}-i\,{}^2\mathrm{D}_{2\frac{1}{2}}$
2764·762		5*h*	36158·82	$z\,{}^4\mathrm{F}^\circ_{4\frac{1}{2}}-j\,{}^4\mathrm{D}_{3\frac{1}{2}}$
2763·809		15*h*	36171·29	$z\,{}^4\mathrm{F}^\circ_{4\frac{1}{2}}-j\,{}^4\mathrm{F}_{4\frac{1}{2}}$
2763·09		1*h*(2)	36180·7	$z\,{}^4\mathrm{D}^\circ_{3\frac{1}{2}}-l\,{}^4\mathrm{D}_{3\frac{1}{2}}$ $z\,{}^4\mathrm{D}^\circ_{2\frac{1}{2}}-l\,{}^2\mathrm{D}_{1\frac{1}{2}}$

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Table 3 (*cont.*)

I	II	III	IV	V
wave-length	authority and intensity	intensity	wave-number	identification
2762·58		1*h*(2)	36187·4	$z\,{}^4\mathrm{P}^\circ_{2\frac{1}{2}}-h\,{}^2\mathrm{G}_{3\frac{1}{2}}$ $z\,{}^4\mathrm{D}^\circ_{3\frac{1}{2}}-l\,{}^4\mathrm{F}_{4\frac{1}{2}}$
2760·25		2*h*(2)	36217·9	$z\,{}^4\mathrm{P}^\circ_{1\frac{1}{2}}-i\,{}^2\mathrm{D}_{1\frac{1}{2}}$
2758·221		1	36244·56	$z\,{}^4\mathrm{P}^\circ_{2\frac{1}{2}}-h\,{}^2\mathrm{P}_{1\frac{1}{2}}$
2755·69		5*h*(2)	36277·8	$z\,{}^4\mathrm{F}^\circ_{2\frac{1}{2}}-j\,{}^4\mathrm{P}_{1\frac{1}{2}}$
2751·810	M	10*h*	36329·00	$z\,{}^2\mathrm{F}^\circ_{3\frac{1}{2}}-o\,{}^2\mathrm{D}_{2\frac{1}{2}}$
2751·29	M	10*h*	36335·9	$z\,{}^4\mathrm{F}^\circ_{2\frac{1}{2}}-j\,{}^2\mathrm{G}_{3\frac{1}{2}}$
2750·786		5*h*	36342·52	$z\,{}^4\mathrm{F}^\circ_{2\frac{1}{2}}-j\,{}^4\mathrm{D}_{2\frac{1}{2}}$
2749·734		2*h*	36356·42	$z\,{}^4\mathrm{F}^\circ_{2\frac{1}{2}}-j\,{}^4\mathrm{F}_{3\frac{1}{2}}$
2749·39		1*h*(2)	36361·0	$4p\,{}^2\mathrm{P}^\circ_{1\frac{1}{2}}-f\,{}^2\mathrm{D}_{2\frac{1}{2}}$
2748·60		1*h*(2)	36371·4	$z\,{}^4\mathrm{F}^\circ_{2\frac{1}{2}}-j\,{}^2\mathrm{D}_{1\frac{1}{2}}$
2746·713		20*h*	36396·41	$z\,{}^4\mathrm{F}^\circ_{2\frac{1}{2}}-j\,{}^2\mathrm{F}_{2\frac{1}{2}}$
2745·452		20*h*	36413·12	$z\,{}^2\mathrm{F}^\circ_{3\frac{1}{2}}-o\,{}^2\mathrm{F}_{3\frac{1}{2}}$
2744·35		1*h*(2)	36427·7	$z\,{}^4\mathrm{P}^\circ_{2\frac{1}{2}}-h\,{}^2\mathrm{D}_{2\frac{1}{2}}$
2737·608		2*h*	36517·45	$z\,{}^4\mathrm{P}^\circ_{2\frac{1}{2}}-h\,{}^2\mathrm{F}_{2\frac{1}{2}}$
2734·858		10	36554·17	$z\,{}^4\mathrm{P}^\circ_{2\frac{1}{2}}-h\,{}^2\mathrm{F}_{3\frac{1}{2}}$
2724·742		1	36688·87	$m\,{}^2\mathrm{D}_{1\frac{1}{2}}-4d\,{}^2\mathrm{D}_{1\frac{1}{2}}$?
2723·953	M	30	36700·50	$z\,{}^4\mathrm{F}^\circ_{3\frac{1}{2}}-j\,{}^4\mathrm{G}_{4\frac{1}{2}}$
2722·702		5*h*	36717·36	$z\,{}^4\mathrm{P}^\circ_{1\frac{1}{2}}-j\,{}^2\mathrm{P}_{1\frac{1}{2}}$
2721·75		1*h*(2)	36730·2	$z\,{}^2\mathrm{F}^\circ_{2\frac{1}{2}}-k\,{}^2\mathrm{D}_{1\frac{1}{2}}$
2721·44		1*h*(2)	36734·4	
2720·62		2*h*	36745·2	$z\,{}^4\mathrm{F}^\circ_{3\frac{1}{2}}-j\,{}^2\mathrm{G}_{3\frac{1}{2}}$
2720·199	M	15*h*	36751·15	$z\,{}^4\mathrm{F}^\circ_{1\frac{1}{2}}-j\,{}^4\mathrm{G}_{2\frac{1}{2}}$
2719·097		15*h*	36766·04	$z\,{}^4\mathrm{F}^\circ_{3\frac{1}{2}}-j\,{}^4\mathrm{F}_{3\frac{1}{2}}$
2718·847		2*h*	36769·42	$z\,{}^4\mathrm{D}^\circ_{1\frac{1}{2}}-o\,{}^2\mathrm{D}_{1\frac{1}{2}}$
2715·543		20*h*	36814·16	$z\,{}^4\mathrm{F}^\circ_{1\frac{1}{2}}-j\,{}^4\mathrm{F}_{2\frac{1}{2}}$
2715·35		5*h*	36816·8	$z\,{}^4\mathrm{F}^\circ_{1\frac{1}{2}}-j\,{}^4\mathrm{F}_{1\frac{1}{2}}$
2714·54		2*h*(2)	36827·8	$z\,{}^2\mathrm{F}^\circ_{2\frac{1}{2}}-l\,{}^2\mathrm{G}_{3\frac{1}{2}}$
2714·00		2*h*(2)	36835·1	$z\,{}^4\mathrm{P}^\circ_{1\frac{1}{2}}-j\,{}^2\mathrm{D}_{2\frac{1}{2}}$
2711·75		0*h*(3)	36865·6	
2707·50		0*h*(2)	36923·5	$z\,{}^4\mathrm{F}^\circ_{2\frac{1}{2}}-k\,{}^4\mathrm{D}_{2\frac{1}{2}}$
2705·18		2*h*	36955·2	$z\,{}^4\mathrm{F}^\circ_{1\frac{1}{2}}-k\,{}^4\mathrm{D}_{1\frac{1}{2}}$
2704·09		1*h*	36970·1	$z\,{}^4\mathrm{D}^\circ_{2\frac{1}{2}}-o\,{}^2\mathrm{F}_{3\frac{1}{2}}$
2702·65		10*h*(2)	36989·8	$z\,{}^4\mathrm{F}^\circ_{4\frac{1}{2}}-j\,{}^2\mathrm{G}_{3\frac{1}{2}}$ $z\,{}^4\mathrm{P}^\circ_{\frac{1}{2}}-j\,{}^2\mathrm{D}_{1\frac{1}{2}}$
2694·080		5*h*	37107·43	$z\,{}^4\mathrm{F}^\circ_{3\frac{1}{2}}-k\,{}^4\mathrm{D}_{3\frac{1}{2}}$
2687·68		1*h*(2)	37195·9	$z\,{}^4\mathrm{F}^\circ_{3\frac{1}{2}}-p\,{}^2\mathrm{D}_{2\frac{1}{2}}$
2686·74		1*h*(2)	37208·8	
2681·02		2*h*(3)	37288·2	
2679·19		0	37313·6	$z\,{}^4\mathrm{P}^\circ_{2\frac{1}{2}}-i\,{}^2\mathrm{D}_{1\frac{1}{2}}$
2677·794		2	37334·49	
2676·428		20	37352·15	$z\,{}^4\mathrm{F}^\circ_{4\frac{1}{2}}-k\,{}^4\mathrm{D}_{3\frac{1}{2}}$
2672·05		5*h*(2)	37413·3	
2671·204		20*h*	37425·31	$z\,{}^4\mathrm{F}^\circ_{2\frac{1}{2}}-j\,{}^4\mathrm{G}_{3\frac{1}{2}}$
2668·32		0*h*(2)	37465·6	
2666·59		2*h*(2)	37489·9	$z\,{}^4\mathrm{F}^\circ_{2\frac{1}{2}}-j\,{}^4\mathrm{G}_{2\frac{1}{2}}$
2662·77		1*h*(2)	37543·8	
2662·47		1*h*(2)	37548·0	
2659·57		2*h*(4)	37589	
2653·90		1*h*(3)	37669·2	
2652·065		2*h*	37695·26	$z\,{}^4\mathrm{F}^\circ_{2\frac{1}{2}}-k\,{}^4\mathrm{D}_{1\frac{1}{2}}$
2651·693		10*h*	37700·54	$z\,{}^4\mathrm{P}^\circ_{1\frac{1}{2}}-j\,{}^4\mathrm{P}_{\frac{1}{2}}$
2651·440		1*h*	37704·14	$z\,{}^4\mathrm{F}^\circ_{2\frac{1}{2}}-k\,{}^2\mathrm{D}_{2\frac{1}{2}}$
2649·840		30*h*	37726·91	$z\,{}^4\mathrm{P}^\circ_{1\frac{1}{2}}-j\,{}^4\mathrm{P}_{1\frac{1}{2}}$
2646·194		1*h*	37778·89	$z\,{}^4\mathrm{D}^\circ_{3\frac{1}{2}}-o\,{}^2\mathrm{D}_{2\frac{1}{2}}$
2645·303		20*h*	37791·61	$z\,{}^4\mathrm{P}^\circ_{1\frac{1}{2}}-j\,{}^4\mathrm{D}_{2\frac{1}{2}}$
2643·834		1*h*	37812·61	$z\,{}^4\mathrm{P}^\circ_{2\frac{1}{2}}-j\,{}^2\mathrm{P}_{1\frac{1}{2}}$
2641·550		5*h*	37845·30	$z\,{}^4\mathrm{P}^\circ_{1\frac{1}{2}}-j\,{}^2\mathrm{F}_{2\frac{1}{2}}$
2635·614		1*h*	37928·72	

TABLE 3 (*cont.*)

I wave-length	II authority and intensity	III intensity	IV wave-number	V identification
2634·933		30*h*	37940·32	$z\ ^4P^{\circ}_{2\frac{1}{2}}-j\ ^4S_{1\frac{1}{2}}$
2630·004		20*h*	38011·43	$z\ ^4P^{\circ}_{2\frac{1}{2}}-j\ ^4P_{2\frac{1}{2}}$
2628·860		1*h*	38027·97	$z\ ^4F^{\circ}_{1\frac{1}{2}}-k\ ^4D_{\frac{1}{2}}$
2627·365		20*h*	38049·61	$z\ ^4P^{\circ}_{2\frac{1}{2}}-j\ ^4D_{3\frac{1}{2}}$
2626·678		10*h*	38059·56	$z\ ^4P^{\circ}_{\frac{1}{2}}-j\ ^4D_{1\frac{1}{2}}$
2622·875		5*h*	38114·74	$z\ ^4F^{\circ}_{3\frac{1}{2}}-k\ ^2D_{2\frac{1}{2}}$
2618·366	IBu	2500R	38180·38	$m\ ^2D_{2\frac{1}{2}}-5p\ ^2P^{\circ}$
2611·30		0*h*(4)	38284	$z\ ^4F^{\circ}_{1\frac{1}{2}}-l\ ^2D_{1\frac{1}{2}}$
2609·31		0*h*	38312·9	$z\ ^4P^{\circ}_{\frac{1}{2}}-k\ ^4D_{1\frac{1}{2}}$
2605·26		3*h*	38372·4	$z\ ^4P^{\circ}_{1\frac{1}{2}}-k\ ^4D_{2\frac{1}{2}}$
2604·84		1*h*	38378·6	
2604·67		1*h*	38381·1	
2595·14		0*h*(2)	38522·1	$z\ ^4F^{\circ}_{3\frac{1}{2}}-l\ ^4P_{2\frac{1}{2}}$
2593·65		2*h*(4)	38544	$z\ ^4F^{\circ}_{3\frac{1}{2}}-l\ ^4F_{4\frac{1}{2}}$?
2580·57		5*h*	38739·5	$m\ ^2D_{2\frac{1}{2}}-4d\ ^2D_{2\frac{1}{2}}$
2579·29		20*h*(2)	38758·8	$z\ ^4F^{\circ}_{4\frac{1}{2}}-l\ ^4G_{5\frac{1}{2}}$
2577·12		2*h*(3)	38791·4	$z\ ^4F^{\circ}_{4\frac{1}{2}}-l\ ^4F_{4\frac{1}{2}}$
2570·800		10*h*	38886·76	$z\ ^4P^{\circ}_{2\frac{1}{2}}-j\ ^4D_{2\frac{1}{2}}$
2569·888		10*h*	38900·55	$z\ ^4P^{\circ}_{2\frac{1}{2}}-j\ ^4F_{3\frac{1}{2}}$
2567·330		2*h*	38939·31	$z\ ^4P^{\circ}_{1\frac{1}{2}}-j\ ^4G_{2\frac{1}{2}}$
2563·955		3*h*	38990·56	$z\ ^4F^{\circ}_{2\frac{1}{2}}-l\ ^2G_{3\frac{1}{2}}$
2563·553		3*h*	38996·68	$z\ ^4F^{\circ}_{2\frac{1}{2}}-l\ ^4F_{3\frac{1}{2}}$
2563·167		10*h*	39002·55	$z\ ^4P^{\circ}_{1\frac{1}{2}}-j\ ^4F_{2\frac{1}{2}}$
2553·29		2*h*	39153·4	$z\ ^4P^{\circ}_{1\frac{1}{2}}-k\ ^2D_{2\frac{1}{2}}$
2552·56		1*h*	39164·7	$z\ ^4F^{\circ}_{3\frac{1}{2}}-n\ ^4D_{3\frac{1}{2}}$
2547·48		10*h*	39242·7	$z\ ^4P^{\circ}_{2\frac{1}{2}}-k\ ^4D_{3\frac{1}{2}}$
2546·77		0*h*	39253·7	
2540·38		5*h*(3)	39352·4	$z\ ^4F^{\circ}_{3\frac{1}{2}}-l\ ^4G_{4\frac{1}{2}}$
2536·86		2*h*	39407·0	$z\ ^4F^{\circ}_{3\frac{1}{2}}-l\ ^4F_{3\frac{1}{2}}$
2536·67		2*h*	39409·9	$z\ ^4F^{\circ}_{4\frac{1}{2}}-n\ ^4D_{3\frac{1}{2}}$
2536·03		2*h*(3)	39419·9	$z\ ^4F^{\circ}_{3\frac{1}{2}}-l\ ^2F_{2\frac{1}{2}}$
2534·03		2*h*(2)	39451·0	
2494·89		10	40069·8	$4p\ ^2P^{\circ}_{1\frac{1}{2}}-g\ ^2P_{1\frac{1}{2}}$
2492·146	IBu	2000R	40113·96	$4s\ ^2S_{\frac{1}{2}}-z\ ^4P^{\circ}_{1\frac{1}{2}}$
2479·754		10	40314·4	$4p\ ^2P^{\circ}_{1\frac{1}{2}}-g\ ^2D_{2\frac{1}{2}}$
2479·594		1	40317·5	$4p\ ^2P^{\circ}_{\frac{1}{2}}-g\ ^2P_{1\frac{1}{2}}$
2474·818		5	40394·8	$4p\ ^2P^{\circ}_{1\frac{1}{2}}-g\ ^4P_{2\frac{1}{2}}$
2472·32		0*h*	40435·6	
2470·83		0*h*(2)	40460	$z\ ^4P^{\circ}_{1\frac{1}{2}}-l\ ^2F_{2\frac{1}{2}}$
2460·93		5*h*(2)	40622·8	$z\ ^4P^{\circ}_{2\frac{1}{2}}-l\ ^4S_{1\frac{1}{2}}$
2458·88		5*h*(2)	40656·4	$z\ ^4P^{\circ}_{2\frac{1}{2}}-l\ ^4P_{2\frac{1}{2}}$
2457·74		5*h*(2)	40675·5	$z\ ^4P^{\circ}_{2\frac{1}{2}}-l\ ^4D_{3\frac{1}{2}}$
2441·637	IBu	1000R	40943·71	$4s\ ^2S_{\frac{1}{2}}-z\ ^4P^{\circ}_{\frac{1}{2}}$
2421·644		1*h*	41281·7	$4p\ ^2P^{\circ}_{1\frac{1}{2}}-g\ ^4D_{2\frac{1}{2}}$
2420·606		1*h*	41299·4	$z\ ^4P^{\circ}_{2\frac{1}{2}}-n\ ^4D_{3\frac{1}{2}}$
2416·605		5	41367·8	$4p\ ^2P^{\circ}_{1\frac{1}{2}}-g\ ^2P_{\frac{1}{2}}$
2415·197		5	41391·9	$4p\ ^2P^{\circ}_{\frac{1}{2}}-g\ ^4P_{1\frac{1}{2}}$
2406·665	IBu	1500	41538·63	$m\ ^2D_{1\frac{1}{2}}-6p\ ^2P^{\circ}_{1\frac{1}{2}}$
2404·864		2*h*	41569·7	$4p\ ^2P^{\circ}_{\frac{1}{2}}-g\ ^2D_{1\frac{1}{2}}$
2392·627	IBu	2500R	41782·32	$m\ ^2D_{1\frac{1}{2}}-6p\ ^2P^{\circ}_{\frac{1}{2}}$
2379·36		2*h*(2)	42015·2	
2372·28		1*h*(2)	42140·7	
2363·220		5	42302·2	$4s\ ^2S_{\frac{1}{2}}-z\ ^4F^{\circ}_{1\frac{1}{2}}$
2354·825		2	42453·0	
2348·352		2	42570·0	$4p\ ^2P^{\circ}_{\frac{1}{2}}-g\ ^4D_{1\frac{1}{2}}$
2319·561	IBu	500	43098·34	$m\ ^2D_{1\frac{1}{2}}-y\ ^2P^{\circ}_{1\frac{1}{2}}$
2303·116	IBu	1000	43406·05	$m\ ^2D_{1\frac{1}{2}}-y\ ^2D^{\circ}_{2\frac{1}{2}}$
2302·036		0*h*	43426·4	
2293·842	IBu	2500R	43581·52	$m\ ^2D_{2\frac{1}{2}}-6p\ ^2P^{\circ}_{1\frac{1}{2}}$
2288·83		0*h*(2)	43676·9	

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TABLE 3 (*cont.*)

I	II	III	IV	V
wave-length	authority and intensity	intensity	wave-number	identification
2282·07		0*h*(2)	43806·3	
2263·079	IBu	2200R	44173·88	$m\,{}^2D_{1\frac{1}{2}}-7p\,{}^2P^\circ_{\frac{1}{2}}$
2260·528	IBu	1300R	44223·73	$m\,{}^2D_{2\frac{1}{2}}-4f\,{}^2F^\circ_{3\frac{1}{2}}$
2255·286		0	44326·5	$4p\,{}^2P^\circ_{1\frac{1}{2}}-h\,{}^2P_{\frac{1}{2}}$
2247·503		2	44480·1	$4p\,{}^2P^\circ_{1\frac{1}{2}}-h\,{}^2P_{1\frac{1}{2}}$
2244·265	IBu	2300R	44544·16	$4s\,{}^2S_{\frac{1}{2}}-z\,{}^4D^\circ_{1\frac{1}{2}}$
2240·40		2*h*(2)	44621·0	
2239·33		2*h*(2)	44642·3	
2238·454	IBu	1100R	44659·78	$m\,{}^2D_{1\frac{1}{2}}-5f\,{}^2F^\circ_{2\frac{1}{2}}$
2237·34		5*h*(2)	44681·9	
2236·278	IBu	900R	44703·24	$m\,{}^2D_{1\frac{1}{2}}-7p\,{}^2P^\circ_{1\frac{1}{2}}$
2230·084	IBu	2500R	44827·39	$m\,{}^2D_{2\frac{1}{2}}-y\,{}^2F^\circ_{3\frac{1}{2}}$
2227·775	IBu	1600R	44873·85	$m\,{}^2D_{1\frac{1}{2}}-y\,{}^2F^\circ_{2\frac{1}{2}}$
2225·697	IBu	2100R	44915·74	$4s\,{}^2S_{\frac{1}{2}}-z\,{}^4D^\circ_{\frac{1}{2}}$
2215·654	IBu	1000R	45119·30	$m\,{}^2D_{1\frac{1}{2}}-y\,{}^2P^\circ_{\frac{1}{2}}$
2214·581	IBu	1600R	45141·16	$m\,{}^2D_{2\frac{1}{2}}-y\,{}^2P^\circ_{1\frac{1}{2}}$
2205·65		5*h*(2)	45323·9	
2199·752	IBu	1300R	45445·43	$m\,{}^2D_{1\frac{1}{2}}-y\,{}^2D^\circ_{1\frac{1}{2}}$
2199·583	IBu	1700R	45448·93	$m\,{}^2D_{2\frac{1}{2}}-y\,{}^2D^\circ_{2\frac{1}{2}}$
2198·560		1*h*	45470·07	
2181·720	IBu	1700R	45821·00	$4s\,{}^2S_{\frac{1}{2}}-z\,{}^2P^\circ_{\frac{1}{2}}$
2178·944	IBu	1600R	45879·37	$4s\,{}^2S_{\frac{1}{2}}-z\,{}^2P^\circ_{1\frac{1}{2}}$
2171·817		200R	46029·91	$m\,{}^2D_{1\frac{1}{2}}-8p\,{}^2P^\circ_{1\frac{1}{2}}$
2169·562		300R	46077·75	$m\,{}^2D_{1\frac{1}{2}}-8p\,{}^2P^\circ_{\frac{1}{2}}$
2165·093	IBu	1300R	46172·85	$4s\,{}^2S_{\frac{1}{2}}-z\,{}^2D^\circ_{1\frac{1}{2}}$
2154·31		2*h*(3)	46403·9	
2149·40		10*h*(3)	46509·9	
2142·72		5*h*(3)	46655	
2141·41		2*h*	46683·4	
2140·56		L.V.A. 2	46702·0	$m\,{}^2D_{2\frac{1}{2}}-5f\,{}^2F^\circ_{2\frac{1}{2}}$
2140·37		L.V.A. 1	46706·1	$m\,{}^2D_{2\frac{1}{2}}-5f\,{}^2F^\circ_{3\frac{1}{2}}$
2138·533	IBu	500R	46746·24	$m\,{}^2D_{2\frac{1}{2}}-7p\,{}^2P^\circ_{1\frac{1}{2}}$
2133·87		0*h*(2)	46848·4	
2130·762	C	50R	46916·72	$m\,{}^2D_{2\frac{1}{2}}-y\,{}^2yF^\circ_{2\frac{1}{2}}$
2124·35		5*h*(2)	47058·3	$4p\,{}^2P^\circ_{1\frac{1}{2}}-j\,{}^4P_{1\frac{1}{2}}$
2113·57		2*h*(2)	47298·3	
2113·26		2*h*(2)	47305·2	$4p\,{}^2P^\circ_{\frac{1}{2}}-j\,{}^4P_{1\frac{1}{2}}$
2111·20		0*h*(2)	47351·4	$m\,{}^2D_{1\frac{1}{2}}-10p\,{}^2P^\circ_{1\frac{1}{2}}$
2110·66		2*h*(2)	47363·5	
2105·112	C	800	47488·30	$m\,{}^2D_{2\frac{1}{2}}-y\,{}^2D^\circ_{1\frac{1}{2}}$
2079·529		20R	48072·48	$m\,{}^2D_{2\frac{1}{2}}-8p\,{}^2P^\circ_{1\frac{1}{2}}$
2068·321		5	48332·89	$4p\,{}^2P^\circ_{1\frac{1}{2}}-j\,{}^4F_{2\frac{1}{2}}$
2045·62		5*h*(4)	48869	$m\,{}^2D_{2\frac{1}{2}}-9p\,{}^2P^\circ_{1\frac{1}{2}}$
2024·335		200R	49382·95	$4s\,{}^2S_{\frac{1}{2}}-5p\,{}^2P^\circ$
λ (vac.)				
1825·348	C	100R	54784·06	$4s\,{}^2S_{\frac{1}{2}}-6p\,{}^2P^\circ_{1\frac{1}{2}}$
{1817·334		20	{55025·6	
{1817·265	C		{55027·74	$4s\,{}^2S_{\frac{1}{2}}-6p\,{}^2P^\circ_{\frac{1}{2}}$
1774·820	C	200R	56343·74	$4s\,{}^2S_{\frac{1}{2}}-y\,{}^2P^\circ_{1\frac{1}{2}}$
1764·540		10*h*	56672·0	$4s\,{}^2S_{\frac{1}{2}}-7s\,{}^2S_{\frac{1}{2}}$
1749·202		2	57168·9	$m\,{}^2D_{1\frac{1}{2}}-x\,{}^4F^\circ_{2\frac{1}{2}}$
1741·574	C	50R	57419·31	$4s\,{}^2S_{\frac{1}{2}}-7p\,{}^2P^\circ_{\frac{1}{2}}$
1732·674		20	57714·3	$m\,{}^2D_{1\frac{1}{2}}-x\,{}^2F^\circ_{2\frac{1}{2}}$
1731·32		2*h*(4)	57759	$m\,{}^2D_{1\frac{1}{2}}-x\,{}^4P^\circ_{\frac{1}{2}}$
1730·576		10	57784·2	$m\,{}^2D_{1\frac{1}{2}}-x\,{}^4D^\circ_{1\frac{1}{2}}$
1725·664	C	50R	57948·71	$4s\,{}^2S_{\frac{1}{2}}-7p\,{}^2P^\circ_{1\frac{1}{2}}$
1713·364	C	50R	58364·73	$4s\,{}^2S_{\frac{1}{2}}-y\,{}^2P^\circ_{\frac{1}{2}}$
1709·396		2	58500·2	$m\,{}^2D_{1\frac{1}{2}}-x\,{}^2D^\circ_{2\frac{1}{2}}$
1707·391		5*h*	58568·9	$4s\,{}^2S_{\frac{1}{2}}-8s\,{}^2S_{\frac{1}{2}}$
1703·843	C	30R	58690·86	$4s\,{}^2S_{\frac{1}{2}}-y\,{}^2D^\circ_{1\frac{1}{2}}$

TABLE 3 (*cont.*)

I wave-length	II authority and intensity	III intensity	IV wave-number	V identification
1701·292		10	58778·8	$m\,^2D_{1\frac{1}{2}}-x\,^2D^{\circ}_{1\frac{1}{2}}$
1692·654		5*h*(3)	59079	$m\,^2D_{2\frac{1}{2}}-x\,^4P^{\circ}_{1\frac{1}{2}}$
1691·076		30	59133·9	$m\,^2D_{2\frac{1}{2}}-x\,^4F^{\circ}_{3\frac{1}{2}}$
1688·865		15	59211·3	$m\,^2D_{2\frac{1}{2}}-x\,^4F^{\circ}_{2\frac{1}{2}}$
1688·093		30	59238·4	$m\,^2D_{2\frac{1}{2}}-x\,^4D^{\circ}_{3\frac{1}{2}}$
1687·043	C	20R	59275·33	$4s\,^2S_{\frac{1}{2}}-8p\,^2P^{\circ}_{1\frac{1}{2}}$
1685·682	C	25R	59323·17	$4s\,^2S_{\frac{1}{2}}-8p\,^2P^{\circ}_{\frac{1}{2}}$
1684·674		20*h*(2)	59358·6	$m\,^2D_{2\frac{1}{2}}-x\,^4D^{\circ}_{2\frac{1}{2}}$
1673·440		5	59757·1	$m\,^2D_{2\frac{1}{2}}-x\,^2F^{\circ}_{2\frac{1}{2}}$
1671·484		3	59827·0	$m\,^2D_{2\frac{1}{2}}-x\,^4D^{\circ}_{1\frac{1}{2}}$
1664·708		10R	60070·6	$4s\,^2S_{\frac{1}{2}}-9p\,^2P^{\circ}_{1\frac{1}{2}}$
1664·303		10R	60085·2	$4s\,^2S_{\frac{1}{2}}-9p\,^2P^{\circ}_{\frac{1}{2}}$
1655·318		30R	60411·3	$m\,^2D_{2\frac{1}{2}}-x\,^2F^{\circ}_{3\frac{1}{2}}$
1651·721		20R	60542·9	$m\,^2D_{2\frac{1}{2}}-x\,^2D^{\circ}_{2\frac{1}{2}}$
1650·301		5R	60595·0	$4s\,^2S_{\frac{1}{2}}-10p\,^2P^{\circ}_{1\frac{1}{2}}$
1650·119		5R	60601·7	$4s\,^2S_{\frac{1}{2}}-10p\,^2P^{\circ}_{\frac{1}{2}}$
1647·030		*h*(4)	60715	$m\,^2D_{2\frac{1}{2}}-x\,^2P^{\circ}_{1\frac{1}{2}}$
1640·474		5R	60958·0	$4s\,^2S_{\frac{1}{2}}-11p\,^2P^{\circ}$
1632·326		5	61262·3	$m\,^2D_{1\frac{1}{2}}-w\,^2D^{\circ}$
1621·316		20	61678·3	$m\,^2D_{1\frac{1}{2}}-w\,^2F^{\circ}_{2\frac{1}{2}}$
1616·940		20*h*	61845·2	$m\,^2D_{1\frac{1}{2}}-w\,^2P^{\circ}_{\frac{1}{2}}$
1585·871		5*h*	63056·8	$m\,^2D_{2\frac{1}{2}}-w\,^2P^{\circ}_{1\frac{1}{2}}$
1583·799		15	63139·3	$m\,^2D_{2\frac{1}{2}}-w\,^2F^{\circ}_{3\frac{1}{2}}$
1579·658		5	63304·9	$m\,^2D_{2\frac{1}{2}}-w\,^2D^{\circ}$
1553·89		0 ?	64355	
1523·851		0*h*	65623·2	
1523·371		1*h*	65643·9	
1522·252		0*h*	65692·1	
1504·091		0 ?	66485·3	