A Spectrum Analysis of Singly Ionized Cobalt.

Lehigh University Bethlehem, Pa.

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A SPECTRUM ANALYSIS
OF SINGLY IONIZED COBALT

By

Nathaniel Ellmaker Hager, Jr.

A DISSERTATION

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A SPECTRUM ANALYSIS OF SINGLY IONIZED COBALT

I. INTRODUCTION

Due in large part to its success in explaining observed spectral regularities, quantum mechanics is today generally accepted as the correct theoretical basis for dealing with atomic and molecular systems. As yet, however, the theory has not yet been developed to the point where the properties of complex systems can be calculated with an accuracy comparable to that of experimental determinations. Experimental spectroscopy continues, as it has in the past, to furnish the best available values for the energy states of particular systems and to provide a proving ground for further development of the theory. The problem of deducing values for the energy levels of particular atoms or molecules from spectral observations is the problem of the spectral analysis.

The analysis of the spectrum of singly ionized cobalt (Co II) was undertaken as the subject of the present thesis at the suggestion of the Spectroscopy Division, National Bureau of Standards. Of many possibilities, this spectrum was chosen because previous analyses were incomplete, because structures for the spectra of neighboring atoms and ions had been fairly well determined, and because it seemed reasonable to suppose that better measurements could be made.

With regard to previous analyses of Co II, the first regularities were reported by Meggers[1] in 1928. In 1930, Findlay[2] discovered a few new energy levels, and also made a study of Zeeman patterns which led to a revised classification for several of the levels located by Meggers. Among the new levels found by Findlay were the second members of two series, from which was calculated a value of 17.3 electron volts for the ionization potential. In all, about 200 lines, which determine the relative positions of 55 energy levels, had been identified before the present study was undertaken.

The following account of additions that have been made to the analysis, begins with a brief description of the experimental data employed. Next considered are the important electron configurations and resulting terms to be expected on the basis of theory. The electron configurations are then treated separately and it is pointed out, with supporting evidence, which of the expected terms have actually been found. Appendix I contains a diagram showing the relative positions of the new terms, while values for the individual energy levels are listed in Section VI.

1- W. F. Meggers, Journ. Wash. Ac. Sci., 18, 325 (1928)
2- J. H. Findlay, Phys. Rev., 36, 5 (1930)

II. OBSERVATIONS

During the course of the present investigation, two new sets of wave length measurements and intensity estimates have been made. Other unpublished experimental data that were available for extending the analysis included wave length measurements in the region from 5000 A to 2000 A made by Dr. Meggers, wave length measurements in the region from 2250 A to 1200 A furnished by Dr. Shenstone, and Zeeman observations made by Dr. Weeks.

One of the new sets of measurements was made from plates furnished by Dr. Kiess of the National Bureau of Standards, These plates cover the wave length region from 5200 A to 2200 A; a condensed spark was used to produce the excitation.

The other set of new measurements was made from spectrograms obtained by the author using a Schuler tube constructed especially for the purpose[3]. With neon in the tube, the spectrum was photographed from 6400 A to 2000 A with the 21 ft. concave grating spectrograph at Princeton University. Wave length measurements were made in the regions from 6400 A to 5000 A, and from 3000 A to 2000 A. These were the most accurate measurements available, not only because of the large dispersion of the

3- Details of the Schuler tube and accompanying apparatus are given in Appendix II.

spectrograph, but also because of the great sharpness of the lines produced when the Schuler tube is used as a source. It is apparent from examination of the array of known energy levels that these measurements are seldom inaccurate by more than 0.1 reciprocal centimeters. With helium in the Schuler tube, the spectrum was photographed from 2250 A to 800 A on the two-meter normal incidence vacuum spectrograph at Princeton, and measurements were made in the wave length region from 1900 A to 1400 A.

III. STRUCTURE OF THE SPECTRUM

Part A. of the present section considers the general energy level structure of Co II to be expected on a basis of theory. It contains a list of the terms that could result from each of the important electron configurations and indicates which of these terms have been found. Details of the analysis are discussed in Part B., where the structure of each electron configuration is treated individually.

An energy level diagram is provided in Appendix I. which may be unfolded, and thus made available for continuous reference. This diagram indicates the relative positions of the known terms and it is included primarily to accompany the following discussion.

A. THEORY

The once ionized cobalt atom possesses twenty-six electrons. Eighteen of these are in closed shells resembling the electron structure of argon, leaving eight outer electrons which are active in producing the optical spectrum.

Application of the _Aufbauprinzip_ of Bohr[4] shows that

4- H. E. White, "Introduction to Atomic Spectra", p. 79, McGraw-Hill (1934) the lowest configurations of these eight electrons should be $3d^8$, $3d^7 4s$, amd $3d^6 4s^2$. Higher configurations should result from an increase in the quantum numbers n or l associated with one or more of the electrons. Of many possible higher configurations, terms have been found for $3d^7 4p$, $3d^7 5s$ and $3d^6 4s4p$. The gross structure of the spectrum, as indicated by the relative positions of the various configurations, is shown schematically in the diagram of Appendix I., where the main structural components are enclosed within dashed-line frames.

In Table I. are listed the terms that, according to theory, should arise from each of the electron configurations if it is assumed that there is Russell-Saunders coupling between the electrons. Each Co II term listed is one of a series that converges to a limit which is the Co III term heading the column in the table. For example, the $3d^7 4s$ ^5F term of Co II is the lowest member of a series converging to the limit ^4F, which is a term in the $3d^7$ configuration of Co III.

Most of the terms which have been established are preceded in the table by small letters in accordance with the usual scheme[5]. The unassigned energy levels listed

5- H. N. Russell, A. G. Shenstone, L. A. Turner, Phys. Rev., 33, 900 (1929) in Table XIII may belong to those terms which are prefixed with a question mark.

In accordance with Pauli's exclusion principle , the $3d^8$ configuration is expected to give rise to fewer terms than one might otherwise expect. In this case, limit structure cannot be unambiguously assigned to the terms.

Table I.

TERMS ARISING FROM THE ELECTRON
CONFIGURATIONS OF CO II

Co III	$3d^7$	^4F	^4P	^2H	^2G	^2F	a^2D	^2P	b^2D
Added Electron	4s	a^5F b^3F	a^5P b^3P	a^3H ^1H	a^3G ^1G	^3F ^1F	a^3D ^1D	c^3P ^1P	^3D ^1D
Co II	4p	z^5D^o z^5F^o z^5G^o z^3D^o z^3F^o z^3G^o	z^5S^o z^5P^o y^5D^o z^3S^o $?^3P^o$ y^3D^o	x^3G^o z^3H^o $^3I^o$ $^1G^o$ $^1H^o$ $^1I^o$	y^3F^o y^3G^o $^3H^o$ $^1F^o$ $^1G^o$ $^1H^o$	$?^3D^o$ $?^3F^o$ $?^3G^o$ $^1D^o$ $^1F^o$ $^1G^o$	$?^3P^o$ $?^3D^o$ $?^3F^o$ $^1P^o$ $^1D^o$ $^1F^o$	$?^3S^o$ $?^3P^o$ $?^3D^o$ $^1S^o$ $^1P^o$ $^1D^o$	$?^3P^o$ $?^3D^o$ $?^3F^o$ $^1P^o$ $^1D^o$ $^1F^o$
	5s	e^5F e^3F	^5P ^3P	^3H ^1H	^3G ^1G	^3F ^1F	^3D ^1D	^3P ^1P	^3D ^1D
Co III	$3d^64s$	^6D	a^4D		(7 quartets and 15 doublets)				
	4s	a^5D			(quintets, triplets, and singlets based on above limits)				
Co II	4p	$^7P^o$ $^7D^o$ $^7F^o$ y^5P^o x^5D^o y^5F^o	$^5P^o$ $^5D^o$ $^5F^o$ $:^3P^o$ $:^3D^o$ $:^3F^o$		(quintets, triplets, and singlets based on above limits)				
Co III	$3d^7$	(See text on page 7)							
Co II	3d	a^3F	a^3P	^1S	^1D	^1G			

? - unassigned levels may be part of term
: - letter not assigned to term

B. DETAILS OF THE ANALYSIS

The low configurations of the spectrum will be discussed individually. Although terms discovered by earlier workers will be mentioned, only the new terms found during this analysis will be treated in detail. Since no singlets have been established, they will be omitted from the following discussion.

THE $3d^8$ CONFIGURATION

As shown in Table I., this configuration should give rise to two triplets. The ^3P term was found during the present analysis, while the ^3F term was found by Findlay. According to Hund's rule, the ^3F term should be lower than the ^3P term, and reference to Table XIII. will show that the terms do occur in this order. Since the ^3F term provides the lowest series limit for the Co I spectrum[6], it is not surprising that Findlay found this triplet to be the lowest term in Co II.

6- H. N. Russell, A. S. King, and C. E. Moore, Phys. Rev., 58, 407 (1940)

Table II[7] indicates the number of combinations and the number of Zeeman patterns helping to establish each level of the new term a^3P.

Table II.

NEW TERM IN $3d^8$ CONFIGURATION

TERM	J	NUMBER OF COMBINATIONS	NUMBER OF ZEEMAN PATTERNS	ZEEMAN IDENTIFICATION
a^3P	2	21	2	
	1	17	1	$^3P_1$
	0	9	1	$^3P_0$

Evidence from the Zeeman patterns does not conclusively establish the identity of the level which has the highest J-value, because the available patterns are too poorly resolved. But the patterns do not disagree with the identification made by the usual method of wave number differences and intensity rules. (See Table XII)

7- If resolved Zeeman patterns provide identification of a level, the last column in the table lists this identification. If no entry appears in the last column, the patterns have not been unambiguously interpreted. The Zeeman patterns are treated more fully in Section V, and the identified combinations are tabulated in Section VII.

THE $3d^7 4s$ CONFIGURATION

Three new triplets have been established and two more have been tentatively established in this group. Table I shows that only one ^3F and one ^3D have not yet been found, and by means of isoelectronic sequences such as those shown in a later part of this report, it can be shown that these two triplets should be higher in the energy level diagram than the others in this group. This should make them harder to find than the lower terms, because the spectral lines required to establish them may be expected to be much weaker in intensity than those used to establish the lower terms.

Table III[8] shows the number of combinations and the number of Zeeman patterns helping to establish each level of the new terms. From the table it is apparent that the terms b^3P, c^3F, and a^3D are quite well established because of the large number of combinations, but that the terms a^3G and a^3H are tentative. The term a^3G is especially questionable because some Zeeman patterns do not completely agree with this assignment. This matter is discussed more fully in Section V.

8- For explanation of this table, see footnote 7; this explanation pertains to the succeeding tables of the same type.

Table III.

NEW TERMS IN THE $3d^7 4s$ CONFIGURATION

TERM	J	NUMBER OF COMBINATIONS	NUMBER OF ZEEMAN PATTERNS	ZEEMAN IDENTIFICATIONS
b^3P	2	23	3	$^3P_2$
	1	19	2	
	0	12	2	$^3P_0$
c^3P	2	17	3	
	1	18	1	
	0	9	1	
a^3D	3	15	2	$^3D_3$
	2	20	1	$^3D_2$
	1	17		
a^3G?	5	4	1	
	4	6	2	$^3G_4$
	3	2		
a^3H	6	4	2	
	5	6	1	$^3H_5$

THE $3d^7 4p$ CONFIGURATION

Six new terms arising from this configuration have been found during this analysis. Six quintets and three triplets were previously reported by Meggers and Findlay. All of the terms based on the ^4F and ^4P limits have been established with the possible exception of $3d^7(^4P)4p\ ^3P^o$. Four of the new triplets belong to the group of terms based on the doublet limit structure. (See Table I.)

In addition to the six new terms, sixteen unassigned levels have been found, five of these being located in the region where the above mentioned term, $3d^7\ (^4P)4p\ ^3P^o$, should be found[9]. It is presumed that the remainder of the sixteen unassigned levels are parts of those terms which have been preceded by a question mark in Table I.

Table IV shows that, of the six new triplets, only $^3D^o$ and $^3S^o$ are well established. The term y^3G^o is especially questionable because two Zeeman patterns do not completely agree with this assignment. This matter is discussed more fully in Section V.

9- The five levels mentioned have been named $^32^o_0$, $^33^o_2$, $^34^o_1$, $^35^o_2$, and $^36^o_1$, and they are listed in Table XIII. As indicated in Table V, they all could be ^3P levels, judging from evidence drawn from Zeeman patterns and studies of their selection of levels with which to combine.

Table IV.

NEW TERMS IN THE $3d^7 4p$ CONFIGURATION

TERM	J	NUMBER OF COMBINATIONS	NUMBER OF ZEEMAN PATTERNS	ZEEMAN IDENTIFICATION
$y\,^3F^o$	4	5	1	
	3	6	1	
	2	4		
$y\,^3G^o$?	5	4		
	4	5	1	$^3G_4$
	3	4		
$x\,^3G^o$	5	4	1	
	4	3	1	
$z\,^3H^o$	6	3	1	$^3H_6$
$y\,^3D^o$	3	9	2	
	2	14	2	
	1	10		
$z\,^3S^o$	1	11	2	$^3S_1$

Table V lists the sixteen unassigned levels, and it is emphasized that the identifications listed in the last column of the table are quite tentative. It should also be understood that, because of the small number of combinations fixing several of these levels, there is a distinct possibility that some of them may not be real.

Table V.

NEW UNASSIGNED LEVELS

LEVEL	J	NUMBER OF COMBINATIONS	NUMBER OF ZEEMAN PATTERNS	TENTATIVE IDENTIFICATIONS
3_{2}^{o}	0	4		$^3P_0$
3_{3}^{o}	2	8	3	$^3P_2$ or $^3D_2$
3_{4}^{o}	1	7	2	$^3P_1$
3_{5}^{o}	2	9	3	$^3P_2$
3_{6}^{o}	1	8	1	$^3P_1$
3_{7}^{o}	3	6		$^3D_3$
3_{8}^{o}	3	4	1	$^3D_3$
3_{9}^{o}	2	7		$^3P_2$
3_{10}^{o}	2	3		$^3D_2$
3_{11}^{o}	1	2		$^3D_1$
3_{12}^{o}	1	5		$^3P_1$
3_{13}^{o}	0	3		$^3P_0$
3_{14}^{o}	2	5		$^3P_2$
3_{15}^{o}	1	5		$^3P_1$
3_{16}^{o}	1	7		$^3P_1$
3_{17}^{o}	0	2		$^3P_0$

There are two reasons for difficulty in grouping these levels into complete terms. First, on the basis of iso-electronic sequence predictions, many terms are expected to fall within a small energy region. This suggests the possibility that the J-levels of two or more terms may be interposed, making it difficult to assign these levels to particular terms on the basis of their relative positions. Second, most of the levels are established by a relatively small number of combinations, and it is consequently difficult to deduce the J and L values of the new levels by application of the selection rules.

There are two reasons why the number of combinations establishing the new levels is small. First, most of these levels must belong to terms based on the doublet limit structure, and they combine so weakly with the established terms based on the quartet limit structure that many of the satellites are missing. Second, many of the lines essential to performing this phase of the analysis fall in a wave length region where they are likely to be hidden by lines of the arc spectrum. Both of these difficulties are illustrated in Table VI, where it is shown how the even term a^3D, which is based on the doublet limit structure, combines with the odd terms z^3F^o, z^3D^o, and y^3D^o, which are based on the quartet limit structure. In this case, because of other combinations, there can be little doubt about the assignments.

Table VI.

WEAK INTER-SYSTEM COMBINATIONS

		z^3F^o			z^3D^o			y^3D^o		
		4	3	2	3	2	1	3	2	1
	1			1		-	10		0	0
a^3D	2		2	2	3	15	CoI	0	3	2
	3	10	CoI	-	50	-		10	-	

The intensities in Table VI were estimated according to an arbitrary scale on which 200 represents the intensity of the brightest lines in the spectrum and 0 represents the intensity of lines which are so weak that they can just barely be observed. It is apparent that the above combinations are weak, and it is not surprising that some of the satellites are missing. Two of the satellites coincide with and may be obscured by arc lines. In the wave length region from 5000 A to 3000 A, where the lines arising from these combinations are found, the plates are so blackened with lines that it is certain that many of them are hidden by or blended with others.

For the same reasons it is difficult to establish combinations between the odd terms of the doublet limit system and the even terms $b\,^3F$ and $b\,^3P$ of the quartet limit system. These odd terms also combine poorly with the even terms $a\,^3P$ and $a\,^3F$ and the $3d^8$ configuration.

THE $3d^7 5s$ CONFIGURATION

The second series members $e\,^3F$ and $e\,^5F$ were established by Findlay, the first series members being the terms $3d^7(^4F)4s\ b\,^3F$ and $3d^7(^4F)4s\ a\,^5F$ respectively.

It is in connection with higher series members such as these that the Schuler tube source should prove particularly useful. The new plates did, in fact, reveal 14 lines not observed by Findlay, representing transitions from e^3F and e^5F to lower terms. Not only was the identity of these terms more firmly established by the combinations involving the new lines, but also the energy values of the levels were determined more accurately because the Schuler tube **yields** sharper lines than the spark source used by Findlay. The lines produced by the condensed spark are known to be not only very broad and fuzzy, but also to be asymmetric in such a way as to introduce at times a consistent error in wave length measurements. Table VII compares Findlay's term values with the revised term values.

Table VII.

ADJUSTMENT OF FINDLAY'S ENERGY VALUES

TERM	J	FINDLAY'S VALUES Cm^{-1}	REVISED VALUES Cm^{-1}	DIFFERENCE Cm^{-1}
e^5F	5	84012.3	84013.70	1.4
	4	84584.8	84586.35	1.6
	3	85165.3	85167.10	1.8
	2	85593.9	85595.70	1.8
	1	85874.1	85875.84	1.7
e^3F	4	85479.2	85481.07	1.9
	3	86343.8	86346.19	2.4
	2	86937.7	86939.60	1.9

Attempts at finding third members of these series, using the wave length measurements from the Schuler tube, were not successful. Even the second series members of the two series whose lowest members are b^3P and a^5P were not established. This was disappointing in view of the expected enhancement in the Schuler tube of lines associated with these upper terms. A search was also made to locate terms in the $3d^7 4d$ configuration, but here again there was no success.

THE $3d^6 4s^2$ CONFIGURATION

Although this is the lowest configuration in Fe I, it is quite high in Co II, and prior to this analysis none of its levels were known. Of the terms arising from the configuration, only the ^5D has been found. According to Table I, there should also be triplets, but they are predicted to be higher than 80,000 cm^{-1} above the normal state, and have not been established.

Predictions (made by the method described in Section IV) indicate that the ^5D term should fall within a few thousand wave numbers of 37,500 cm^{-1}. The new term was actually found to be at 41,000 cm^{-1}. The new wave length measurements needed for establishing this term were taken from Kiess' plates in the wave length region above 5000 A.

Table VIII shows the number of combinations establishing each level of the new term. No Zeeman data were available in the wave length region above 5000 A.

Table VIII

NEW TERM IN THE $3d^6 4s^2$ CONFIGURATION

TERM	J	NUMBER OF COMBINATIONS
a^5D	4	10
	3	14
	2	11
	1	7

THE $3d^6 4s4p$ CONFIGURATION

There should be a large number of septets, quintets, triplets and singlets in this configuration, but space has been taken in Table I for listing only a small group of these terms because so few of them have been established. The terms which have been established are listed in Table IX.

Table IX.

THE NEW TERMS IN THE $3d^6 4s4p$ CONFIGURATION

TERM	J	NUMBER OF COMBINATIONS
x^5D^o	4	5
	3	4
	2	4
	1	3
	0	1
y^5F^o	5	3
	4	3
	3	3
	2	2
y^5P^o	3	3
	2	3
	1	2
$^3D^o$	3	2
	2	3
$^3F^o$	4	2
	3	2
	2	2
$^3P^o$	2	3
	1	3

Although the table shows that the levels are not well established as far as the number of combinations is concerned, confidence in the reality of both the quintet and the triplet terms may be gained by examination of the line list in the vacuum region, where the lines used in establishing these terms are found. In this region there is a large average wave length interval between lines, and an unusually large percentage of these lines arise from combinations involving the new multiplets.[10] The importance of this is that the paucity of lines reduces the chance of finding by coincidence the proper wave number differences for establishing terms.

UNASSIGNED TERMS

Table X indicates the number of combinations helping to establish some terms which were found near 100,000 cm^{-1} above the ground state. These terms could belong to the $3d^6 4s4p$, $3d^7 4f$, or $3d^7 5p$ configurations, but it is not possible at present to make a configuration assignment.

TABLE X.

NEW UNASSIGNED TERMS

TERM	J	NUMBER OF COMBINATIONS
x^5F^o	5	2
	4	4
	3	4
	2	4
v^5D^o	4	6
	3	5
	2	2
w^5D^o	4	3
	3	3
	2	2

10- See Appendix III.

IV. COMPARISONS WITH NEIGHBORING SPECTRA

A. ISOELECTRONIC SPECTRA

If, by ionization, one electron is removed from the cobalt atom and two are removed from the nickel atom, then both have the same number of electrons as neutral iron, and the three elements form an isoelectronic sequence. Because they have the same electron configurations, the three atoms should give rise to similar **spectra** and systems of energy levels.

This similarity affords a method of using data taken from the analyses of Fe I[11] and Ni III[12] both for predicting the energy values of unknown Co II terms relative to the established system of levels, and for substantiating the identity of terms which have already been established.

Use of the familiar Mosley diagram for studying isoelectronic sequences is suggested by Hertz's relation

$$T = \frac{R(Z - \sigma)^2}{n^2} \qquad (1)$$

where T is called the term value, and is the energy difference between a term in a given series and the limit of that series. R is the Rydberg constant, Z is the atomic number, n is the principle quantum number of the valence

11- H. N. Russell and C. E. Moore, Trans. Am. Phil. Soc., 34, 113 (1944)
12- A. G. Shenstone, unpublished material (1950)

electron, and σ is the so-called screening constant, which accounts for the reduction of the effectiveness of the nuclear charge due to the presence of all of the electrons other than the valence electron. It is possibly misleading that σ is called a constant because it has different values for the different terms in the spectrum of one atom, and it has different values for corresponding terms in different atoms.

Transposing equation (i) and taking the square root of both sides gives the expression

$$\sqrt{\frac{T}{R}} = \frac{Z - \sigma}{n} \qquad \text{(ii)}$$

To make a Mosley diagram, values of $\sqrt{T/R}$ are plotted as ordinates and values of Z are plotted as abscissae. According to equation (ii) such a diagram may produce straight lines, provided that the behavior of σ does not upset the linear relationship between the variables.

Gibbs and White[13] have made an extensive study of isoelectronic sequences in complex spectra, and their Mosley diagrams show lines which are not only quite straight, but also, for those terms having the same value of n, the lines are parallel with each other. The parallelism requires that the difference between values of σ for two

13- R. C. Gibbs and H. E. White, Phys. Rev., 29, 426 (1927), Phys. Rev., 29, 655 (1927), and Proc. Nat. Acad. Sci., 13, 525 (1927) terms be the same for all elements in the sequence, and the straightness of the lines requires that if σ varies with Z for a given term, this variation must be linear with respect to changes in Z.

The energy difference between two terms belonging to the same element and having the same value of n may be written

$$T_1 - T_2 = \frac{R}{m^2}\left[(Z-\sigma_1)^2 - (Z-\sigma_2)^2\right]$$

$$= \frac{R(\sigma_1 - \sigma_2)}{m^2}\left[Z + (\sigma_1 + \sigma_2)\right]$$

If $(\sigma_1 - \sigma_2)$ is constant and if $(\sigma_1 + \sigma_2)$ is a linear function of Z, as suggested by the parallel and straight lines on the Mosley diagram, then we may write

$$T_1 - T_2 = AZ + B \qquad \text{(iii)}$$

where A and B are constants for a given value of n, which do not depend on Z.

Therefore, as a substitute for plotting the Mosley diagram, graphs of the type shown in Figs. 1 and 2 may be used. The particular advantage of this type of plot is that it may be made without knowledge of the position of the series limits, and it is used here because the limit structures of Co II and Ni III are not yet well established.

In the diagrams shown, the term which lies lowest in the Co II spectrum has been arbitrarily assigned an energy level value of zero in all three spectra, and the energy differences between this term and the other terms in the same configuration have been plotted with respect to the same scale for all three elements.

Since the individual J-levels of each term would not be resolved in drawings made to the scale shown in the figures, a single point has been plotted to represent the "center of gravity" of the terms. The energy value of the center of gravity of a term having more than one J-level is computed from the equation

$$E_c = \frac{\sum_J E_J(2J+1)}{\sum_J (2J+1)}$$

where E_c is the energy value of the center of gravity and E_J is the energy value of an individual J-level.

Although all of the new terms found in Co II except $3d^8\ {}^3P$ have been found in Fe I, only a few have been reported in the case of Ni III. Fig. 1 shows that straight lines are obtained for the two new terms $3d^7({}^2G)4s\ {}^3G$, and $3d^7({}^4P)4s\ {}^3P$. Fig. 2 shows a straight line for the term $3d^7({}^2G)4p\ {}^3G^o$, and a line for the term $3d^7({}^2G)4p\ {}^3F^o$ which is no less straight than are the lines for several of the better established terms.

Fig. 1

ISOELECTRONIC SEQUENCE DIAGRAM FOR EVEN TERMS

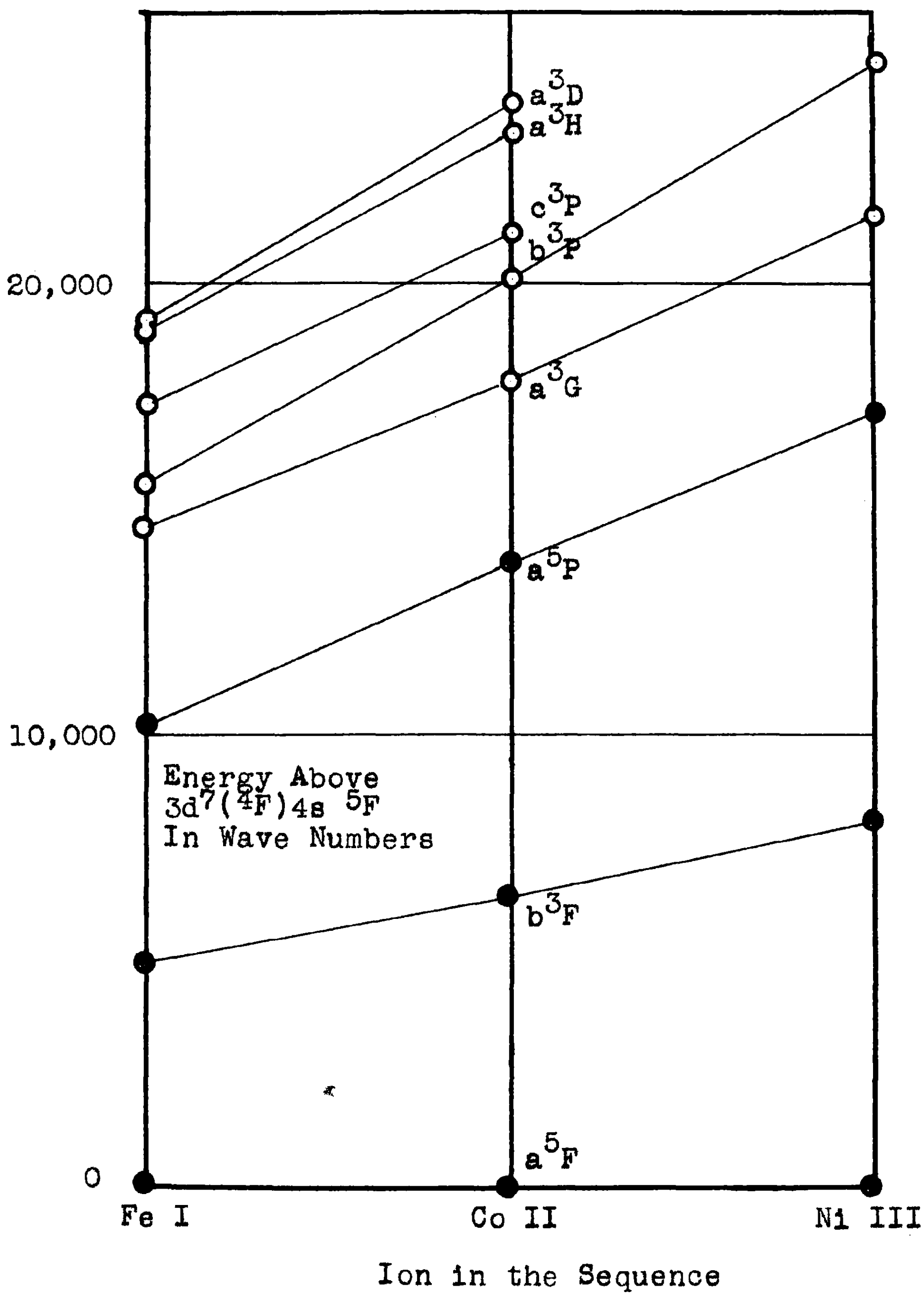
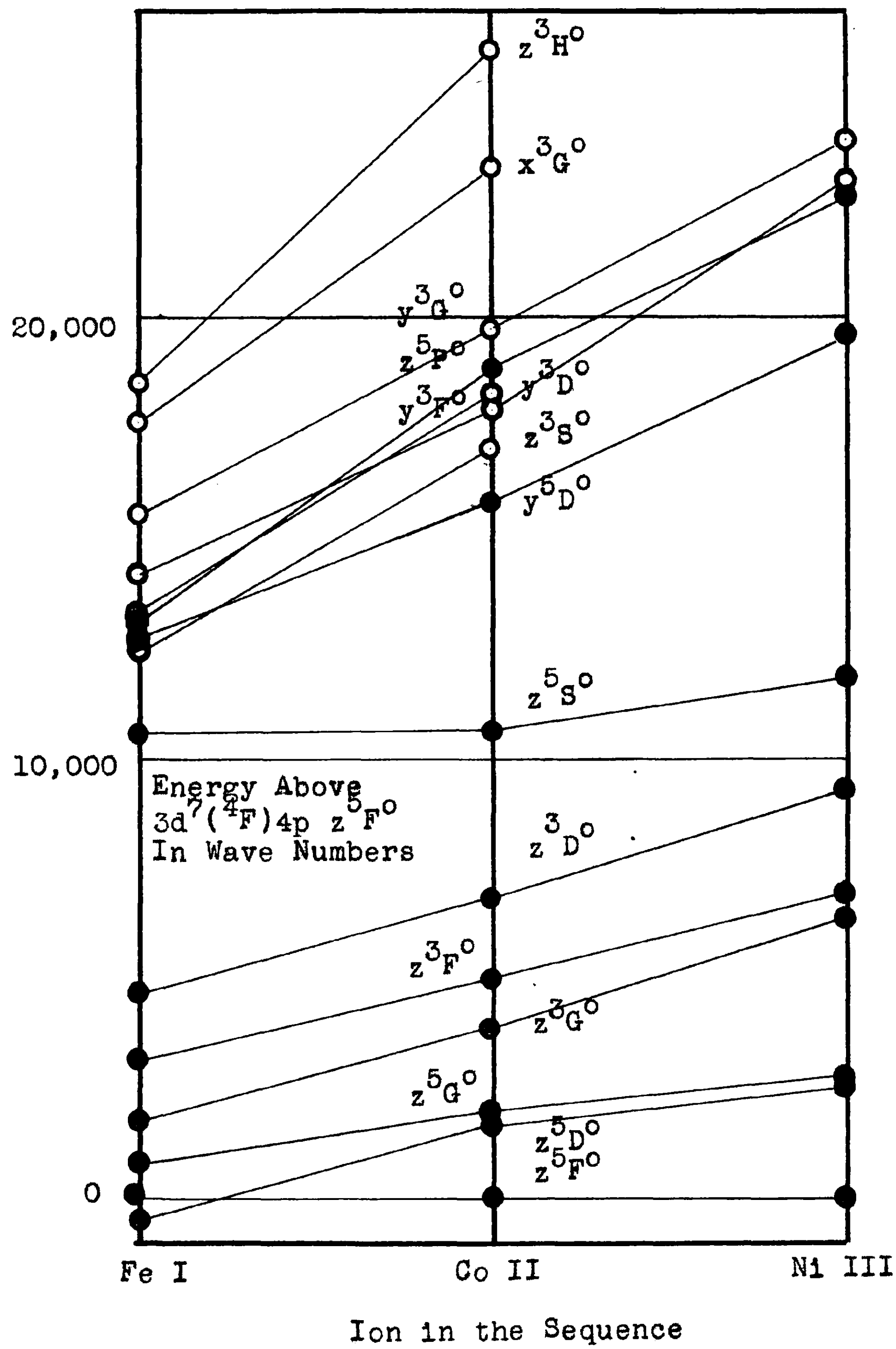


Fig. 2

ISOELECTRONIC SEQUENCE DIAGRAM FOR ODD TERMS



The isoelectronic sequence drawings do not positively confirm or deny the correctness of the term identifications, but it is encouraging to note that terms in the three spectra are located as expected from Hertz's formula and from implications drawn from the isoelectronic studies of Gibbs and White.

Additional similarities may be shown to exist between the term of Fe I, Co II, and Ni III by comparing the intervals between the levels of the same term in each of the three spectra. Table XI is devoted to such a comparison. The intervals between the levels of each term have been tabulated for the three spectra, and two other columns indicate the ratios of the intervals in one spectrum to those in the psectrum of the neighboring atom in the isoelectronic sequence. The comparisons show striking consistencies in many cases, and this material is included because it helps confirm the identity of terms which have been established in the $3d^6 4s4p$, $3d^6 4s^2$, $3d^7 5s$, and $3d^7 4s$ groups.

There are discrepancies in the case of the terms in the $3d^7 4p$ configuration, but these irregularities may be caused by perturbations arising from the fact that there are so many terms crowded into such a small energy region.

Although the nature of this perturbation is discussed by White[14], it will be briefly stated here that if two levels, belonging to the same or to different configurations, have approximately the same energy value, the same parity, and the same J value, then there may be an apparent repulsion between the two levels. The displacement of the two levels will cause a rearrangement of the intervals in both terms, and hence lead to irregularities of the type seen in Table XI.

As an example, the intervals in the terms $3d^7(^4F)4p\ ^5F^o$, $3d^7(^4F)4p\ ^5G^o$, and $3d^7(^4P)4p\ ^5D^o$ are subject to this type of perturbation. Since the terms of the $3d^7 4p$ and the $3d^6 4s4p$ configurations of Fe I fall in the same energy level region and since both configurations include a very large number of terms, it seems reasonable that the repulsion effect should cause irregularities when the intervals within the terms in this spectrum are compared with those within the terms of the Co II spectrum, where the $3d^7 4p$ and the $3d^6 4s4p$ configurations do not fall in the same energy region.

14- H. E. White, op. cit., p. 390

Table XI.

MULTIPLET INTERVAL COMPARISONS

CONFIG.	DESIG.	J	FE I DIFF.	RATIO	CO II DIFF.	RATIO	NI III DIFF.
$3d^8$	a^3F	4					
			539.1	1.8	950.28	1.4	1360.7
		3					
			352.6	1.8	647.15	1.4	908.9
		2					
$3d^7(^4F)4s$	a^5F	5					
			448.5	1.5	678.53	1.4	954.2
		4					
			351.3	1.5	531.84	1.4	748.2
		3					
			257.6	1.5	389.25	1.4	545.9
		2					
			168.9	1.5	254.61	1.4	356.2
		1					
$3d^7(^4F)4s$	b^3F	4					
			584.7	1.5	895.58	1.4	1267.0
		3					
			407.6	1.5	613.53	1.4	866.3
		2					
$3d^8$	a^3P	2					
					143.66	2.2	316.2
		1					
					188.93	1.3	252.9
		0					
$3d^7(^4P)4s$	a^5P	3					
			176.8	1.5	259.9	1.2	260.0
		2					
			200.4	1.5	307.2	1.5	307.0
		1					
$3d^7(^2G)4s$	a^3G	5					
			283.4	1.4	384.7?	1.4	523.1
		4					
			250.3	0.8	217.3?	2.7	590.9
		3					

Table XI. (Continued)

CONFIG.	DESIG.	J	FE I DIFF.	RATIO	CO II DIFF.	RATIO	NI III DIFF.
$3d^7(^4P)4s$	b^3P	2					
			108.5	1.8	193.1		
		1					
			104.9	1.4	143.8		
		0					
$3d^7(^2P)4s$	c^3P	2					
			436.3	1.0	431.4		
		1					
			319.6	1.7	543.8		
		0					
$3d^7(^2H)4s$	a^3H	6					
			245.1	1.5	363.4		
		5					
			276.6				
		4					
$3d^7(^2D)4s$	a^3D	3					
			398.7	1.6	627.4		
		2					
			-217.2	2.4	-526.5		
		1					
$3d^6 4s^2$	a^5D	4					
			415.9	1.5	619.0		
		3					
			288.1	1.5	424.0		
		2					
			184.1	1.5	270.8		
		1					
			89.9				
		0					

Table XI. (Continued)

CONFIG.	DESIG.	J	FE I DIFF.	RATIO	CO II DIFF.	RATIO	NI III DIFF.
$3d^7(^4F)5s$	e^5F	5					
			372.5	1.5	572.65		
		4					
			377.6	1.5	580.75		
		3					
			281.1	1.5	428.60		
		2					
			184.7	1.5	280.14		
		1					
$3d^7(^4F)5s$	e^3F	4					
			570.9	1.5	865.12		
		3					
			396.5	1.5	593.41		
		2					
$3d^7(^4F)4p$	z^5F^o	5					
			344.1	0.5	181.06	0.9	158.7
		4					
			289.2	2.0	593.23	1.4	849.8
		3					
			218.5	2.2	480.76	1.4	693.2
		2					
			144.9	2.3	333.64	1.4	487.4
		1					
$3d^7(^4F)4p$	z^5D^o	4					
			411.2	1.7	718.30	1.4	1036.8
		3					
			294.4	1.7	498.36	1.4	715.7
		2					
			215.5	1.4	311.39	1.4	444.4
		1					
			104.5	1.4	146.77	1.4	199.8
		0					

Table XI. (Continued)

CONFIG.	DESIG.	J	FE I DIFF.	RATIO	CO II DIFF.	RATIO	NI III DIFF.
$3d^7(^4F)4p$	z^5G^o	6					
			-61.5	-4.4	267.29	1.3	353.4
		5					
			474.9	1.0	461.66	1.2	564.2
		4					
			354.3	1.0	343.40	1.2	404.9
		3					
			244.8	1.0	237.43	1.1	260.9
		2					
$3d^7(^4F)4p$	z^3G^o	5					
			388.4	2.0	792.35	1.8	1402.0
		4					
			311.8	2.2	687.94	1.2	868.6
		3					
$3d^7(^4F)4p$	z^3F^o	4					
			476.6	1.6	684.01	1.6	1058.9
		3					
			358.4	1.5	532.73	1.6	864.3
		2					
$3d^7(^4F)4p$	z^3D^o	3					
			502.7	1.4	717.49	1.3	924.3
		2					
			317.7	1.4	454.88	1.3	602.7
		1					
$3d^7(^4P)4p$	y^5D^o	4					
			24.2	-6.1	-147.6	2.4	-358.4
		3					
			143.5	0.1	19.7	-2.0	-41.1
		2					
			288.7	0.3	89.9	0.5	44.8
		1					
			-5.73	-18.7	107.6		
		0					

Table XI. (Continued)

CONFIG.	DESIG.	J	FE I DIFF.	RATIO	CO II DIFF.	RATIO	NI III DIFF.
$3d^7(^4P)4p$	z^5P^o	3					
			196.9	0.1	23.0	4.8	109.4
		2					
			126.4	2.4	298.0		
		1					
$3d^7(^4P)4p$	y^3D^o	3					
			118.9	0.2	29.1		
		2					
			136.0	1.8	249.2		
		1					
$3d^7(^2G)4p$	y^3F^o	4					
			203.6	4.2	850.0	1.6	1365.9
		3					
			104.3	6.0	657.0	1.6	1074.4
		2					
$3d^7(^2G)4p$	y^3G^o	5					
			167.0	4.5	752.4?	1.0	723.6
		4					
			222.7	0.1	20.6?		
		3					
$3d^7(^2H)4p$	x^3G^o	5					
			294.3	2.2	640.4?		
		4					
			157.6				
		3					
$3d^64s(^6D)4p$	x^5D^o	4					
			240.2	1.0	243.7		
		3					
			199.5	1.2	245.7		
		2					
			139.7	1.3	182.7		
		1					
			71.1	1.3	95.4?		
		0					

Table XI. (Continued)

CONFIG.	DESIG.	J	FE I DIFF.	RATIO	CO II DIFF.	RATIO	NI III DIFF.
$3d^6 4s(^6D)4p$	$y\,^5F^o$	5					
			292.3	1.3	373.1		
		4					
			227.9	1.3	284.3		
		3					
			164.9	2.0	332.0		
		2					
			106.7				
		1					
$3d^6 4s(^6D)4p$	$y\,^5P^o$	3					
			412.7	1.6	668.4		
		2					
			263.7	1.6	421.7		
		1					
$3d^6 4s(a\,^4D)4p$	$^3D^o$	3					
			363.7	1.4	508.7		
		2					
			251.0				
		1					
$3d^6 4s(a\,^4D)4p$	$^3F^o$	4					
			497.8	1.6	784.7		
		3					
			328.9	1.6	521.3		
		2					
$3d^6 4s(a\,^4D)4p$	$^3P^o$	2					
			415.9	1.4	586.8		
		1					
			192.8				
		0					

B. HOMOLOGOUS SPECTRA

Those elements of the first long period which are immediate neighbors of cobalt in the periodic table give rise, when singly ionized, to the configurations $3d^n$, $3d^{n-1}4s$, and $3d^{n-2}4s^2$. These elements are said to form a homologous sequence.[15]

If, for each member of this sequence, the lowest lying level in each configuration is plotted with respect to the lowest level in the $3d^n$ configuration of the same element, as shown in Fig. 3[16], there is sufficient regularity to provide a basis for predicting the approximate position of the $3d^6 4s^2$ configuration of Co II.

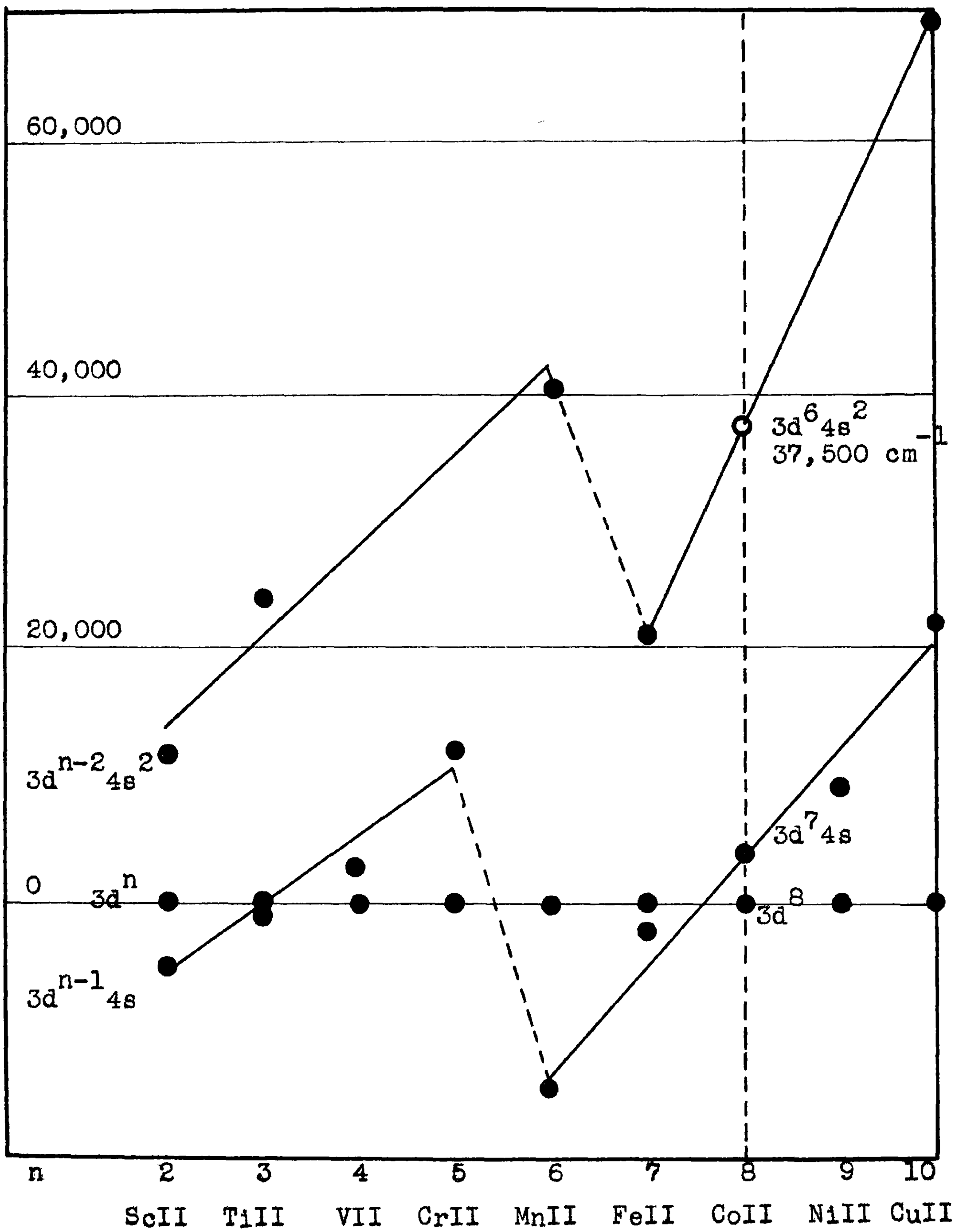
In the figure it is seen that this configuration should fall at an energy level which is higher than the level of the $3d^8$ configuration by about 37,000 wave numbers, with a possible error of a few thousand wave numbers.

15- For further illustration see H. E. White, op. cit., pp. 277-78.

16- Data for other elements obtained from R. F. Bacher and S. Goudsmit, "Atomic Energy States", McGraw-Hill (1932).

Fig. 3

HOMOLOGOUS SEQUENCE



Elements in Sequence

V. ZEEMAN PATTERNS

Weeks has observed Zeeman patterns for some of the newly identified lines. In Table XII, data from these observed patterns are compared with values calculated from the Lande theory. In cases where no assignment has been made to one of the two energy levels involved in a combination, no comparison with theory is possible, and only the observed data have been tabulated.

In the third column of the table, "O" designates the experimentally observed pattern, and "C" designates the pattern calculated from theory. The numbers enclosed within parentheses represent measurements of the intervals between the components of the pattern obtained when the observations are made along a line parallel with the magnetic field, and the numbers outside the parentheses represent the measurements obtained when the observations are made along a line perpendicular to the field.

There are several cases in which the observed pattern does not fully agree with that expected from theory. Because the plates were not available for further examination, it was not possible to reconcile these discrepancies completely, and the remarks in the last column of the table are necessarily speculative.

Table XII.

ZEEMAN PATTERN COMPARISONS

WAVELENGTH	COMBINATION	ZEEMAN PATTERN	REMARKS
4160.69 A.	$a^3D_3 - z^3D^o_3$	O(0.00)1.32 C(0.00)1.33	
4145.15	$a^3D_2 - z^3D^o_2$	O(0.00)1.17 C(0.00)1.17	
3754.71	$b^3P_2 - z^3D^o_3$	O(0.02,0.16, -)0.90,1.07, 1.25, - , - C(0.00,0.17,0.3)1.00,1.17, 1.33, 1.50,1.67	Missing components should be weak according to selection rules
3553.93	$b^3P_0 - z^3D^o_1$	O(0.00)0.50 C(0.00)0.50	
2636.04	$a^3D_3 - {}^35^o_2$	O(0.00)1.11	
2628.80	$b^3P_0 - z^3S^o_1$	O(0.00)2.04 C(0.00)2.00	
2613.51	$a^3P_2 - z^3D^o_3$	O(0.00, - , -)1.28 C(0.00,0.17,0.33)1.00,1.17 1.33,1.50,1.67	Weak σ components missing; π components may be unresolved
2605.71	$b^3P_1 - z^3S^o_1$	O(0.53)0.95,1.49,1.96 C(0.50)1.00,1.50,2.00	
2583.18	$b^3P_2 - y^3D^o_3$	O(0.00, - , -)1.16 C(0.00,0.17,0.33)1.00,1.17 1.33,1.50,1.67	Weak σ components missing; π components may be unresolved

Table XII. (Continued)

WAVELENGTH	COMBINATION	ZEEMAN PATTERN	REMARKS
2574.90 A.	$a^3P_1 - z^3D^0_2$	O(0.01,0.35)0.82,1.16,1.49 C(0.00,0.33)0.83,1.17,1.50	
2565.39	$a^3P_2 - z^3D^0_2$	O(0.45)0.95,1.17,1.38,1.59 C(0.33,0.67)0.83,1.17,1.50,1.83	pattern may be partly unresolved; discrepancies unexplained
2557.36	$a^3P_0 - z^3D^0_1$	O(0.00)0.49 C(0.00)0.50	
2552.40	$c^3P_0 - {}^34^0_1$	O(0.00)1.49	
2546.74	$b^3P_0 - z^5P^0_1$	O(0.27)1.04 C(0.00)2.50	Zeeman effect indicates identification incorrect
2540.63	$b^3P_1 - y^3D^0_2$	O(0.00, -)0.82, - , - C(0.00,0.33)0.83,1.17,1.50	Weak components missing
2530.09	$b^3P_2 - y^3D^0_3$	O(- , - , -) 1.14 C(0.00,0.17,0.33)1.00,1.17 1.33,1.50,1.67	π components too weak; σ components may be unresolved
2528.21	$b^3P_2 - y^3D^0_2$	(- ,0.37) 1.30?,1.47? C(0.33,0.67)0.83,1.17,1.50,1.83	Discrepancies unexplained

Table XII. (Continued)

WAVE LENGTH	COMBINATION	ZEEMAN PATTERN	REMARKS
2497.48	$c^3P_2 - {}^33^o_2$	0(0.15)1.44	
2490.40	$c^3P_2 - {}^34^o_1$	0(0.00)1.50	
2467.06	$c^3P_2 - {}^35^o_2$	0(0.00)1.49	
2459.46	$b^3P_1 - {}^33^o_2$	0(0.36,0.73)0.67,1.04, - ,1.72	
2447.83	$b^3P_2 - {}^33^o_2$	0(0.28)0.98	
2432.53	$a^3H_6 - x^3G^o_5$	0(0.00)1.09 C(0.00,0.03,0.07,0.10,0.14,0.17) 1.00,1.03,1.07 ······1.33	Pattern may be unresolved
2429.93	$b^3P_1 - {}^35^o_2$	0(0.00)1.53	
2418.50	$c^3P_1 - {}^36^o_1$	0(0.00)1.04	
2416.22	$a^3H_5 - x^3G^o_4$	0(0.00)1.00 C(0.00,0.03,0.06,0.09,0.12) 0.90,0.93,0.96········1.14	Pattern may be unresolved
2386.74	$a^3G_5 - y^3F^o_4$	0(0.00)1.32 C(0.00,0.05,0.10,0.15,0.20) 1.00,1.05,1.10 ······· 1.40	Pattern may be unresolved
2360.51	$a^3G_4 - y^3F^o_3$	0(0.00)1.07 C(0.00 ······ 0.10)0.99 ····1.15	Pattern may be unresolved
2341.10	$a^3D_3 - {}^38^o_3$	0(0.00,1.10)	

Table XII. (Continued)

WAVE LENGTH	COMBINATION	ZEEMAN PATTERN	REMARKS
2337.00	$a^3G_5-y^3G^o_5$	O(0.00)1.61 C(0.00)1.20	Discrepancy unexplained
2327.67	$a^3G_3-y^3G^o_3$	O(0.00)1.00 C(0.00)0.75	Discrepancy unexplained
2256.73	$a^3H_6-z^3H^o_6$	O(0.00)1.17 C(0.00)1.17	

From the observed Zeeman patterns, it appears that the line whose wave length is 2546.74 A. does not arise from the combination $3d^7(^4P)4s\ b^3P_0-\ 3d^7(^4P)4p\ z^5P^o_1$. The intensity of this line is anomalously large, and it must have fitted into the intersystem multiplet by coincidence.

The lines whose wave lengths are 2337.00 A. and 2327.67 A. exhibit Zeeman patterns that do not agree with their identifications as the combinations $3d^7(^2G)4s\ a^3G_5-$ $3d^7(^2G)4p\ y^3G^o_5$, and $3d^7(^2G)4s\ a^3G_3-\ 3d^7(^2G)4p\ y^3G^o_3$. Both of the ^3G terms involved in these combinations are therefore to be considered questionable. This evidence is not, however, sufficient to warrant discarding either term, because it is only necessary for one of the terms to be incorrectly identified to produce this disagreement, and there is no way of telling which term may be faulty.

VI. ENERGY LEVELS

The known energy levels in the Co II spectrum are listed in Table XIII. They have been grouped together into terms whenever such grouping was justified, and the first two columns list the designations given to these terms and the configurations to which they have been assigned. There is a group of quintets which could not be assigned to a configuration on the basis of existing evidence. In cases where the levels could not be grouped into terms, they have been listed separately and designated by a sequence of numbers running from 2 to 17.

The observed g values for the new terms have been deduced from Weeks' data. Observed values for the previously established terms have been taken from Findlay's paper. The g values calculated from the Lande theory are presented in the table for comparison.

With the exception of the levels of the term $3d^8$ a^3F, all of those levels which are listed in the table with seven significant figures are consistent among themselves to within one-tenth of a wave number. The absolute values of these levels with respect to the normal state $3d^8$ a^3F may be in error by several tenths of a wave number because all combinations with the normal state give rise to lines whose wave lengths fall in the vacuum region, where measurements are less precise because the vacuum spectrograph used did not have as large dispersion as did the larger grating instrument used in the longer wave length region, and also because an error in wave length produces a larger error in wave number as the wave length decreases.

The following explanation pertains to the symbols used in Table XIII:

M - Meggers

F - Findlay

M*- Meggers, revised by Findlay

F*- Findlay, energy value adjusted by Hager

H - Hager

Table XIII.

ENERGY LEVELS

CONFIG.	DESIG.	J	ENERGY LEVEL	ENERGY DIFF.	AUTHOR	g OBS.	g LANDE
$3d^8$	a^3F	4	0.00		F		
				950.28			
		3	950.28		F		
				647.15			
		2	1597.43		F		
$3d^7(^4F)4s$	a^5F	5	3349.86		M	1.39	1.40
				678.53			
		4	4028.39		M	1.36	1.35
				531.84			
		3	4560.23		M	1.25	1.25
				389.25			
		2	4949.48		M	1.00	1.00
				254.61			
		1	5204.09		M	0.00	0.00
$3d^7(^4F)4s$	b^3F	4	9812.24		F	1.28	1.25
				895.58			
		3	10707.82		F	1.10	1.08
				613.53			
		2	11321.35		F	0.60	0.67
$3d^8$	a^3P	2	13260.12		H	1.38	1.50
				143.66			
		1	13403.78		H	1.50	1.50
				188.93			
		0	13592.71		H	0.00	0.00
$3d^7(^4P)4s$	a^5P	3	17771.1		M*	1.70	1.67
				259.9			
		2	18031.0		M*	1.86	1.83
				307.2			
		1	18338.2		M*	2.48	2.50
$3d^7(^2G)4s$	a^3G	5	21624.2?		H		
				384.7			
		4	22008.9		H	1.06	1.05
				217.3			
		3	22226.2?		H		

Table XIII. (Continued)

CONFIG.	DESIG.	J	ENERGY LEVEL	ENERGY DIFF.	AUTHOR	g OBS.	g LANDE
$3d^7(^4P)4s$	b^3P	2	24074.2		H	1.49	1.50
				193.1			
		1	24267.3		H		
				143.8			
		0	24411.1		H	0.00	0.00
$3d^7(^2P)4s$	c^3P	2	24886.0		H		
				431.4			
		1	25317.4		H		
				543.8			
		0	25861.2		H		
$3d^7(^2H)4s$	a^3H	6	27105.2?		H	1.17	1.17
				363.4			
		5	27468.6?		H		
		4					
$3d^7(^2D)4s$	a^3D	3	27484.1		H	1.32	1.33
				627.4			
		2	28111.5		H	1.17	1.17
				-526.5			
		1	27585.0		H		
$3d^64s^2$	a^5D	4	40694.8		H		
				619.0			
		3	41313.8		H		
				424.0			
		2	41737.8		H		
				270.8			
		1	42008.6		H		
		0					

Table XIII. (Continued)

CONFIG.	DESIG.	J	ENERGY LEVEL	ENERGY DIFF.	AUTHOR	g OBS.	g LANDE
$3d^7(^4F)5s$	e^5F	5	84013.70		F*		
				572.65			
		4	84586.35		F*		
				580.75			
		3	85167.10		F*		
				428.60			
		2	85595.70		F*		
				280.14			
		1	85875.84		F*		
$3d^7(^4F)5s$	e^3F	4	85481.07		F*		
				865.12			
		3	86346.19		F*		
				593.41			
		2	86939.60		F*		
$3d^7(^4F)4p$	z^5F^o	5	45197.14		M	1.40	1.40
				181.06			
		4	45378.20		M*	1.38	1.35
				593.23			
		3	45971.43		M*	1.26	1.25
				480.76			
		2	46452.19		M*	1.02	1.00
				333.64			
		1	46785.83		M*	0.00	0.00
$3d^7(^4F)4p$	z^5D^o	4	46320.29		M*	1.48	1.50
				718.30			
		3	47038.59		M*	1.51	1.50
				498.36			
		2	47536.95		M*	1.52	1.50
				311.39			
		1	47848.34		M*	1.53	1.50
				146.77			
		0	47995.11		F	0.00	0.00

Table XIII. (Continued)

CONFIG.	DESIG.	J	ENERGY LEVEL	ENERGY DIFF.	AUTHOR	g OBS.	g LANDE
$3d^7(^4F)4p$	z^5G^o	6	47078.06		M	1.33	1.33
				267.29			
		5	47345.35		M	1.27	1.27
				461.66			
		4	47807.01		M	1.15	1.15
				343.40			
		3	48150.41		M	0.92	0.92
				237.43			
		2	48387.84		M	0.33	0.33
$3d^7(^4F)4p$	z^3G^o	5	48555.45		F	1.20	1.20
				792.35			
		4	49347.80		F	1.09	1.05
				687.94			
		3	50035.74		F	0.80	0.75
$3d^7(^4F)4p$	z^3F^o	4	49697.11		F	1.20	1.25
				684.01			
		3	50381.12		F	1.08	1.08
				532.73			
		2	50913.85		F	0.65	0.67
$3d^7(^4F)4p$	z^3D^o	3	51511.73		F	1.32	1.33
				717.49			
		2	52229.22		F	1.16	1.17
				454.88			
		1	52684.10		F	0.45	0.50
$3d^7(^4P)4p$	z^5S^o	2	56010.1		F	1.99	2.00

Table XIII. (Continued)

CONFIG.	DESIG.	J	ENERGY LEVEL	ENERGY DIFF.	AUTHOR	g OBS.	g LANDE
$3d^7(^4P)4p$	y^5D^o	4	61388.0		F	1.50	1.50
		3	61240.4	-147.6	M	1.51	1.50
		2	61260.1	19.7	M	1.51	1.50
		1	61350.0	89.9	F*		
		0	61457.6	107.6	F	0.00	0.00
$3d^7(^4P)4p$	z^3S^o	1	62439.6		H	2.03	2.00
$3d^7(^4P)4p$	z^5P^o	3	63344.0		M*	1.67	1.67
		2	63367.0	23.0	M*	1.86	1.83
		1	63665.0	298.0	M*	2.62	2.50
$3d^7(^4P)4p$	y^3D^o	3	63586.7		H		
		2	63615.8	29.1	H		
		1	63865.0	249.2	H		
$3d^7(^2G)4p$	y^3F^o	4	63510.2		H		
		3	64360.2	850.0	H		
		2	65017.2	657.0	H		
$3d^7(^2G)4p$	y^3G^o	5	64401.8?		H		
		4	65154.2?	752.4	H		
		3	65174.8?	20.6	H		

Table XIII. (Continued)

CONFIG.	DESIG.	J	ENERGY LEVEL	ENERGY DIFF.	AUTHOR	g OBS.	g LANDE
$3d^7(^2H)4p$	x^3G^o	5	68203.7?	640.4	H		
		4	68844.1?		H		
		3					
$3d^7(^2H)4p$	z^3H^o	6	71403.2?		H		
		5					
		4					
$3d^74p$ (?)	$^32^o$	0	64605.3		H		
	$^33^o$	2	64914.3		H		
	$^34^o$	1	65028.2		H		
	$^35^o$	2	65408.0		H		
	$^36^o$	1	65657.0		H		
	$^37^o$	3	69060.0		H		
	$^38^o$	3	70186.0		H		
	$^39^o$	2	70265.8		H		
	$^310^o$	2	70457.5		H		
	$^311^o$	1	70774.9		H		
	$^312^o$	1	70856.8		H		
	$^313^o$	0	71281.1		H		
	$^314^o$	2	72653.4		H		
	$^315^o$	1	73112.4		H		
	$^316^o$	1	73143.9		H		
	$^317^o$	0	73823.2		H		

Table XIII. (Continued)

CONFIG.	DESIG.	J	ENERGY LEVEL	ENERGY DIFF.	AUTHOR	g OBS.	g LANDE
$3d^6 4s(^6D)4p$	x^5D^o	4	80298.8		H		
				243.7			
		3	80542.5		H		
				245.7			
		2	80788.2		H		
				182.7			
		1	80970.9		H		
				95.4			
		0	81066.3?		H		
$3d^6 4s(^6D)4p$	y^5F^o	5	81970.2		H		
				373.1			
		4	82343.3		H		
				284.3			
		3	82627.6		H		
				332.0			
		2	82959.6		H		
		1					
$3d^6 4s(^6D)4p$	y^5P^o	3	85043.9		H		
				668.4			
		2	85712.3		H		
				421.7			
		1	86134.0		H		
$3d^6 4s(a^4D)4p$	$^3D^o$	3	86981.0		H		
				508.7			
		2	87489.7		H		
		1					
$3d^6 4s(a^4D)4p$	$^3F^o$	4	87111.4?		H		
				784.7			
		3	87896.1		H		
				521.3			
		2	88417.4		H		

Table XIII. (Continued)

CONFIG.	DESIG.	J	ENERGY LEVEL	ENERGY DIFF.	AUTHOR	g OBS.	g LANDE
$3d^6 4s(a^4D)4p$	$^3P^o$	2	90702.2	586.8	H		
		1	91289.0		H		
		0					
	$^5F^o$	5	99969.6	470.0	H		
		4	100439.6	578.7	H		
		3	101018.3	270.7	H		
		2	101289.0		H		
	$^5D^o$	4	101328.0	685.8	H		
		3	102013.8	413.5	H		
		2	102427.3		H		
		1					
		0					
	$^5D^o$	4	102264.7	493.6	H		
		3	102758.3	327.5	H		
		2	103085.8		H		
		1					
		0					
	$^5P^o$	3	98204.2	297.8	H		
		2	98502.0		H		
		1					

VII. IDENTIFIED LINES

Table XIV lists the wave length, estimated intensity, and wave number of each line that arises from combinations between established energy levels. These wave length measurements and intensity estimates are taken from the master list reproduced in Appendix III, which was compiled from many sets of measurements, and the method used for assembling the data for the master list is described in the appendix.

The following explanation pertains to the symbols used in Table XIV:

- F - Findlay
- M - Meggers
- M*- Meggers, revised by Findlay
- P - Combinations, arising from terms discovered by Meggers and Findlay, which appeared in Shenstone's vacuum measurements
- H - Hager
- w - Wide Line
- W - Very wide line
- CO I- Lines which may arise from the normal cobalt atom

Table XIV.

IDENTIFIED LINES

WAVE LENGTH IN VACUUM	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
1010.971		0	98914.8	$a^5F_5 - v^5D^o_4$	H
1012.864		0	98729.9	$a^5F_4 - v^5D^o_3$	H
1265.930		4	78993.3	$a^5F_5 - y^5F^o_4$	H
71.936		5	620.3	$a^5F_5 - y^5F^o_5$	H
72.278		3	599.2	$a^5F_4 - y^5F^o_3$	H
76.901		4	314.6	$a^5F_4 - y^5F^o_4$	H
80.677		0	083.7	$b^3F_4 - 4s4p\ ^3F^o_3$	H
80.950		1	067.1	$a^5F_3 - y^5F^o_3$	H
81.884		1	78010.2	$a^5F_2 - y^5F^o_2$	H
83.003		1	77942.1	$a^5F_4 - y^5F^o_5$	H
85.619		1	783.5	$a^5F_3 - y^5F^o_4$	H
86.083		0	755.5	$a^5F_1 - y^5F^o_2$	H
86.841		1	709.7	$b^3F_3 - 4s4p\ ^3F^o_2$	H
87.361		1	678.3	$a^5F_2 - y^5F^o_3$	H
93.671		6	299.4	$b^3F_4 - 4s4p\ ^3F^o_4$	H
95.539		4	188.0	$b^3F_3 - 4s4p\ ^3F^o_3$	H
95.864		7	168.6	$b^3F_4 - 4s4p\ ^3D^o_3$	H
97.094		3	77095.4	$b^3F_2 - 4s4p\ ^3F^o_2$	H
1299.574		8	76948.3	$a^5F_5 - x^5D^o_4$	H
1302.390		6	76781.9	$b^3F_3 - 4s4p\ ^3D^o_2$	H

Table XIV. (Continued)

WAVE LENGTH IN VACUUM	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
1306.966		8	76513.1	$a^5F_4 - x^5D^\circ_3$	H
11.117		5	270.8	$a^5F_4 - x^5D^\circ_4$	H
11.856		5	227.9	$a^5F_3 - x^5D^\circ_2$	H
12.869		2	169.1	$b^3F_2 - 4s4p\,^3D^\circ_2$	H
15.419		4	76021.4	$a^5F_2 - x^5D^\circ_1$	H
16.077		5	75983.0	$a^5F_3 - x^5D^\circ_3$	H
18.180		2	862.2	$a^5F_1 - x^5D^\circ_0$	H
18.586		3	838.8	$a^5F_2 - x^5D^\circ_2$	H
1319.836		3	75767.0	$a^5F_1 - x^5D^\circ_1$	H
1424.784	0	5	70186.1	$a^3F_4 - {}^38^\circ_3$	H
38.693		4	69507.5	$a^3F_3 - {}^310^\circ_2$	H
44.335		2	236.0	$a^3F_3 - {}^38^\circ_3$	H
45.544		3	178.1	$a^3F_2 - {}^311^\circ_1$	H
48.009	2	10	69060.3	$a^3F_4 - {}^37^\circ_3$	H
52.558		1	68844.1	$a^3F_4 - x^3G^\circ_4$	H
66.196	3	10	203.7	$a^3F_4 - x^3G^\circ_5$	H
68.204		6	110.4	$a^3F_3 - {}^37^\circ_3$	H
68.356	1w	6	68103.4	$a^5P_2 - y^5P^\circ_1$	H
71.860	1	6	67941.2	$a^5P_3 - y^5P^\circ_2$	H
72.892	4	8	894.0	$a^3F_3 - x^3G^\circ_4$	H
1475.018		2	67795.8	$a^5P_1 - y^5P^\circ_1$	H

Table XIV. (Continued)

WAVE LENGTH IN VACUUM	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
1484.251		5	67374.1	$a^5P_1 - y^5P_2^o$	H
86.483	4	9	272.9	$a^5P_3 - y^5P_3^o$	H
87.768	2	2	214.8	$b^3P_2 - 4s4p\,^3P_1^o$	H
92.064		1	021.3	$b^3P_1 - 4s4p\,^3P_1^o$	H
92.254	0	6	67012.3	$a^5P_2 - y^5P_3^o$	H
1495.256		2	66878.2	$b^3P_0 - 4s4p\,^3P_1^o$	H
1500.875	1	5	627.8	$b^3P_2 - 4s4p\,^3P_2^o$	H
05.234		2	66434.9	$b^3P_1 - 4s4p\,^3P_2^o$	H
19.391		4	65815.8	$c^3P_2 - 4s4p\,^3P_2^o$	H
34.820		3	65154.2	$a^3F_4 - y^3G_4^o$?	H
52.752		9	64401.8	$a^3F_4 - y^3G_5^o$?	H
53.754		4	360.3	$a^3F_4 - y^3F_3^o$	H
57.039		6	224.5	$a^3F_3 - y^3G_3^o$?	H
57.542		6	203.6	$a^3F_3 - y^3G_4^o$?	H
60.865		4	64067.0	$a^3F_3 - y^3F_2^o$	H
72.645	1	7	63587.1	$a^3F_4 - y^3D_3^o$	H
72.886	0	4	577.4	$a^3F_2 - y^3G_3^o$?	H
74.548	0	8	510.3	$a^3F_4 - y^3F_4^o$	H
76.789	2	7	420.0	$a^3F_2 - y^3F_2^o$	H
77.042	2	7	409.9	$a^3F_3 - y^3F_3^o$	H
1581.715		1	63222.5	$b^3P_1 - 4s4p\,^3D_2^o$	H

Table XIV. (Continued)

WAVE LENGTH IN VACUUM	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
1589.654		3	62906.8	$b^3P_2 - 4s4p^3\,{}^3D^o_3$	H
93.299		5	762.9	$a^3F_2 - y^3F^o_3$	H
93.439		2	757.3	$a^5P_2 - x^5D^o_2$	H
95.773	0	6	665.6	$a^3F_3 - y^3D^o_2$	H
96.508		3	636.7	$a^3F_3 - y^3D^o_3$	H
96.614		1	632.6	$a^5P_1 - x^5D^o_1$	H
98.470		5	559.8	$a^3F_3 - y^3F^o_4$	H
99.308		4	527.0	$a^5P_3 - x^5D^o_4$	H
1599.701		3	511.7	$a^5P_2 - x^5D^o_3$	H
1601.282		2	450.0	$a^5P_1 - x^5D^o_2$	H
05.962		5	268.0	$a^3F_2 - y^3D^o_1$	H
12.410		2	62019.0	$a^3F_2 - y^3D^o_2$	H
24.024	0	4	61570.0	$a^5D_4 - v^5D^o_4$	H
27.482		3	444.6	$a^5D_3 - v^5D^o_3$	H
30.044		1	348.0	$a^5D_2 - v^5D^o_2$	H
37.269		3	077.3	$a^5D_1 - v^5D^o_2$	H
38.787	Ow	4	61020.7	$a^5D_2 - v^5D^o_3$	H
40.669		4	60950.8	$a^5D_3 - v^5D^o_4$	H
47.446	0	6	700.0	$a^5D_3 - w^5D^o_3$	H
47.729		3	689.6	$a^5D_2 - w^5D^o_2$	H
1649.263	1	7	60633.1	$a^5D_4 - w^5D^o_4$	H

Table XIV. (Continued)

WAVE LENGTH IN VACUUM	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
1655.119		3	60418.6	$a^5D_1 - w^5D^\circ_2$ $a^3P_2 - {}^317^\circ_0$	H H
59.032		4	276.1	$a^5D_2 - w^5D^\circ_3$	H
66.276		5	60014.1	$a^5D_3 - w^5D^\circ_4$	H
70.799	0	2	851.6	$a^3P_3 - {}^315^\circ_1$	H
73.787		1	744.8	$a^5D_4 - x^5F^\circ_4$	H
73.918		3	740.1	$a^3P_1 - {}^316^\circ_1$	H
74.921	1	5	704.3	$a^5D_3 - x^5F^\circ_3$	H
77.093	0	1	627.0	$a^3D_3 - 4s4p\,^3F^\circ_4$	H
79.232		2	60551.0	$a^5D_2 - x^5F^\circ_2$ $a^3P_0 - {}^316^\circ_1$	H H
80.125		3	59519.4	$a^3P_1 - {}^315^\circ_1$	H
83.722	3	6	392.2	$a^3P_2 - {}^314^\circ_2$	H
86.896	1	5	280.5	$a^5D_2 - x^5F^\circ_3$ $a^5D_1 - x^5F^\circ_2$	H H
87.057	1	5	274.8	$a^5D_4 - x^5F^\circ_5$	H
87.788		1	249.1	$a^3P_1 - {}^314^\circ_2$	H
91.310	2	4	125.8	$a^5D_3 - x^5F^\circ_4$	H
1693.330	1	3	59055.2	$a^5F_3 - y^3D^\circ_2$	H
1700.487		1	58806.7	$a^5F_3 - z^5P^\circ_2$	P
12.614		1	390.3	$b^3F_4 - x^3G^\circ_5$	H
23.013		4	58037.9	$a^5F_5 - y^5D^\circ_4$	P
27.806	1	3	57876.9	$a^3P_1 - {}^313^\circ_0$	H
1736.225		2	57596.2	$a^3P_2 - {}^312^\circ_1$	H

Table XIV. (Continued)

WAVE LENGTH IN VACUUM	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
1743.381	0	3	57359.8	$a^5F_4 - y^5D^o_4$	P
46.297		2	264.0	$a^3P_0 - {}^312^o_1$	H
47.882		5	212.0	$a^5F_4 - y^5D^o_3$	P
48.343		3	197.0	$a^3P_2 - {}^310^o_2$	H
54.217		7	57005.5	$a^3P_2 - {}^39^o_2$	H
58.642		6	56862.1	$a^3P_1 - {}^39^o_2$	H
63.675		5	699.8	$a^5F_3 - y^5D^o_2$	P
64.279		4	680.4	$a^5F_3 - y^5D^o_3$	P
73.040	1	4	400.3	$a^5F_2 - y^5D^o_1$	P
75.867		3	310.5	$a^5F_2 - y^5D^o_2$	P
77.658		3	253.8	$a^5F_1 - y^5D^o_0$	P
81.068	1	2	146.1	$a^5F_1 - y^5D^o_1$	P
1783.909		2	56056.7	$a^5F_1 - y^5D^o_2$	P
1833.271		1	54547.3	$b^3F_4 - y^3F^o_3$	H
55.037	2	2 CO I	53907.3	$b^3F_3 - y^3D^o_2$	H
59.625		2	774.3	$b^3F_4 - y^3D^o_3$	H
1862.353		6	53695.5	$b^3F_2 - y^3F^o_2$	H
1908.518	0	6	52396.7	$a^3P_2 - {}^36^o_1$	H
13.756		2	253.3	$a^3P_1 - {}^36^o_1$	H
17.627	1	7	147.8	$a^3P_2 - {}^35^o_2$	H
1920.706		3	52064.2	$a^3P_0 - {}^36^o_1$	H

Table XIV. (Continued)

WAVE LENGTH IN VACUUM	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
1922.927		5	52004.1	$a^3P_1 - {}^35^o_2$	H
35.963		1	51653.9	$a^3P_2 - {}^33^o_2$	H
37.069		4	624.4	$a^3P_1 - {}^34^o_1$	H
40.64		50 F	512.3	$a^3F_4 - z^3D^o_3$	F
44.188		3	435.4	$a^3P_0 - {}^34^o_1$	H
50.098		15	279.5	$a^3F_3 - z^3D^o_2$	F
53.071		3	201.4	$a^3P_1 - {}^32^o_0$	H
57.424		14	51087.6	$a^3F_2 - z^3D^o_1$	F
75.008		4	50632.7	$a^3F_2 - z^3D^o_2$	F
81.736		2	460.8	$a^3P_1 - y^3D^o_1$	H
83.953		4	404.4	$a^3P_2 - z^5P^o_1$	H
84.843		3	381.8	$a^3F_4 - z^3F^o_3$	F
87.030		4	326.4	$a^3P_2 - y^3D^o_3$	H
91.567		3	211.7	$a^3P_1 - y^3D^o_2$	H
95.733		2	106.9	$a^3P_2 - z^5P^o_2$	H
97.135		3	071.7	$a^3P_0 - z^5P^o_1$	H
1998.549		1	50036.3	$a^3F_4 - z^5G^o_3$	F
2001.445		7	49963.9	$a^3F_3 - z^3F^o_2$	F
08.877		4	779.1	$a^3G_5 - z^3H^o_6$	H
12.199	0	16	697.18	$a^3F_3 - z^3F^o_4$	F
2023.019	0	15	49430.84	$a^3F_3 - z^3F^o_3$	M*

Table XIV. (continued)

WAVE LENGTH IN VACUUM	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
2026.424	0	13	49347.73	$a^3F_4 - z^3G^o_4$	M*
27.703	0	14	316.42	$a^3F_2 - z^3F^o_2$	M*
33.379		10	179.2	$a^3P_2 - z^3S^o_1$	H
37.244		11	085.9	$a^3F_3 - z^3G^o_3$	M*
39.333		9	49035.6	$a^3P_1 - z^3S^o_1$	H
47.223		3	48846.7	$a^3P_0 - z^3S^o_1$	H
49.831		5	784.5	$a^3F_2 - z^3F^o_3$	M*
51.42		10	746.8	$a^3F_3 - z^3F^o_4$	F
51.999		3	733.0	$b^3P_0 - {}^316^o_1$	H
59.480		11	555.9	$a^3F_4 - z^3G^o_5$	M*
64.453		10	439.0	$a^3F_2 - z^3G^o_3$	M*
72.209		3	257.7	$c^3P^o_2 - {}^316^o_1$	H
79.485		1	48088.8	$a^3P_2 - y^5D^o_1$	H
83.358	Ow	10	47999.70	$a^3P_2 - y^5D^o_2$	H
90.889		1	826.5	$c^3P_1 - {}^316^o_1$	H
91.738		4	807.1	$a^3F_4 - z^5G^o_4$	M*
94.931		2	734.3	$a^5F_2 - z^3D^o_1$	M*
97.809		3	668.8	$a^5F_3 - z^3D^o_2$	M*
2099.230		2	636.5	$a^5P_3 - {}^35^o_2$	H
2106.019		3	47483.0	$a^5F_4 - z^3D^o_3$	M*

Table XIV. (Continued)

WAVE LENGTH IN VACUUM	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
2106.162		3	47479.7	$a^5F_1 - z^3D^o_1$	M*
12.140		7	345.3	$a^3F_4 - z^5G^o_4$	M*
12.540		1	336.4	$c^3P_1 - {}^3 14^o_2$	H
13.335		2	318.1	$a^5P_1 - {}^3 6^o_1$	H
14.966	0	4	282.10	$c^3P_0 - {}^3 16^o_1$	H
15.088		2	279.4	$a^5F_2 - z^3D^o_2$	M*
18.644		4	200.0	$a^3F_3 - z^5G^o_3$	M*
24.524		2	069.4	$a^5P_1 - {}^3 5^o_2$	H
26.532		3	47024.9	$a^5F_1 - z^3D^o_2$	M*
29.87		1	46951.3	$a^5F_3 - z^3D^o_3$	M*
34.174		4	856.5	$a^3F_3 - z^5G^o_4$	M*
37.178		3	790.7	$a^3F_2 - z^5G^o_2$	M*
46.932		6	561.8	$a^5F_2 - z^3D^o_3$	M*
48.06		2	553.6	$a^3F_2 - z^5G^o_3$	M*
57.381		10 M	352.5	$a^5F_3 - z^3F^o_2$ $a^5F_4 - z^3F^o_3$	M* M*
57.635		40 M	347.0	$a^5F_5 - z^3F^o_4$	M*
58.862		1	320.7	$a^3F_4 - z^5D^o_4$	M*
62.67		2 M	239.1	$a^3D_1 - {}^3 17^o_0$	H
69.766	0	3	087.90	$a^3F_3 - z^5D^o_3$	H
73.573		3	46007.2	$a^5F_4 - z^3G^o_3$	M*
2174.008	1	9	45998.40	$a^5F_5 - z^3G^o_4$ $b^3P_1 - {}^3 9^o_2$	M* H

Table XIV. (Continued)

WAVE LENGTH IN VACUUM	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
2175.614		2	45964.0	$a^5F_2 - z^3F^o_2$ $c^3P_2 - {}^313^o_2$	M* H
81.299		6	844.3	$a^5P_3 - y^3D^o_2$	H
82.414		4	820.8	$a^5F_3 - z^3F^o_3$	F
82.679		7	815.3	$a^5P_3 - y^3D^o_3$	H
87.730		25 M	709.5	$a^5F_1 - z^3F^o_2$	M*
89.686		25 M	668.6	$a^5F_4 - z^3F^o_4$	M*
91.34		75 M	634.2	$a^5P_2 - z^5P_1$	M*
91.638		7	628.0	$a^3D_3 - {}^315^o_1$	H
93.180		11	595.9	$a^5P_3 - z^5P^o_2$	M*
94.293	3w	12	572.85	$a^5P_3 - z^5P^o_3$	M*
95.89		1 M	539.7	$c^3P_1 - {}^312^o_1$	H
96.515	0	4	526.56	$a^5P_1 - y^3D^o_1$ $a^3D_1 - {}^315^o_1$	H H
2198.968		6	475.9	$a^5F_3 - z^3G^o_3$	M*
2201.101	0	25 M	431.79	$a^5F_2 - z^3F^o_3$	M*
03.617		11	372.9	$c^3P_2 - {}^39^o_2$ $a^3F_4 - z^5F^o_4$	H M*
04.106		3	369.9	$a^3F_3 - z^5D^o_4$	M*
05.750		8	336.1	$a^5P_2 - z^5P^o_2$	H
06.205		9	326.7	$a^5P_1 - z^5P^o_1$	M*
06.576		9	319.1	$a^5F_4 - z^3G^o_4$	M*
06.905	4w	75 M	312.99	$a^5P_2 - z^5P^o_3$	M*
2212.102		10	45205.9	$a^5F_5 - z^3G^o_5$	M*

Table XIV. (continued)

WAVE LENGTH IN VACUUM	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
2212.902	0	2	45189.27	$a^3F_2 - z^5F_1^0$	H
13.825		7	170.1	$a^3D_3 - {}^3 14_2^0$	H
15.456	1	20 M	137.11	$a^5F_3 - z^3F_4^0$	M*
17.968	3w	10	086.10	$a^5F_2 - z^3G_3^0$	M*
20.594	1	8	032.41	$a^3D_2 - {}^3 16_1^0$	H
20.775	2	10	028.89	$a^5P_1 - z^5P_2^0$	M*
21.171	0w	4	020.83	$a^3F_3 - z^5F_3^0$	H
22.123	1	9	45001.44	$a^3D_2 - {}^3 15_1^0$	H
22.422	2	9	44995.54	$c^3P_0 - {}^3 12_1$	H
22.915		4	986.0	$b^3P_2 - {}^3 7_3^0$	H
2224.745	1	6	44948.49	$c^3P_1 - {}^3 9_2^0$	H

Table XIV. (Continued)

WAVE LENGTH IN AIR	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
2232.065	3	50	44787.60	$a^5F_3 - z^3G^0_4$	M*
45.120	15	100	527.20	$a^5F_4 - z^3G^0_5$	M*
48.66		8	457.1	$a^5F_5 - z^5G^0_4$	M*
51.10		10	408.9	$a^5P_2 - z^3S^0_1$	H
51.63		2	398.5	$a^5D_3 - y^5P^0_2$	H
54.181	0	1	348.13	$a^5D_4 - y^5P^0_3$	H
65.76		6	121.7	$a^5F_4 - z^5G^0_3$	M*
66.795	1w	10	44101.47	$a^5P_1 - z^3S^0_1$	H
72.265	0	20	43995.42	$a^5F_5 - z^5G^0_5$	M*
80.938	0	7	828.05	$a^5F_3 - z^5G^0_2$	M*
83.511	3w	20	778.77	$a^5F_4 - z^5G^0_4$	M*
86.147	50	150	728.20	$a^5F_5 - z^5G^0_6$	M*
87.82		4 CO I	696.2	$a^3D_1 - {}^313^0_0$	H
91.981	12	40w	616.91	$a^5P_3 - y^5D^0_4$	M*
93.411	10w	30	589.71	$a^5F_3 - z^5G^0_3$	M*
98.727	0	10	488.92	$a^5P_3 - y^5D^0_2$	M*
2299.76		25	469.4	$a^5P_3 - y^5D^0_3$	M*
2301.401	2	15	438.39	$a^5F_2 - z^5G^0_2$	M*
07.507	0	2	323.46	$a^5P_2 - y^5D^0_1$	M*
07.854	25	75	317.04	$a^5F_4 - z^5G^0_5$	M*
2311.596	25	50	43246.81	$a^5F_3 - z^5G^0_4$	M*

Table XIV. (Continued)

WAVE LENGTH IN AIR	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
2312.548	6	10	43229.02	$a^5P_2 - y^5D^o_1$	M*
13.619	3w	8	209.02	$a^5P_2 - y^5D^o_3$	M*
14.053	25	40	200.91	$a^5F_2 - z^5G^o_3$	M*
14.646	1	1	189.84	$a^3D_1 - {}^311^o_1$	H
14.969	40	30	183.81	$a^5F_1 - z^5G^o_2$	M*
18.420	2w	8	119.21	$a^5P_1 - y^5D^o_0$	M*
24.310	10	40	43010.29	$a^5P_1 - y^5D^o_1$ $a^5F_4 - z^5D^o_3$	M* M*
26.103	35	20	42977.14	$a^5F_3 - z^5D^o_2$	M*
26.458	30	25	970.59	$a^5F_5 - z^5D^o_4$	M*
29.094	8w	10	921.96	$a^5P_1 - y^5D^o_2$	M*
30.361	15	30	898.81	$a^5F_2 - z^5D^o_1$	M*
36.223	15	20	790.99	$a^5F_1 - z^5D^o_0$ $a^3G_3 - y^5F^o_2$	M* H
38.72		6	745.2	$a^3D_2 - {}^312^o_1$	H
41.112	15	40	701.64	$a^3D_3 - {}^38^o_3$	H
42.247	0w	2	680.95	$a^3D_1 - {}^39^o_2$	H
44.254	15	25	644.42	$a^5F_1 - z^5D^o_1$	M*
47.382	25	30	587.60	$a^5F_2 - z^5D^o_2$	M*
53.386	75	60	478.95	$a^5F_3 - z^5D^o_3$	M*
60.508	25	20	350.80	$a^3G_4 - y^3F^o_3$	H
60.784	20	8	345.84	$a^3D_2 - {}^310^o_2$	H
2361.510	8	10	42332.83	$a^5F_1 - z^5D^o_2$	M*

Table XIV. (Continued)

WAVE LENGTH IN AIR	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
2363.802	100	90	42291.78	$a^5F_4 - z^5D^o_4$	M
75.190	15	15	089.05	$a^5F_2 - z^5D^o_3$	M
76.023	0		074.28	$a^3D_2 - {}^38^o_3$	H
78.620	100	100	42028.35	$a^5F_5 - z^5F^o_4$	M
83.455	100	80	41943.10	$a^5F_4 - z^5F^o_3$	M
86.367	75	50	891.92	$a^5F_3 - z^5F^o_2$	M
86.717	75w	25	885.83	$a^3G_5 - y^3F^o_4$	H
88.918	100	100	847.19	$a^5F_5 - z^5F^o_5$	M
89.537	30	40	836.35	$a^5F_2 - z^5F^o_1$	M
93.901	10	10	760.09	$a^5F_3 - z^5D^o_4$	M
2397.380	20	60	699.50	$b^3F_4 - z^3D^o_3$	M
2404.106	25	20	581.65	$a^5F_1 - z^5F^o_1$	M
04.523	10w	10	575.63	$a^3D_3 - {}^37^o_3$	H
07.664	10	20	521.39	$b^3F_3 - z^3D^o_2$	M
08.746	15	25	502.74	$a^5F_2 - z^5F^o_2$	M
08.833	3	0?	501.24	$a^3G_4 - y^3F^o_4$	H
14.068	50	40	411.26	$a^5F_3 - z^5F^o_3$	M
16.214	25	15	374.48	$a^3H_5 - x^3G^o_4$	H
16.899	30	30	362.74	$b^3F_2 - z^3D^o_1$	M
17.659	75	40	349.75	$a^5F_4 - z^5F^o_4$	M
2418.584	1		41333.93	$b^3P_2 - {}^35^o_2$	H

Table XIV. (Continued)

WAVE LENGTH IN AIR	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
2422.04		1	41274.8	$a^5D_4 - y^5F_5^o$	H
23.626	10	10	247.96	$a^5F_1 - z^5F_2^o$	M
23.756	2	3	245.75	$b^3P_0 - {}^36_1^o$	H
28.289	10	10	168.77	$a^5F_4 - z^5F_5^o$	M
29.928	4	5	140.99	$b^3P_1 - {}^35_2^o$	H
32.517	35	30	097.20	$a^3H_6 - x^3G_5^o$	H
36.983	4	10	41021.90	$a^5F_2 - z^5F_3^o$	M
43.781	15	40	40907.81	$b^3F_2 - z^3D_2^o$	M
47.826	8	12	840.20	$b^3P_2 - {}^33_2^o$	H
49.166	6	10	817.86	$a^5F_3 - z^5F_4^o$	M
50.005	12	35	803.88	$b^3F_3 - z^3D_3^o$	M
52.556	1w	2	761.44	$b^3P_1 - {}^34_1^o$	H
54.14		1	735.30	$a^3H_5 - x^3G_5^o$	H
59.452	10	10	647.16	$b^3P_1 - {}^33_2^o$	H
64.200	20	35	568.85	$b^3F_4 - z^3F_3^o$	M
67.051	15	20	521.97	$c^3P_2 - {}^35_2^o$	H
78.195	6	4	339.75	$c^3P_1 - {}^36_1^o$	H
78.299	5	5	338.06	$b^3P_1 - {}^32_0^o$	H
81.534	2	0	285.49	$b^3P_2 - y^3F_3^o$	H
85.358	8	10	223.51	$b^3F_3 - z^3G_3^o$	H
2486.439	15	35	40206.02	$b^3F_4 - z^3F_2^o$	M

Table XIV. (Continued)

WAVE LENGTH IN AIR	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
2487.150	3	5	40194.62	$b^3P_0 - {}^32^o_0$	H
87.376	3w	4	190.88	$b^3F_2 - z^3D^o_3$	M
90.392	10w	15	142.16	$c^3P_2 - {}^34^o_1$	H
93.572	0	0	091.03	$c^3P_1 - {}^35^o_2$	H
2497.490	6w	10	40028.14	$c^3P_2 - {}^33^o_2$	H
2506.473	75	70	39884.68	$b^3F_4 - z^3F^o_4$	M
12.061	5w	3	796.00	$c^3P_0 - {}^36^o_1$	H
12.406	2w	2	790.54	$b^3P_2 - y^3D^o_1$	H
17.439	4	3	710.95	$c^3P_1 - {}^34^o_1$	H
19.823	40	60	673.39	$b^3F_3 - z^3F^o_3$	M
24.212	1		604.45	$a^5D_4 - x^5D^o_4$	H
24.643	8w	7	597.68	$b^3P_1 - y^3D^o_1$ $c^3P_1 - {}^33^o_2$	H H
24.971	75	80	592.55	$b^3F_2 - z^3F^o_2$	M
28.216	8w	5	541.70	$b^3P_2 - y^3D^o_2$	H
28.613	75	50	535.49	$b^3F_4 - z^3G^o_4$	M
30.105	50w	40	512.18	$b^3P_2 - y^3D^o_3$	H
33.821	35w	30	454.23	$b^3P_0 - y^3D^o_1$	H
37.454*	1	3	397.75	$b^3P_1 - z^5P^o_1$	H
40.621	25	20	348.86	$b^3P_1 - y^3D^o_2$	H
41.958	30	50	327.95	$b^3F_3 - z^3G^o_3$	M
2544.267	75 CO	I	39292.26	$b^3P_2 - z^5P^o_2$	H

Table XIV. (Continued)

WAVE LENGTH IN AIR	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
2544.541	2w	4	39288.03	$c^3P_1 - {}^3 2^o_0$	H
45.040	2w	5	280.33	$a^3P_1 - z^3D^o_1$	H
45.718	1	2	269.8	$b^3P_2 - z^5P^o_3$	H
46.743	20	20	254.06	$b^3P_0 - z^5P^o_1$	H
49.723	4	0W	208.19	$z^5F^o_4 - e^5F_5$	F
50.534	2		195.72	$z^5F^o_3 - e^5F_3$	F
52.391	4	4	167.20	$c^3P_0 - {}^3 4^o_1$	H
53.938	3	0W	143.48	$z^5F^o_2 - e^5F_2$	F
56.761	25	8 CO I	100.26	$b^3P_1 - z^5P^o_2$	H
57.341	6	8	091.39	$a^3P_0 - z^3D^o_1$	H
57.438	1		089.91	$z^5F^o_1 - e^5F_1$	H
59.410	60	40	39059.80	$b^3F_2 - z^3F^o_3$	M
64.044	100	75	38989.21	$b^3F_3 - z^3F^o_4$	M
64.293	0		985.42	$a^5D_3 - x^5D^o_4$	H
65.367	2	6	969.10	$a^3P_2 - z^3D^o_2$	H
74.860	8	10	825.44	$a^3P_1 - z^3D^o_2$	H
75.474	20	0w	816.19	$z^5F^o_5 - e^5F_5$	F
75.893	1		809.87	$z^5F^o_2 - e^5F_1$	H
76.206	3		805.16	$a^5D_2 - x^5D^o_3$	H
77.927		1	779.3	$c^3P_2 - z^5P^o_1$	H
2580.335	50	100	38743.07	$b^3F_4 - z^3G^o_5$	M

Table XIV. (continued)

WAVE LENGTH IN AIR	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
2581.211	2w	2w	38729.92	$c^3P_2 - y^3D_2^o$	H
82.244	30	50	714.42	$b^3F_2 - z^3G_3^o$	M
83.170	15	15	700.55	$c^3P_2 - y^3D_3^o$	H
87.223	50	60	639.93	$b^3F_3 - z^3G_4^o$	M
87.521	12		635.48	$z^5F_4^o - e^5F_5$	F
88.900	10	0W	614.90	$z^5F_3^o - e^5F_4$	F
92.709	1	2w	558.18	$z^5D_3^o - e^5F_2$	F
2593.429	0w	2	547.47	$c^3P_1 - y^3D_1^o$	H
2605.724		20	365.7	$b^3P_2 - z^3S_1^o$	H
06.950		1	347.6	$c^3P_1 - z^5P_3^o$	H
07.600		0	338.0	$b^3F_4 - z^5G_3^o$	H
10.300		1	298.4	$c^3P_1 - y^3D_2^o$	H
12.499	15	1W	266.11	$z^5D_4^o - e^5F_4$	F
13.494	25	10	251.54	$a^3P_2 - z^3D_3^o$	H
14.353	30w	20	238.97	$a^5P_3 - z^5S_2^o$	M
18.894	8	20	172.4	$b^3P_1 - z^3S_1^o$	H
21.924	8		128.57	$z^5D_3^o - e^5F_3$	F
26.728	8	2W	058.83	$z^5D_2^o - e^5F_2$	F
28.83		6	028.4	$b^3P_0 - z^3S_1^o$	H
28.886	2		027.60	$z^5D_1^o - e^5F_1$	F
2630.540		3	38003.6	$c^3P_0 - y^3D_1^o$	H

TABLE XIV. (Continued)

WAVE LENGTH IN AIR	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
2632.239	20w	30	37979.16	$a^5P_2 - z^5S_2^o$	M
36.070	12w	6	923.96	$a^3D_3 - {}^35_2^o$	H
39.081	3	1W	880.69	$z^5D_0^o - e^5F_1$	F
43.108		2	823.0	$a^3D_1 - {}^35_2^o$	H
44.464	0w	1	803.59	$c^3P_0 - z^5P_1^o$	H
48.407	3		747.32	$z^5D_1^o - e^5F_2$	H
52.193	8	5W	693.44	$z^5D_4^o - e^5F_5$	F
53.095	0	1	680.63	$b^3F_3 - z^5G_2^o$	M
53.713	12w	15	671.85	$a^5P_1 - z^5S_2^o$	M
55.05		0	652.9	$a^3P_2 - z^3F_2^o$	H
56.641	3w		630.33	$z^5D_2^o - e^5F_3$	H
62.056		1	553.8	$c^3P_2 - z^3S_1^o$	H
62.482	4		547.78	$z^5D_3^o - e^5F_4$	F
62.640	0	1	545.55	$a^3D_2 - {}^36_1^o$	H
63.534	30	60	532.95	$b^3F_4 - z^5G_5^o$	M
65.344	0		507.46	$a^3P_1 - z^3F_2^o$	H
66.728	5	5w	488.00	$z^5G_2^o - e^5F_1$	F
69.773	20	4 W	445.24	$z^5G_3^o - e^5F_2$	F
* 70.831	2W	2w	430.42	$a^3D_3 - {}^33_2^o$	H
75.856	20	15W	360.13	$z^5G_4^o - e^5F_3$	H
2680.435	0	1	37296.35	$a^3D_2 - {}^35_2^o$	H

Table XIV. (Continued)

WAVE LENGTH IN AIR	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
2681.903	0	1w	37275.90	$b^3P_2 - z^5D^o_1$	H
84.421	20	15W	240.94	$z^5G^o_5 - e^5F_4$	F
88.41		0	185.7	$b^3P_2 - y^5D^o_2$	H
89.826		2	166.1	$b^3P_2 - y^5D^o_3$	H
92.982	1	1	122.55	$c^3P_1 - z^3S^o_1$	H
93.090	1	2	121.06	$a^3P_2 - z^3F^o_3$	H
94.680	25	30	099.16	$b^3F_3 - z^5G^o_4$	M
95.857		5	082,9	$b^3P_1 - y^5D^o_1$	H
2697.069		8	066.3	$b^3F_2 - z^5G^o_2$	M
2700.415	0	2	020.38	$a^3D_1 - {}^32^o_0$	H
00.686	1		37016.66	$z^5G^o_3 - e^5F_3$	H
02.019	8	2W	36998.41	$z^3G^o_4 - e^3F_3$	F
02.424	0		992.86	$b^3P_1 - y^5D^o_2$	H
06.507	30	10W	937.06	$z^5G^o_6 - e^5F_5$ $b^3P_0 - y^5D^o_1$	F H
07.348	20	8W	925.58	$z^3G^o_5 - e^3F_4$	F
08.002	2	8	916.67	$a^3D_2 - {}^34^o_1$	H
08.943	8	1W	903.84	$z^3G^o_3 - e^3F_2$	F
14.437	6w	20	829.15	$b^3F_3 - z^5D^o_2$ $b^3F_2 - z^5G^o_3$	M M
16.380	0	5	802.80	$a^3D_2 - {}^33^o_2$	H
18.111	1		779.37	$z^5G^o_4 - e^5F_4$	H
2718.423		0	36775.2	$a^3P_2 - z^3G^o_3$	H

Table XIV. (Continued)

WAVE LENGTH IN AIR	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
2727.773	10	10W	36649.10	$z^3F^\circ_4 - e^3F_3$	F
33.009	0	6	578.90	$c^3P_0 - z^3S^\circ_1$	H
34.539	8	5W	558.44	$z^3F^\circ_3 - e^3F_2$	F
36.91		2	526.8	$b^3F_2 - z^5D^\circ_1$	M
38.322		4	507.80	$b^3F_4 - z^5D^\circ_4$	F
41.656		0	463.5	$c^3P_2 - y^5D^\circ_1$	H
48.433		1	373.6	$c^3P_2 - y^5D^\circ_2$	H
49.909		3	354.1	$c^3P_2 - y^5D^\circ_3$	H
51.688		0	330.6	$b^3F_3 - z^5D^\circ_3$	H
53.216	6	2W	310.45	$z^3G^\circ_3 - e^3F_3$	F
55.511	0	0	280.21	$a^3D_1 - y^3D^\circ_1$	H
60.443	0	0	215.39	$b^3F_2 - z^5D^\circ_2$	H
64.721	1	0	159.35	$b^3F_4 - z^5F^\circ_3$	F
66.719	15	8W	133.24	$z^3G^\circ_4 - e^3F_4$	F
69.072	1w	10	102.54	$a^3D_3 - y^3D^\circ_3$	H
70.818		0	079.8	$a^3D_1 - z^5P^\circ_1$	H
74.578	0	0	030.90	$a^3D_1 - y^3D^\circ_2$	H
74.964	15	2W	36025.89	$z^3F^\circ_2 - e^3F_2$	F
79.660	5	5W	35965.03	$z^3F^\circ_3 - e^3F_3$	F
81.399		0	942.5	$c^3P_1 - y^5D^\circ_2$	H
2786.049		3	35882.6	$a^3D_3 - z^5P^\circ_2$	H

Table XIV. (Continued)

WAVE LENGTH IN AIR	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
2787.832		1	35859.6	$a^3D_3 - z^5P^o_3$	H
93.726	15	5W	783.99	$z^3F^o_4 - e^3F_4$	F
96.134		2	753.1	$a^3D_2 - y^3D^o_1$	H
96.837		3	744.2	$b^3F_3 - z^5F^o_2$	F
2798.949	Ow	3w	717.19	$b^3F_2 - z^5D^o_3$	F
2807.173	1	10	612.55	$b^3F_3 - z^5D^o_4$	M
10.853	8	12	565.93	$b^3F_4 - z^5F^o_4$	M
15.745	0	3	504.14	$a^3D_2 - y^3D^o_2$	H
16.971		0	488.7	$c^3P_0 - y^5D^o_1$	H
18.074		0	474.8	$a^3D_2 - y^3D^o_3$	H
18.900	1w	5	464.41	$b^3F_2 - z^5F^o_1$	M
19.382	Ow		458.34	$z^3G^o_5 - e^5F_5$	H
20.402	0		445.53	$z^3G^o_3 - e^3F_4$	H
21.449	5	1W	432.37	$z^3F^o_2 - e^3F_3$	F
25.235	2	15	384.89	$b^3F_4 - z^5F^o_5$	M
34.942	2	10	263.74	$b^3F_3 - z^5F^o_3$	M
37.480		0	232.2	$a^3D_2 - z^5P^o_3$	H
45.688	*	5	130.6	$a^3F_2 - z^5F^o_2$	F
45.890	0		128.10	$a^3P_2 - z^5G^o_2$	H
48.167	6	2W	35100.01	$z^3F_3 - e^3F_4$	F
2857.585	0		34984.33	$a^3P_1 - z^5G^o_2$	H

Table XIV. (Continued)

WAVE LENGTH IN AIR	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
2865.293	0		34890.21	$a^3P_2 - z^5G^\circ_3$	H
65.378	3	1W	889.18	$z^3F^\circ_4 - e^5F_4$	H
69.876	6	1W	834.51	$z^3D^\circ_3 - e^3F_3$	F
73.833	1		785.92	$z^3F^\circ_3 - e^5F_3$	H
80.134	5	4W	710.45	$z^3D^\circ_2 - e^3F_2$	F
82.504	0		681.91	$z^3F^\circ_2 - e^5F_2$	H
83.464	0	2	670.36	$b^3F_3 - z^5F^\circ_4$	F
2885.165		0	649.9	$b^3F_2 - z^5F^\circ_3$	H
2918.387	15	?	255.50	$z^3D^\circ_1 - e^3F_2$	H
22.672	1		205.78	$z^3F^\circ_3 - e^5F_4$	H
30.239	12	20w	34116.95	$z^3D^\circ_2 - e^3F_3$	F
42.968	25	15W	33969.40	$z^3D^\circ_3 - e^3F_4$	F
49.744		0	891.4	$a^5P_1 - z^3D^\circ_2$	H
51.396	0		872.40	$a^3D_1 - y^5D^\circ_0$	H
59.589	0w	5	778.63	$a^3P_2 - z^5D^\circ_3$	H
60.795		0	764.9	$a^3D_1 - y^5D^\circ_1$	H
61.548	1	0w	756.29	$a^3D_3 - y^5D^\circ_3$	H
2968.688	0		33675.10	$a^3D_1 - y^5D^\circ_2$	H
3130.335		0	31936.2	$b^3P_2 - z^5S^\circ_2$	H
3131.329		0w	926.1	$a^5P_3 - z^3F^\circ_4$	H
3212.019		3	31124.1	$c^3P_2 - z^5S^\circ_2$	H

Table XIV. (Continued)

WAVE LENGTH IN AIR	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
3290.761		0	31379.4	$a^5P_3 - z^5G^\circ_3$	H
3328.380		0	30036.0	$a^5P_3 - z^5G^\circ_4$	H
52.786		30	29817.4	$a^5P_2 - z^5D^\circ_1$	M
58.608		10	765.7	$a^5P_3 - z^5D^\circ_2$	M
70.933		50	656.9	$a^5P_1 - z^5D^\circ_0$	M
87.698		60	510.1	$a^5P_1 - z^5D^\circ_1$	M
3388.18		35	505.8	$a^5P_2 - z^5D^\circ_2$	M
3415.785		75	267.8	$a^5P_3 - z^5D^\circ_3$	M
23.846		40	198.6	$a^5P_1 - z^5D^\circ_2$	M
3446.401		50	29007.5	$a^5P_2 - z^5D^\circ_3$	M
3501.708		200	28549.4	$a^5P_3 - z^5D^\circ_4$	M
14.219		2	447.7	$a^5P_1 - z^5F^\circ_1$	M
17.503		10	421.2	$a^5P_2 - z^5F^\circ_2$	M
17.988		0	417.2	$b^3P_1 - z^3D^\circ_1$	H
35.940		15	272.9	$b^3P_0 - z^3D^\circ_1$	H
45.032		25	200.5	$a^5P_3 - z^5F^\circ_3$	M
55.925		6	114.1	$a^5P_1 - z^5F^\circ_2$	M
61.123		50	073.0	$a^3G_5 - z^3F^\circ_4$	H
66.977		5	28026.9	$a^3G_4 - z^3G^\circ_3$	H
3578.022		30	27940.5	$a^5P_2 - z^5F^\circ_3$	M
3610.60		3	27688.4	$a^3G_4 - z^3F^\circ_4$	H

Table XIV. (Continued)

WAVE LENGTH IN AIR	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
3621.177		100	27607.5	$a^5P_3 - z^5F^o_4$	M
43.589		6	437.7	$b^3P_2 - z^3D^o_3$	H
56.18		2	343.2	$c^3P_2 - z^3D^o_2$	H
3656.845		2	27338.2	$a^3G_4 - z^3G^o_4$	H
3714.709		3	26912.4	$c^3P_1 - z^3D^o_2$	H
3754.700		30	26625.8	$c^3P_2 - z^3D^o_3$	H
3983.040		10	25099.4	$a^3D_1 - z^3D^o_1$	H
4040.057		3?	24745.16	$a^3D_3 - z^3D^o_2$	H
4145.153		15	117.8	$a^3D_2 - z^3D^o_2$	H
4160.672		50	24027.8	$a^3D_3 - z^3D^o_3$	H
4272.202		3	23400.6	$a^3D_2 - z^3D^o_3$	H
4285.36		1w	23329.2	$a^3D_1 - z^3F^o_2$	H
4384.25		2?	22802.5	$a^3D_2 - z^3F^o_2$	H
4413.864		30	649.5	$a^5D_4 - z^5P^o_3$	H
82.707		5w	301.7	$a^5D_3 - y^3D^o_2$	H
4489.12		2	269.9	$a^3D_2 - z^3F^o_3$	H
4516.432		10	135.2	$a^3D_3 - z^3F^o_4$	H
33.206		10	053.3	$a^5D_3 - z^5P^o_2$	H
37.971		10	22030.1	$a^5D_3 - z^5P^o_3$	H
59.28		8	21927.2	$a^5D_2 - z^5P^o_1$	H
4569.27		25	21879.2	$a^3H_5 - z^3G^o_4$	H

Table XIV. (Continued)

WAVE LENGTH IN AIR	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
4616.234		5	21656.6	$a^5D_1 - z^5P_1^o$	H
22.011		2w	629.6	$a^5D_2 - z^5P_2^o$	H
60.66		25	450.2	$a^3H_6 - z^3G_5^o$	H
4680.72		0	21358.3	$a^5D_1 - z^5P_2^o$	H
4831.16		10w	20693.2	$a^5D_4 - y^5D_4^o$	H
4865.83		1w	545.8	$a^5D_4 - y^5D_3^o$	H
4980.113		3	20074.3	$a^5D_3 - y^5D_4^o$	H
5012.082		5	19946.2	$a^5D_3 - y^5D_2^o$	H
17.025		3	926.6	$a^5D_3 - y^5D_3^o$	H
5097.445		1	612.2	$a^5D_2 - y^5D_1^o$	H
5120.957		3	522.2	$a^5D_2 - y^5D_2^o$	H
40.114		3	449.4	$a^5D_1 - y^5D_0^o$	H
5192.947	0w	3	19251.50	$a^5D_1 - y^5D_2^o$	H
5477.588	4w		18251.16	$e^5F_5 - v^5D_4^o$	H
5501.548	4w		18171.67	$e^5F_4 - v^5D_3^o$	H
5683.165	1w		17590.96	$e^5F_3 - v^5D_3^o$	H
5773.944	0w		17314.39	$e^5F_5 - w^5D_4^o$	H
5934.252	1 w		16846.66	$e^5F_3 - w^5D_3^o$	H
6083.964	3w		432.11	$e^5F_4 - x^5F_3^o$	H
86.496	1w		425.28	$e^5F_5 - x^5F_4^o$?	H
6088.017 .	1w		16421.17	${}^3 7_3^o - e^3F_4$	H

Table XIV. (Continued)

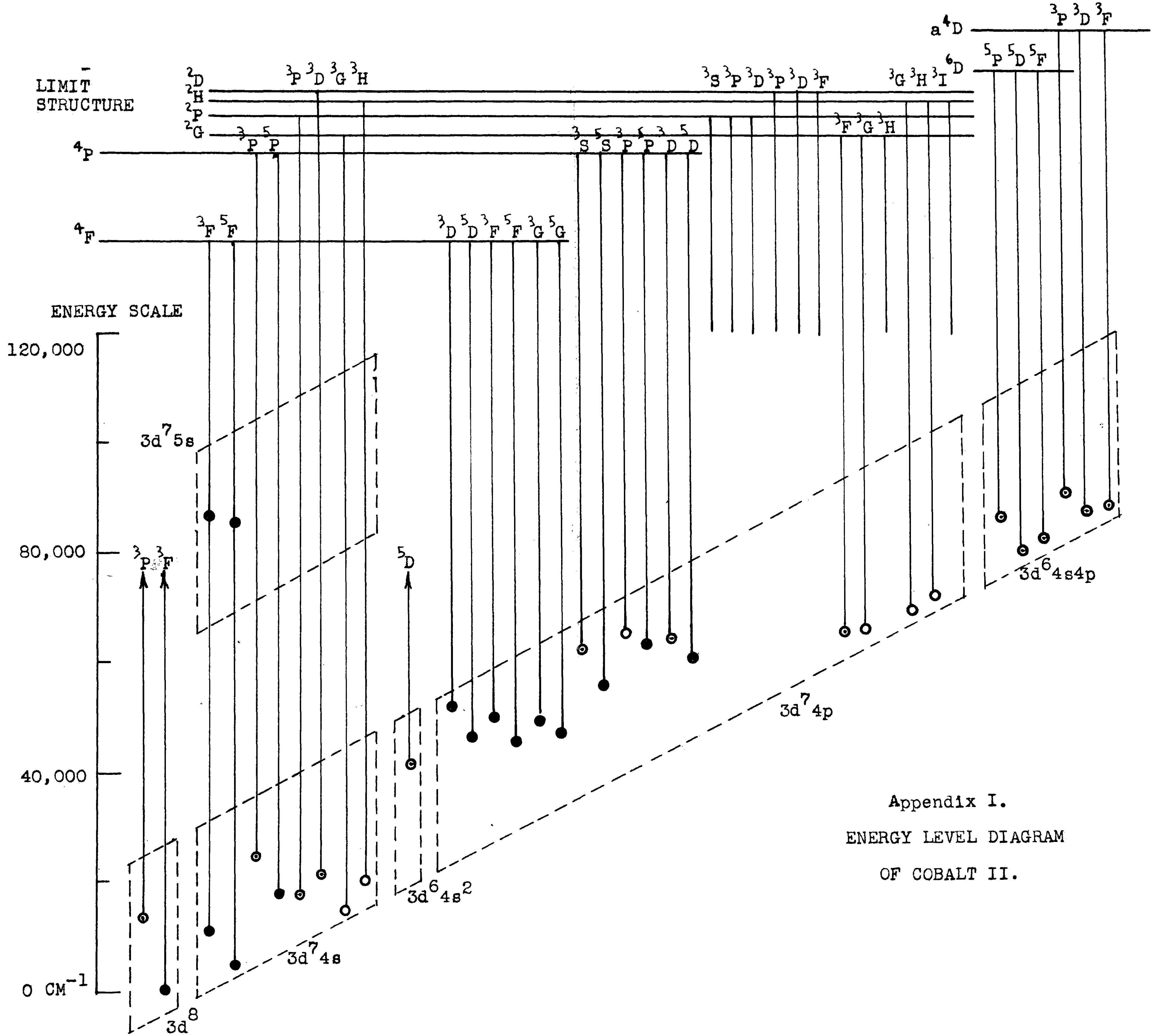
WAVE LENGTH IN AIR	S.T. INT.	SPK. INT.	WAVE NUMBER IN VACUUM	COMBINATION	AUTHOR
6201.034	1w		16121.89	$e^5F_3 - x^5F^o_2$	H
65.561	1w		15955.86	$e^5F_5 - x^5F^o_5$	H
6292.156	Ow		888.42	$^310^o_2 - e^3F_3$	H
6305.768	1w		854.12	$e^5F_4 - x^5F^o_4$	H
06.655	OW		851.89	$e^5F_3 - x^5F^o_3$	H
6370.218	1w		15693.72	$e^5F_2 - x^5F^o_2$	H

VIII. CONCLUSION

Although a considerable majority of the strong lines in the spectrum have now been classified, many still remain unidentified. Most of these should be the result of combinations between the many odd triplets of the $3d^7 4p$ configuration and the even triplets of the $3d^7 4s$ configuration. At least traces of some of these triplets have been found, but it has not been possible to completely establish them, even though it is felt that their approximate positions are well enough known so that it should not have been difficult to establish them. Apparently neither the condensed spark nor the Schuler tube provide the proper excitation to permit completion of this phase of the analysis. In order to further develope these lower levels of the spectrum, it is recommended that the method of the cathode spot be tried. The work of Dobbie[16a] on the Fe II spectrum shows that there is some hope for success with this type of excitation.

It now appears that the Schuler tube, employed in the manner described in Appendix II, is not a useful source for extending the study of the Co II spectum in the

16a - J. C. Dobbie, Annals of the Solar Physics Observatory, Volume V, Part I, Cambridge (1938) region of higher energy levels. For further development of these high levels, there is need for some new method of excitation. It should be stated that the experimental work was not completely fruitless. Most of the lines previously observed in the condensed spark were also observed in the hollow cathode discharge, and because of the great sharpness of the lines produced by the Schuler tube, and because fo the high dispersion of the 21 ft. grating instrument, the measurement of these lines has been accurate. Consequently the energy levels of Co II have been established with a higher degree of accuracy than heretofore. Also the terms e^3F and e^5F in the $3d^75s$ configuration have been given much support by the appearance of 14 new lines which did appear in the discharge.



KEY TO SYMBOLS

● Designates terms found by Meggers and Findlay

⊙ Designates new terms established by Hager

○ Designates incomplete or tentatively established new terms

Appendix I.

ENERGY LEVEL DIAGRAM

OF COBALT II.

Appendix II.

SCHULER TUBE DEVELOPMENT

The condensed spark is unsatisfactory for exciting the high levels of Co II. The few lines which do appear as a result of combinations with high levels cannot be measured accurately, because they are broad, asymmetric, and very weak. It is necessary to employ an excitation agent other than the spark to establish the high series members required for more accurately determining the ionization potential. A possible source is the hollow cathode discharge tube, called the Schuler tube, which has been useful for exciting high levels in the spectra of several similar metallic ions.

The work of Paschen, Schuler, Shenstone and others has shown that when a hollow cathode discharge is run in a noble gas, and when a sample of a metal is placed inside the cathode, the spectrum of the metal will be produced, and marked enhancements of certain lines will appear. Sawyer[17] suggests that free atoms of the metal experience collisions of the second kind with noble gas atoms which have either been ionized or excited to metastable states. As a consequence of the collision, the ionization energy or the excitation energy may be transferred from the noble

17 - R.A. Sawyer, Phys. Rev., 36, 44 (1930)

gas atoms to the metallic atoms. One may observe enhancements of those lines in the spectrum of the metallic atom which originate in levels whose energy values, as measured above the ground state of the neutral atom, correspond to the excitation energy obtained from the atoms of the gas.

In the case of many metals, the levels where maximum enhancements occur fall somewhere in the spectrum of the singly ionized atom, depending on the noble gas used in the tube. By prudently choosing gases, it is possible to achieve selective excitation in several energy level regions. Table XV lists the levels at which three of the noble gases may produce enhancements in the spectrum of singly ionized cobalt. The energy required to ionize the cobalt atom must, of course, be accounted for when computing the values of these levels. The table shows that both neon and helium should be useful for exciting those upper series members which are predicted to fall in a region between 80,000 and 100,000 wave numbers above the ground state of the singly ionized cobalt atom.

The discharge must not only maintain the collision process which produces the excitation, but it must also provide the means for freeing metallic ions from the solid

Table XV.

ENHANCEMENT BY NOBLE GASES

GAS	IONIZATION POTENTIAL CM^{-1}	METASTABLE STATES CM^{-1}	IONIZATION POTENTIAL CM^{-1}	LEVEL OF ENHANCEMENT CM^{-1}
He	198308		63400	134,908
		159830	63400	96,430
		166251	63400	102,851
Ne	173930		63400	110,530
		134819	63400	71,419
A	127104		63400	63,704
		94546	63400	31,146

body of the sample inserted in the cathode. It does this by cathodic sputtering or boiling, and cobalt cannot be expected to respond readily to either process, because it will boil only at very high temperatures as shown in Table XVI, and it is not a good sputterer, as shown in Table XVII.

Table XVI.

MELTING AND BOILING POINTS OF METALS[18]

METAL	MELTING POINT	BOILING POINT
Co	1495 °C.	3000 °C.
Fe	1535	3000
Cu	1083	2300
Pt	1774	4300
Mn	1260	1900

18 - Handbook of Chemistry and Physics, p. 1898 (1950-51)

Table XVII.

SPUTTERING RATES OF METALS[19]

METAL	SPUTTERING RATE (mg/amp-hr)
Bi	1470
Te	1200
As	1100
Tl	1080
Sb	890
Ag	740
Au	460
Pb	400
Zn	340
Cu	300
C	262
Sn	196
Fe	68
Ni	65
W	57
Co	56
Mo	56
Mn	38
Cd	32
Al	29
Cr	27
Ta	16
Mg	9

19 - Gunterschulze, Zeits fur Physik, 36, 563 (1926) These measurements were made in hydrogen with a 770 volt cathode fall, and a current density of 7 milliamperes per square centimeter.

Shenstone suceeded in running the Schuler tube with Cu[20] and Pt[21]. Although platinum is seen to have a very high boiling point, it is a moderately good sputterer[22]. Curtis[23] was successful in exciting Mn by this method, and in this case it is likely that the successful excitation may have been due to the relatively low boiling point of the metal, because the sputtering rate of this metal is quite low. Green[24]. had difficulty in exciting iron, and cobalt is unfortunately very similar to iron with respect to both boiling point and sputtering characteristics.

20 - A. G. Shenstone, Phil. Trans. Roy. Soc. 237 453 (1938)

21 - A. G. Shenstone, Phil. Trans. Roy. Soc. 235 195 (1936)

22- Platinum is not included in Table XVII, but is considered to be as good a sputterer as copper by other observers. See, for example, J. Strong, "Procedures in Experimental Physics", p. 163, Prentice-Hall,(1938)

23 - C. W. Curtis, Phys. Rev. 53, 474 (1938)

24 - L. C. Green, Thesis, Princeton University (1937)

A. THE POWER SUPPLY

Because the Schuler tube has negative resistance characterisitics, i.e., the potential drop across the tube decreases when the current increases, it was necessary to provide some external means for stabilizing the current. The simple series ballast resistor is not practical in this case because a potential of 1000 volts is required to pass a current of more than 2 amperes through the Schuler tube, and the potential drop across such a ballast resistor would make it necessary for the power supply to furnish a potential considerably higher than that required by the Schuler tube itself. Increasing the voltage of the power supply is very costly when such large currents are required.

The power supply used was a three phase constant current source designed by Green[25] for running the Schuler tube in the iron experiment. This system was partially re-designed to permit use of easily obtained components. The circuit is shown in Fig. 4, and the specifications for the parts are listed in Table XVIII. A mathematical analysis of the circuit is given in the above reference.

Fig. 5 shows how nearly constant the current remains when the load resistance is varied. The safety cutoff circuit is mandatory, because an open load circuit pro-

25- L. C. Green and J. B. Horner Kuper, Rev. Sci. Instruments, 11, 250 (1940)

Fig. 4

POWER SUPPLY CIRCUIT

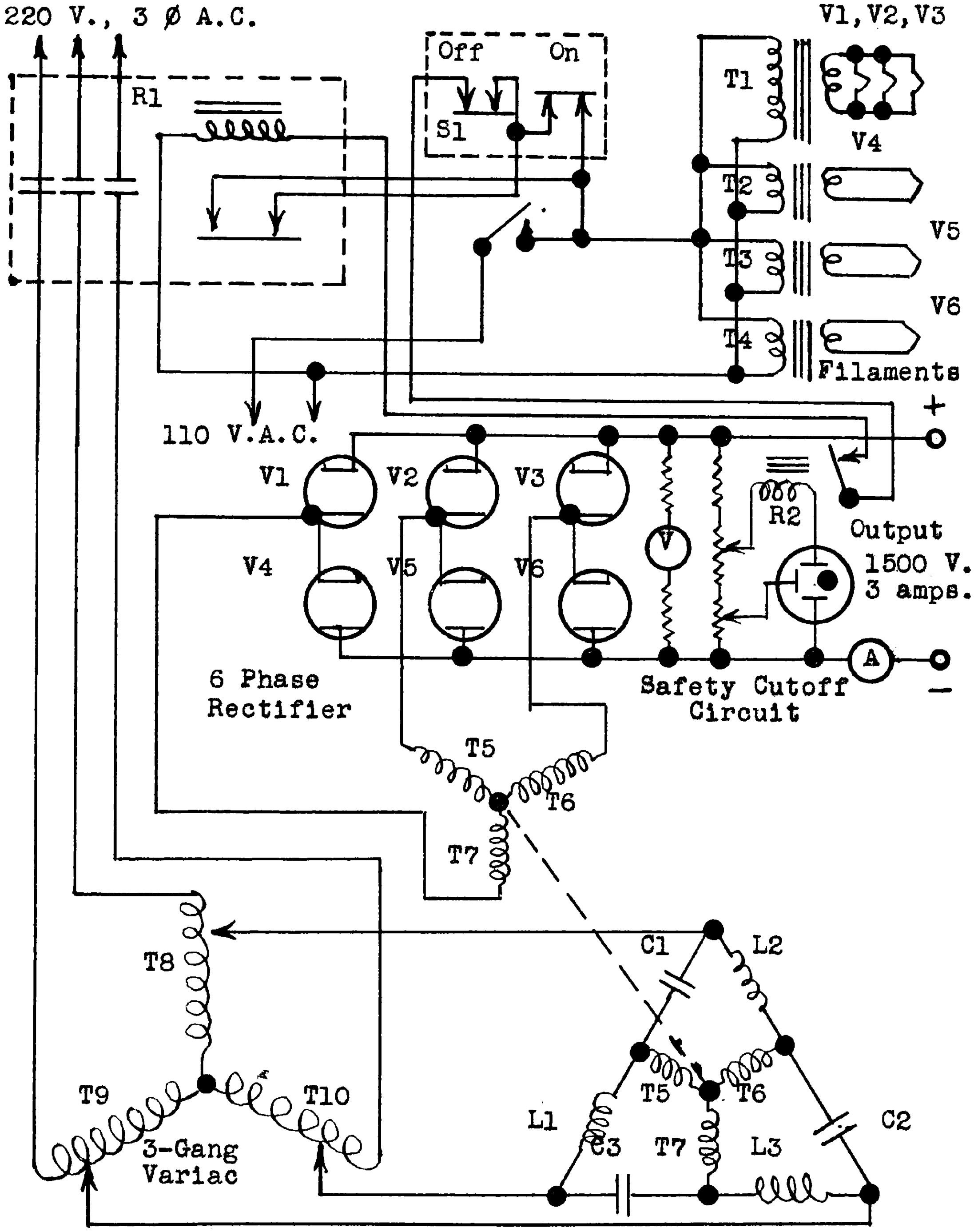


Fig. 5

CONSTANT CURRENT POWER SUPPLY

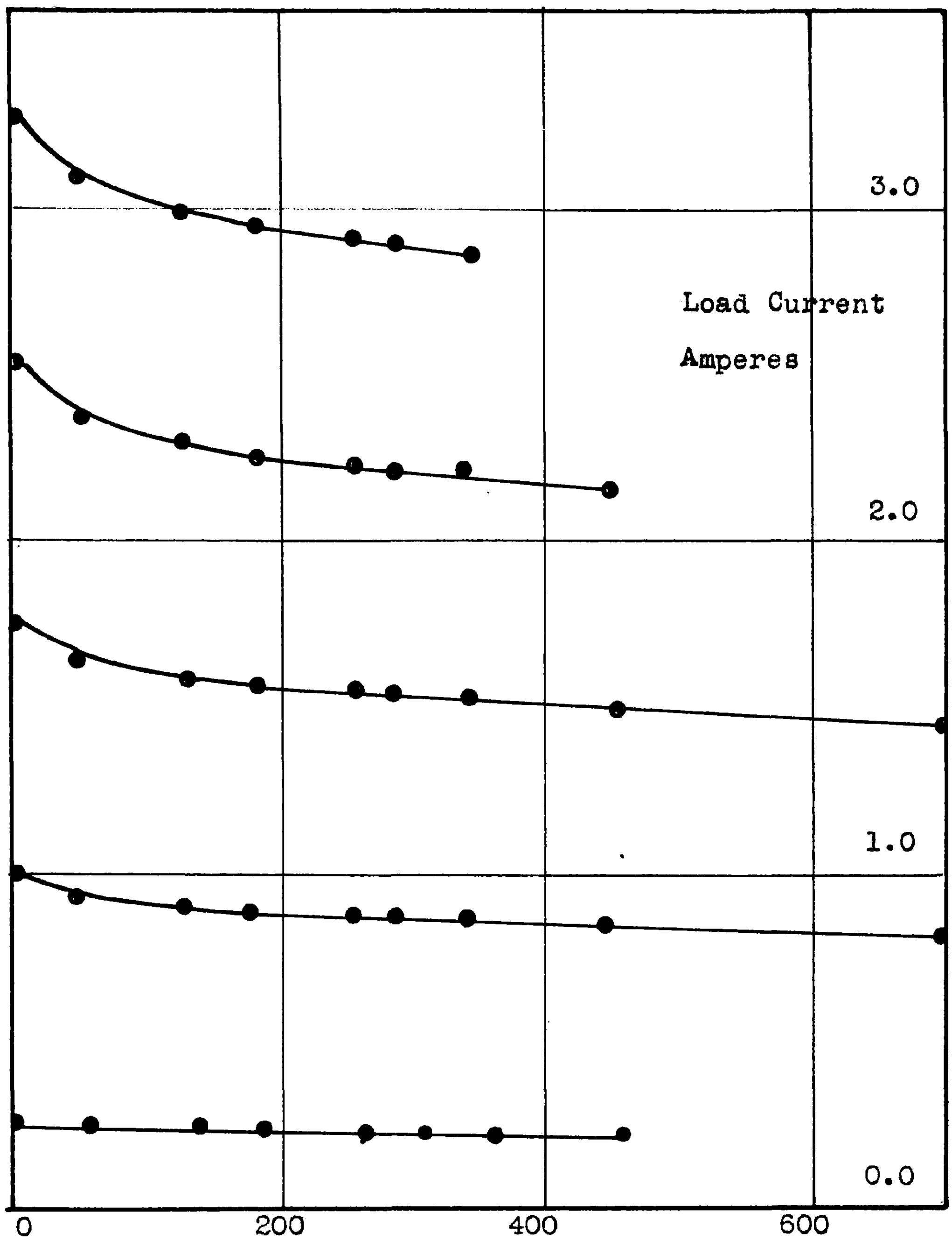


Table XVIII.

SPECIFICATIONS FOR CONSTANT CURRENT POWER SUPPLY

DESIGNATION IN FIG. 4	DESCRIPTION
V1 - V6	Type 872-A mercury rectifier tubes
V7	Type OA4G cold cathode thyratron
T2, T3, T4	Filament transformers, 5 v., 10 amps.
T1	Filament transformer, 5 v., 30 amps.
T5, T6, T7	Standard 1½ K.V.A. stepdown transformers, connected so that ratio of turns is 4:1, and used backwards to step voltage up.
T8, T9, T10	Standard Variacs, 115 v., 10 amps., ganged on single control shaft. (115 volt Variacs run safely on 230 volt 3 phase line, if they are connected in a wye network.)
R2	Sensitive plate circuit relay.
R1	Standard motor start relay with lock-in contacts.
S1	Spring-load push switches
S2	Single pole single throw switch
C1, C2, C3	Banks of condensers totalling 125 mfd. each. Should be oil capacitors rated at 330 V. A.C.
L1, L2, L3	Inductances made of #8 D.C.C. wire wound on a hollow-cored spool. The core is 10 cm. in diameter and 15 cm. long. The outside diamter of the wound coil is 19 cm. The value of the inductance was adjusted to give resonance with the capacitors by inserting iron wire into the open core while passing 60 cycle current through a series combination of the inductance and the capacitance and adjusting the voltage applied to the combination to keep the current at about 15 amperes.
	Resistors chosen to match relays and meters.

duces a large voltage drop across the large banks of condensers in the constant current network, and these condensers may be completely destroyed.

B. THE VACUUM SYSTEM

Fig. 6 shows the vacuum system employed in conjunction with the Schuler tube. It had two functions: with stopcocks A, E, and F open, and with stopcocks B, C, and D closed, the system served to evacuate the Schuler tube and the associated traps. With A, C, and D closed and B, E, and F open, the diffusion pump circulated the noble gas through the system. The gas was inserted by opening and closing D, putting gas into the small dosing chamber, and then opening and closing C. Liquid air was used on the traps.

A "getter" tube using a hollow cathode discharge over mischmetal[26] was provided for cleaning small impurities

26 - Mischmetal may be obtained from New Process Metals Co., 46 Center St., Newark, N.J. Airco "reagent grade" noble gases were found to be pure enough so that the tube ran well without mischmetal cleaning, provided the cathode was well out-gassed, using an induction furnace, or by heating the cathode in the Schuler tube discharge and then pumping out the gaseous impurities from the system before dosing with clean noble gas.

Fig. 6

THE VACUUM SYSTEM

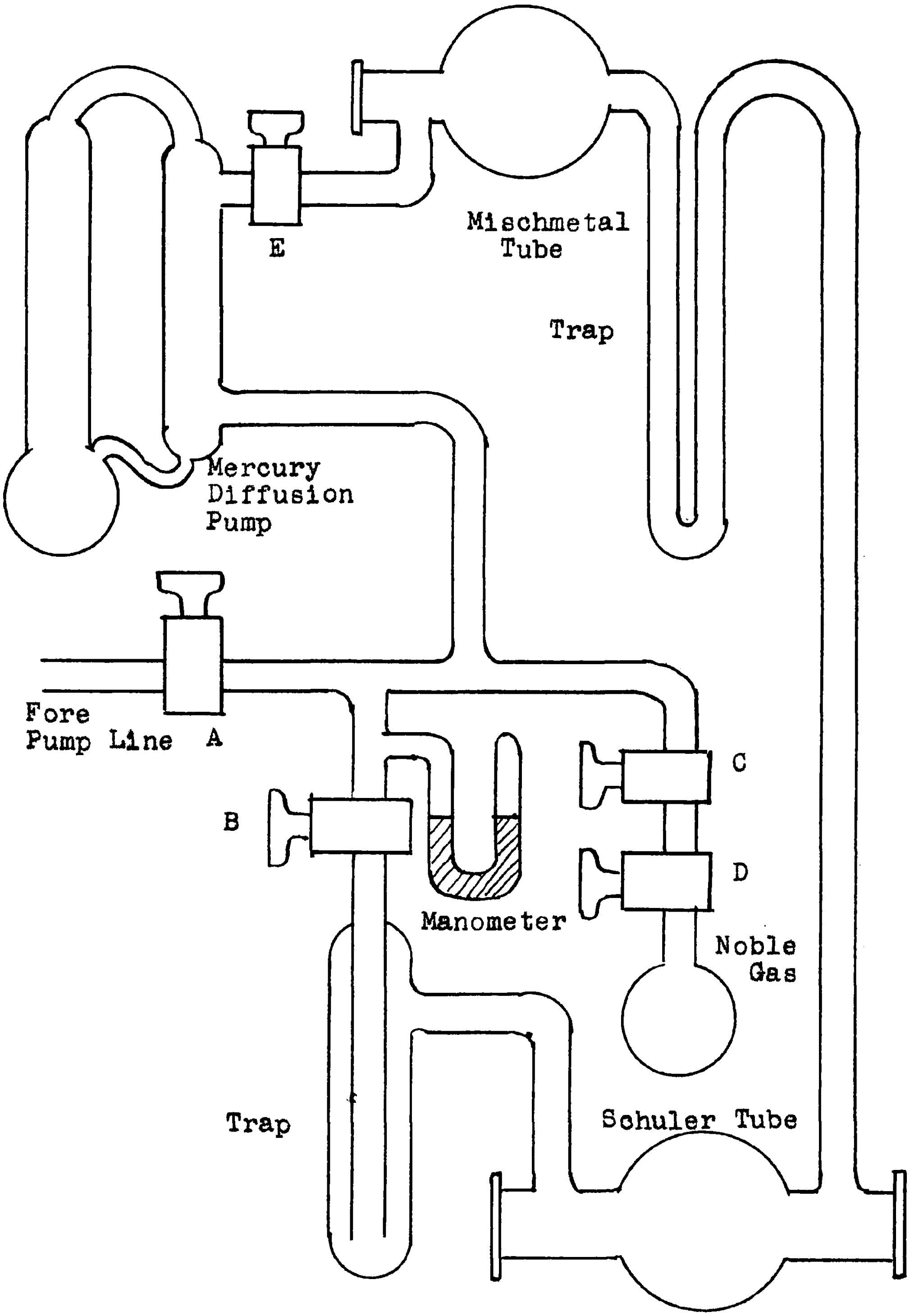
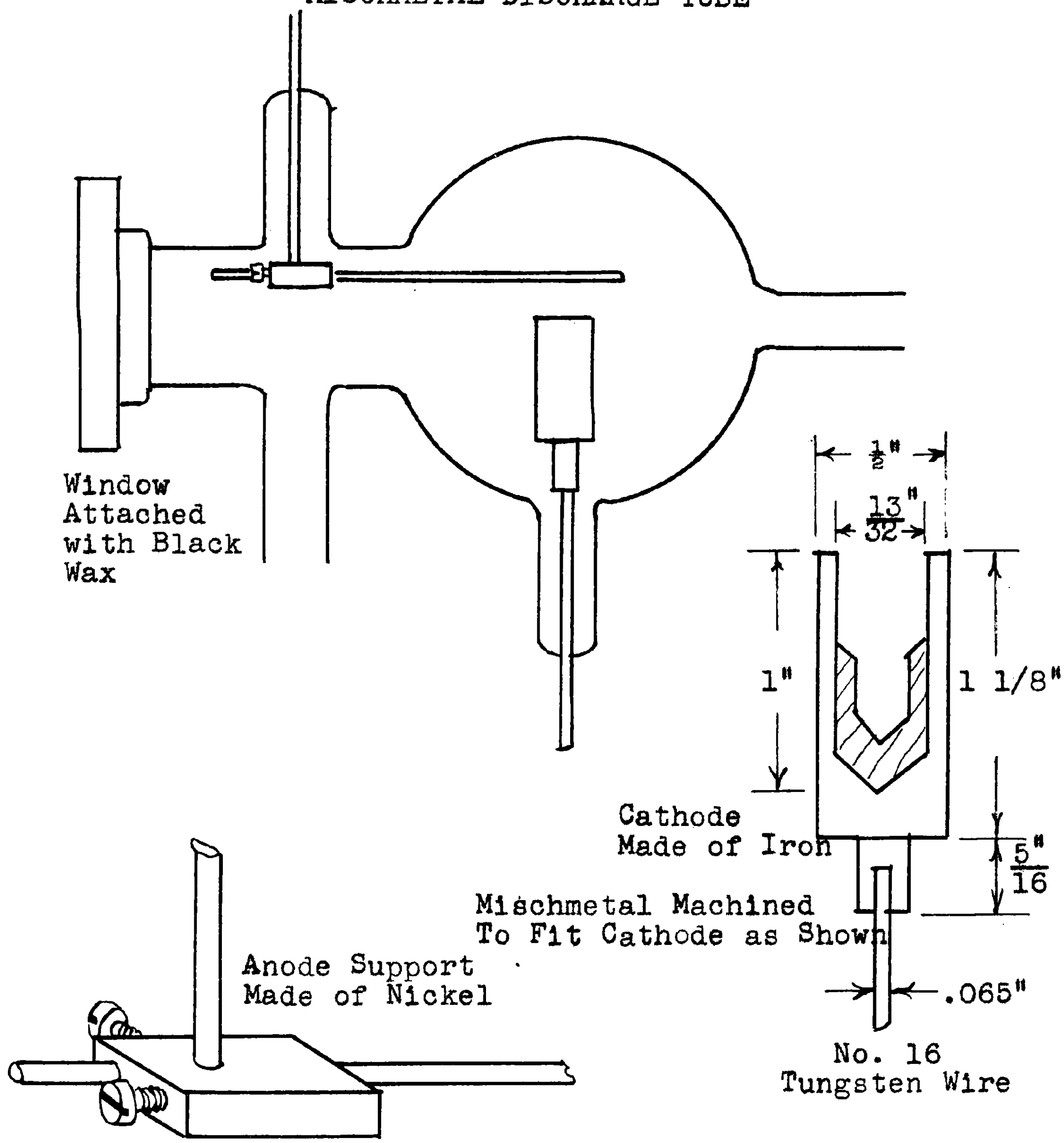
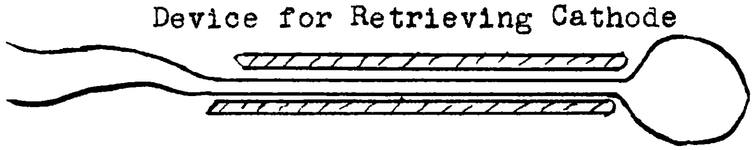


Fig. 7

MISCHMETAL DISCHARGE TUBE



Device for Retrieving Cathode



from the gas in the system. Fig. 7 shows the construction details of a mischmetal discharge tube with a cathode that is removable for re-charging. After the window and the anode were removed, the cathode was lifted out quite easily with a section of glass tubing and a piece of wire arranged as shown in the figure. When operated at a pressure that produced a 5 mm. differential on the mercury manometer, the mischmetal discharge required a current of 0.25 ampere and 3 to 4 hundred volts potential across the tube.

C. THE SCHULER TUBE

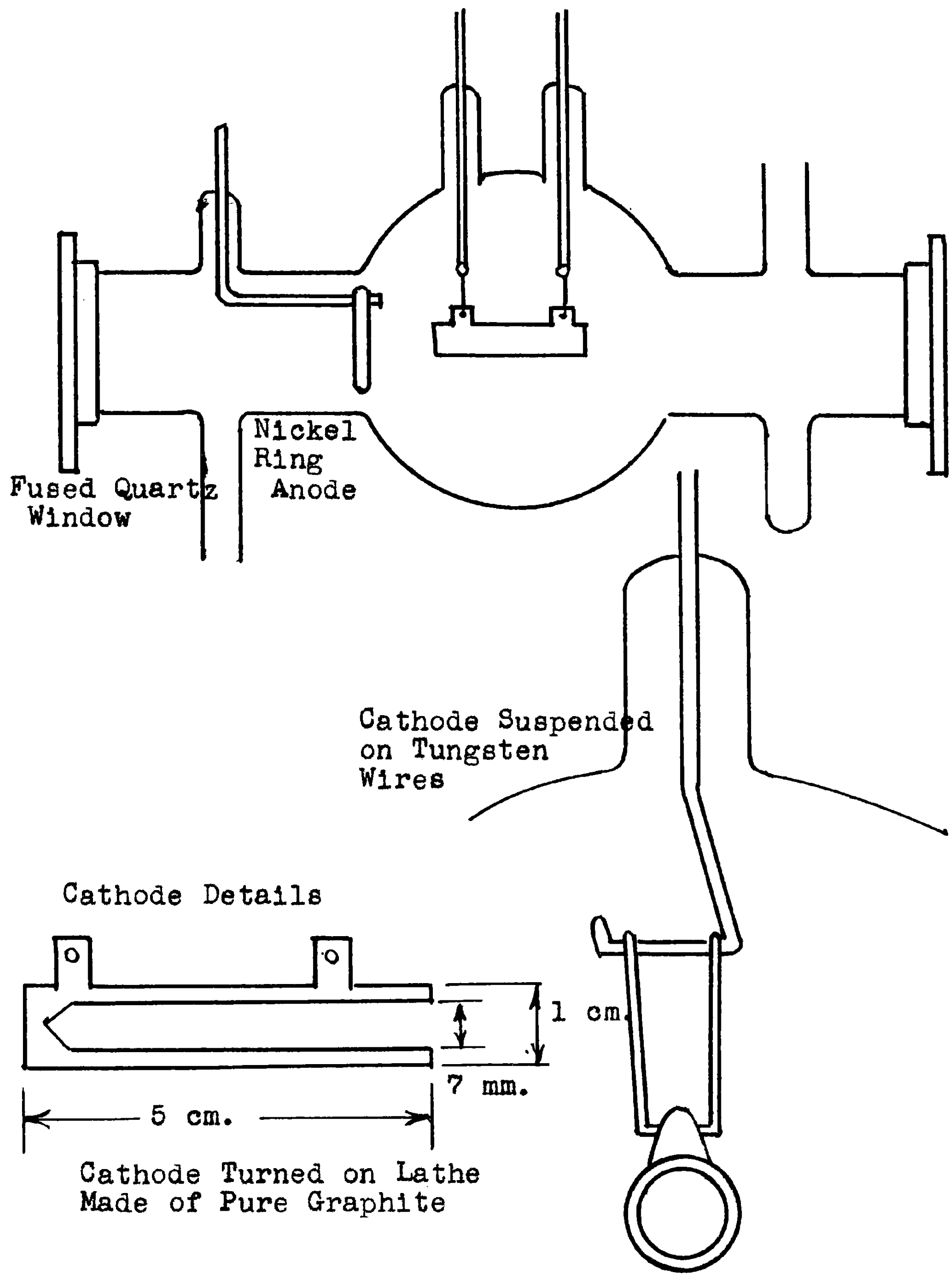
The Schuler tube used was a 3-liter Pyrex flask with a second neck fastened on the side of the bulb opposite the original neck, as shown in Fig. 8. The hollow cathode was machined from graphite[27] on a lathe. The inside diameter of the most satisfactory cathode was 7 millimeters.

The cathode was loaded with about five 1 mm. cubes of pure cobalt and was suspended inside the tube with tungsten wires. The windows were fastened onto both ends of the tube with black wax. An electric fan circulated air around the tube during running to prevent softening the wax and overheating of the main bulb.

27 - ACHESON GRAPHITE rod, 1 inch in diameter, was obtained from the National Carbon Div. of Union Carbide and Carbon Corp., 30 E. 42nd St., New York.

Fig. 8

DETAILS OF THE SCHULER TUBE



Before running the discharge, the system was evacuated to about 10^{-5} mm. of mercury, and it was then dosed with noble gas until the manometer showed a differential of a few millimeters. With the system used, this required about two doses, with a 3 c.c. dosing chamber, when the supply flask was new, i.e., when the noble gas pressure in the flask was approximately equal to atmospheric pressure.

Then the constant current source was turned on at low power, and it was gradually turned up. If the discharge did not take place inside the cathode, the pressure was increased until it did. If, on the other hand, there was excessive arcing, the pressure was decreased.

When the current reached about 2 amperes, the cathode was white hot. Usually, the cobalt spectrum could be observed when the current was above 1.5 amperes. Often, when there was a fresh charge of cobalt inside the cathode, excessive arcing occurred which could not be eliminated by lowering the pressure. But after running for a few minutes at 1.5 amperes or more, the discharge settled down and ran smoothly. After about 30 minutes of running, the suspending wires began to heat up slowly. After another 30 minutes, the wires became so hot that the tube had to be turned off.

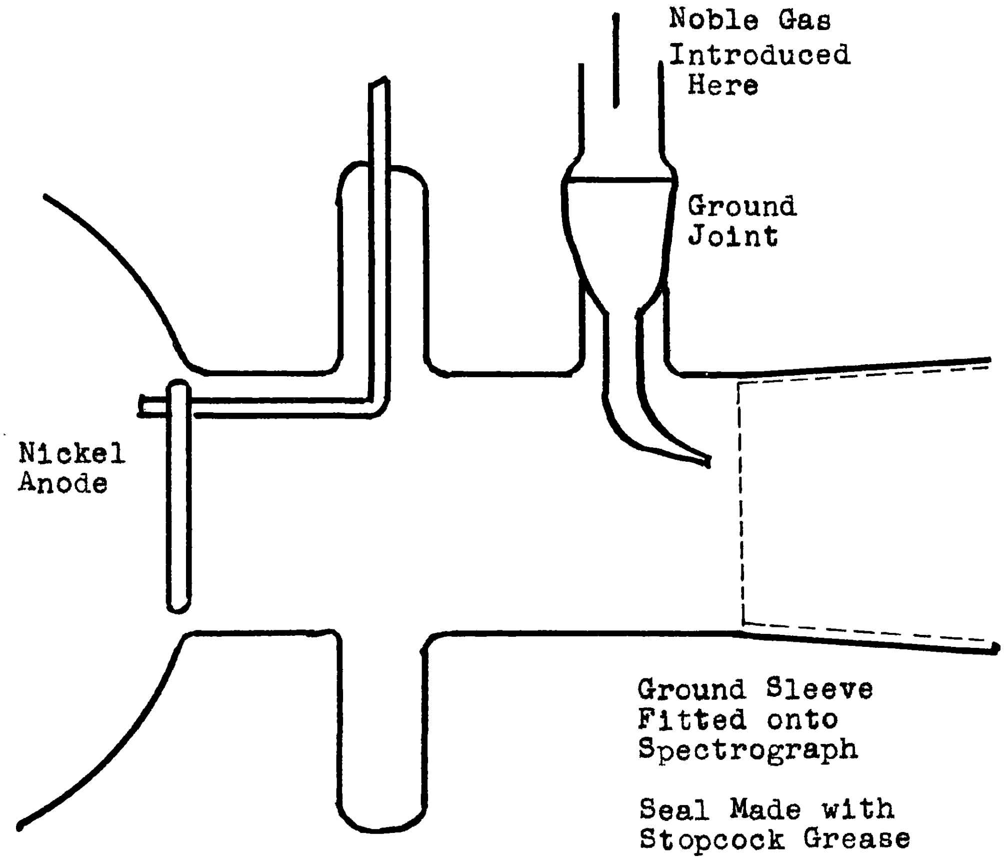
No change in the geometry of the cathode or the method of suspending the cathode permanently removed this trouble, but a small fresh lump of cobalt in the cathode always returned the tube to proper running condition for another 30 minute period.

When the Schuler tube was used with the vacuum spectrograph, only a few changes had to be made. They are shown in Fig. 9. Instead of circulating the gas as before, the gas was injected into the tube through a glass nozzle which directed the stream of gas toward the slit of the spectrograph. The gas passed through the slit into the vacuum chamber. This served to charge the tube with the noble gas and also to keep the slit clear of matter that was thrown from the cathode from time to time during the running of the discharge. The noble gas used was helium, and it was purified with a chabazite[28] trap. The rate of flow into the Schuler tube was kept uniform by passing the gas through a small artificial leak.

28 - Purification by chabazite is described by G. P..Baxter and H. W. Starkweather, Pro. Nat. Acad. Sci., 11, 231 (1925)

Fig. 9

SCHULER TUBE MODIFIED FOR VACUUM SPECTROGRAPH



D. THE EXPERIMENTAL RESULTS

The results of the experiment were not gratifying in that no new terms have been established as a result of the plates obtained with the Schuler tube.

It is true that some atoms of cobalt must have been released from the solid sample because the cobalt spectrum was produced. It is also evident that some of the desired collision excitation was occurring because so many lines appeared that resulted from combinations with the high terms e^3F and e^5F. These lines were very sharp and could not have resulted from the type of excitation produced by either the arc or the spark. But it seems that the collision excitation did not take place on a large enough scale to produce the lines needed to fix the position of new energy levels. The extremely high temperature required to produce free cobalt atoms may have been a factor in reducing the excitation due to collisions of the second kind. Also, at this high temperature, molecular band spectra appeared, causing some sections of the plates to be so over-populated with lines that they were virtually unmeasurable.

With neon in the Schuler tube, the spectrum was photographed from 2000 to 6400 A. The plates were measured from 2000 A to 3000 A, and from 5000 to 6400 A. The region from 3000 to 5000 A did not seem worth measuring, especially when it became clear that the enhancement was poor. With helium in the tube, a plate was exposed on the vacuum spectrograph. This plate was measured from 1400 to 1900 A, and again the enhancement was poor.

Appendix III.

MASTER LINE LIST

The following pages are photostatic reproductions of a master line list which is a compilation of all of the available measurements of the Co II spectrum.

The wave number values calculated from wave length measurements made of the Schuler tube plates are listed with one more significant figure than the values reduced from spark plates.

The intensity estimates for lines taken from the Schuler tube plates are based on a 0-200 scale. In the wave length region 1010 to 2225 A the intensity of the spark lines is estimated on the basis of a 1-16 scale, except where the estimates are followed by the letters "F" and "M", in which case they are based on a 0-200 scale. In the region from 2225 to 5140 A the spark intensities represent the average of several estimates, and the 0-200 scale was used.

λ vac	SPK	ν cm⁻¹		λ vac	HST	SPK	ν cm⁻¹		λ vac	HST	SPK	ν		λ vac	HST	SPK	ν	HST - Helium Schuler Tube; SPK - Spark
903.734	0	1106520		1303.657		2	76707.3		1473.502 (73.818)		2	67865.8	$a^5P_1-y^5P_1^o$	1576.789	2	7	63420.0	$a^3F_2-y^3F_2^o$
08.473	1	110074.8		04.663		1	648.1		75.452	0	2	775.8		77.042	2	7	409.9	$a^3F_3-y^3F_3^o$ in Helium
12.826	0w	109549.9		04.972		2	630.0		75.018		2	759.6		77.800	0		379.4	
13.260	0	492.8		05.175		1	617.1		76.072	8		747.4		78.610		1	344.5	
16.687	0	109088.5		06.197		1	561.1		76.663	0	7	720.3		79.338		2	317.7	
18.230	0	108905.2		06.760		1	525.1		77.023	3		703.8		79.600		2	307.2	
20.369	0	652.1		06.966		3	513.1	$a^5F_4-x^5D_3^o$	78.237	4		648.2		80.371	0		276.3	
23.070	2	334.1		07.435		0	485.4		78.358		0	642.6		81.715		1	222.5	$b^3P_1-4s4p\,^3D_2^o$
25.030	1	108104.6		11.117		5	270.3	$a^5F_4-x^5D_4^o$	80.945		8	524.5		82.005	4		210.9	
27.223	1	107848.9		11.856		5	227.7	$a^5F_3-x^5D_2^o$	81.764		1	487.1		85.371	0		63076.7	
29.966	1	530.8		12.883		2	169.1	$b^3F_2-4s4p\,^3D_2^o$	81.893		1	481.3		87.129	0		62983.0	
32.730	0	107212.2		13.937		0	136.1		84.251		5	374.1	$a^5P_1-y^5P_2^o$	89.568	3		62910.2	
37.303	4	106689.1		15.419		4	76021.4	$a^5F_2-x^5D_1^o$	84.584	1		358.9		89.654		3	906.8	$b^3P_2-4s4p\,^3D_3^o$
38.073	3	601.5		16.077		5	75983.0	$a^5F_3-x^5D_3^o$	85.165		0	332.6		90.361	0		878.8	
39.049	5	490.7		18.180		2	862.2	$a^5F_1-x^5D_0^o$?	86.076		0w	291.3		90.451	0		875.2	
42.369	4	106115.5		18.586		3	838.8	$a^5F_2-x^5D_2^o$	86.483	4	9	272.7	$a^5P_3-y^5P_3^o$	90.533		6	871.3	
44.751	4	105848.0		19.836		3	75767.0	$a^5F_1-x^5D_1^o$	87.166	1		241.9		93.299		5	762.9	$a^3F_2-y^3F_3^o$
46.584	4w	643.0		38.346		0	74719.1		87.768	2	2	214.8	$b^3P_2-4s4p\,^3P_1^o$	93.439		2	757.3	$a^5P_2-x^5D_2^o$
47.827	1	504.5		46.383		0	273.1		87.977	2		204.4		95.181	0		688.8	
48.493	1	105430.4		47.229		1	74224.4		88.115	2		199.1		95.773	0	6	665.6	$a^3F_3-y^3D_2^o$
81.242	0	101911.7		51.646	·	0	73983.9		88.303	1		190.6		96.508		3	636.7	$a^3F_3-y^3D_3^o$
90.164	1w	100993.4		55.844		0	73754.2		88.832	2		166.7		96.619		1	632.6	$a^5P_1-x^5D_1^o$
91.898	0	816.8		70.934	0		72943.0		90.117	2		108.8		98.470		5	559.8	$a^3F_3-y^3F_4^o$
92.146	0	791.6		73.035	0		831.4		91.614	1		041.5		99.308		4	527.0	$a^5P_3-x^5D_4^o$
996.546	1	100346.6		78.065		2	565.5		92.064		1	021.3	$b^3P_1-4s4p\,^3P_1^o$	1599.701		3	511.7	$a^5P_2-x^5D_3^o$
1003.806	0	99620.8		83.955		0	256.7		92.254	0	6	67012.3	$a^5P_2-y^5P_3^o$	1601.282		2	450.0	$a^5P_1-x^5D_2^o$
10.971	0	98914.8	$a^5F_5-x^5D_4^o$	84.185		1	244.7		92.774		6	66989.4		02.124		2	417.4	
12.864	0	729.9	$a^5F_4-x^5D_3^o$	84.575		1	224.3		93.110	1	0	974.3		03.637	1		358.3	
16.137	0	98411.9		85.494	0		72176.4		1495.256		2	878.2	$b^3P_0-4s4p\,^3P_1^o$	04.146	2		338.5	
35.663	0	96556.5		1389.087		1	71989.7		1500.875	1	5	627.8	$b^3P_2-4s4p\,^3P_2^o$	05.962		5	268.0	$a^3F_2-y^3D_1^o$
43.237	4	95855.5		1400.291		3	413.7		05.234		2	434.9	$b^3P_1-4s4p\,^3P_2^o$	06.189	3		259.2	
44.276	4	760.1		05.799			133.9		09.222	5	5	259.3		08.408	1		173.5	
46.758	0	533.1		08.150		2	71015.2		09.940		3	227.8		12.410		2	62019.0	$a^3F_2-y^3D_2^o$
48.882	0	95339.6		08.649	0	4	70990.0		14.735	3	1	66018.2		14.499	4		61938.7	
53.258	1	94943.5		09.320	1	5	956.2		16.439	0	2	65944.0		12.723		2	628.9	
70.033	0	93455.1		10.822		1	880.7		19.391		4	815.8	$b^3P_2-4s4p\,^3P_2^o$	22.616		3	591.3	
82.011	0	92415.4		11.908		3	826.1		20.020	0		798.6		23.606		2	584.1	
92.574	1	91527.0		20.000	0		422.5		20.459	2		771.8		23.796		2	576.4	
1095.441	2	91282.4		23.705		1	239.3		23.906	3		620.8		24.024	0	4	573.0	$a^5D_4-x^5D_4^o$
1163.964	0	85913.3		24.784	0	5	186.1	$a^3F_4-{}^38_3^o$	25.784		3	540.1		24.163		4	562.1	
68.423	0	585.1		26.390	0		70107.1		27.069	0		395.3		24.662	0		551.3	
78.717	0	838.0		30.999	0		69881.3		29.393	0		385.4		24.375	0	2	547.3	
78.918	0	823.5		31.614	0		851.2		31.342	6w		306.2		25.111	0	1	533.9	
81.600	0	631.0		32.519	0		807.1		32.818	1		239.3		25.657	0		513.6	
83.498	0	495.3		33.900	15		739.9		34.488	1		168.3		26.602		1	477.9	
87.395	0	85218.0		34.792	3		696.5		34.636	1		162.0		26.674		1	475.1	
87.611	0	84202.7		35.409		4	666.5		34.820		3	154.2	$a^3F_4-y^3G_4^o$	27.482		3	444.6	$a^5D_3-x^5D_3^o$
93.234	0w	83805.9		35.819		0	646.7		37.340			65047.4		27.765	0		433.9	
96.779	0w	557.6		36.212		1	627.6		38.594	1		64994.4		28.767		2	376.1	
1198.392	0	83445.1		36.473		3	590.7		39.076	0		974.0		29.601		1	364.7	
1207.386	0	82823.6		38.693		4	507.5	$a^3F_3-{}^3N_2^o$	39.627		3	950.8		30.044		1	348.0	$a^5D_2-x^5D_2^o$
1224.823	0	81644.1		39.099	20	7	487.9		42.434	2		833.5		32.323	0	4	262.4	
1226.970	0	501.7		41.998	0		348.2		43.138	1		803.0		33.303		2	225.4	
28.109	0	426.0		43.823		2	260.6		43.239	0		798.3		36.980	1		121.7	
30.835	0	81245.7		44.335		2	236.0	$a^3F_3-{}^38_3^o$	43.675	0		780.5		37.060	0		095.1	
55.315	3	79661.3		45.549		3	178.1	$a^3F_2-{}^311_1^o$	45.373	1	1	709.3		37.191	0		080.2	
60.158	3	355.1		48.009	2	10	69060.3	$a^3F_4-{}^37_3^o$	47.771		7	609.0		37.269		3	077.3	$a^5D_1-x^5D_2^o$
61.502	3	270.6		50.787	1w		68928.1		48.432	3		581.5		38.787	0w	4	020.7	$a^5D_2-x^5D_3^o$
61.548	1	79267.7		52.558		1	844.1	$a^3F_4-x^3G_4^o$	52.033	1		431.6		39.269	0w	5	61002.8	
65.930	4	78993.3	$a^5F_5-y^5F_4^o$	53.982	2		776.6		52.295		2	420.7		40.669		4	60950.8	$a^5D_3-x^5D_4^o$
68.512	2	832.5		54.942	1	8	731.3		52.752		9	401.8	$a^3F_4-y^3G_5^o$	40.994		1	938.7	
71.936	5	620.3	$a^5F_5-y^5F_5^o$	55.686	1		696.1		53.026	1		390.4		42.474	0	5	883.4	
72.278	3	599.2	$a^5F_4-y^5F_3^o$	55.875	1	10	687.2		53.337	0		377.5		42.161		1	873.1	
76.901	4	314.6	$a^5F_4-y^5F_4^o$	56.918	25		638.0		53.754		4	360.3	$a^3F_4-y^3F_3^o$	43.632	1		847.9	
80.677	0	083.7	$b^3F_4-4s4p\,^3F_3^o$	57.438	6		613.5		54.286	1		338.2		45.127	0		831.4	
80.950	1	067.1	$a^5F_3-y^5F_3^o$	58.396	1		568.5		56.018	0		266.6		45.649	1		766.2	
81.884	1	78010.2	$a^5F_2-y^5F_2^o$	59.033	5		520.7		56.745	3w		236.6		47.446	0	6	700.0	$a^5D_3-w^5D_3^o$
83.003	1	77942.1	$a^5F_4-y^5F_5^o$	59.844	0		500.5		57.039		6	224.5	$a^3F_3-y^3G_3^o$	47.729		3	689.6	$a^5D_2-w^5D_2^o$
84.026	1	880.0		60.104		8	488.3		57.394	0	3	209.8		47.924	0		682.4	
85.619	1	783.5	$a^5F_3-y^5F_4^o$	60.333	0	·	477.5		57.542		6	203.6	$a^3F_3-y^3G_4^o$	49.263	1	7	633.1	$a^5D_4-w^5D_4^o$
86.083	0	755.5	$a^5F_1-y^5F_2^o$	60.477	0		470.8		58.809	0		151.5		49.651	4		618.9	
86.639	0	721.9		64.619	2		277.1		59.166	6		136.9		50.465	0		589.0	
86.699	1	718.3		66.196	3	10	203.7	$a^3F_4-x^3G_5^o$	60.226		2	093.3		51.280	0		559.1	
86.841	1	709.7	$b^3F_3-4s4p\,^3F_2^o$	67.376		0	148.9		60.865		4	067.0	$a^3F_3-y^3F_2^o$	51.839	0		538.6	
87.361	1	678.3	$a^5F_2-y^5F_3^o$	67.637		0	136.7		61.350		4	64047.1		54.570		2	438.7	
93.671	6	299.4	$b^3F_4-4s4p\,^3F_4^o$	68.204		6	110.4	$a^3F_3-{}^37_3^o$	64.169	1		63907.2		55.119		3	418.6	$a^5D_1-w^5D_2^o$; $a^3P_2-{}^31_2^o$
95.519 ●	4	189.1		68.356	1w	6	103.4	$a^5P_2-y^5P_1^o$	67.571		5	793.0		56.645		4	363.0	
95.539	4	188.0	$b^3F_3-4s4p\,^3F_3^o$	68.984		0	074.3		71.626	1		628.4		58.518		3	294.8	
95.864	7	168.6	$b^3F_4-4s4p\,^3D_3^o$	69.717		6	040.3		72.324		1	600.1		58.750		3	286.4	
97.094	3	77095.4	$b^3F_2-4s4p\,^3F_2^o$	69.843	1		68034.5		72.645	1	7	587.1	$a^3F_4-y^3D_3^o$	59.032		4	276.1	$a^5D_2-w^5D_3^o$
1299.574	8	76948.3	$a^5F_5-x^5D_4^o$	71.063			67978.1		72.886	0	4	577.4	$a^3F_2-y^3G_3^o$	59.930		3	243.5	
1300.850	1	872.8		71.860	1	6	941.2	$a^5P_3-y^5P_2^o$	74.548	0	8	510.3	$a^3F_4-y^3F_4^o$	60.314		1	229.6	
01.967	1	806.9		72.014		1	934.1		75.590	0	·	468.2		60.906		1	208.1	
1302.390	6	76781.9	$b^3F_3-4s4p\,^3D_2^o$	1472.892	4	8	67894.0	$a^3F_3-x^3G_4^o$	1576.045	0		63450.0		1661.261		6	60195.2	

110652

60195

λ vac	HST	SPK	ν	
1664.775		3	60068.2	
66.276	11.9 1w	5	014.1	$a^5D_3-w^5D^o_4$
66.380		5	60010.3	
68.613	2	5	59930.0	
69.907		4	888.4	
70.334	1	2	868.3	
70.799	0	2	851.6	$a^3P_3-{}^315^o_1$
70.943	0	1	846.4	
71.553	12		824.6	
73.145	2	3	767.7	
73.787		1	744.8	$a^5D_4-x^5F^o_4$
73.918		3	740.1	$a^3P_1-{}^316^o_1$
74.921	1	5	704.3	$a^5D_3-x^5F^o_3$
75.183		2	695.0	
75.758	1	2	674.5	
77.000	0	1	630.3	
77.093	0	1	627.0	$a^3D_3-x^3F^o_4$
77.473		1	613.5	
77.685		1	606.0	
79.232		2	551.0	$a^5D_2-x^5F^o_2$; $a^3P_0-{}^316^o_1$
79.368		3	546.2	
79.490		2	541.9	
79.558		2	539.5	
80.125		3	519.4	$a^3P_1-{}^315^o_1$
80.285		1	513.7	
80.897	0	.	492.0	
81.165	0		482.6	
82.102	10	3	449.4	
82.821	5	6	424.0	
83.164		2	411.9	
83.722	3	6	392.2	$a^3P_2-{}^314^o_2$
84.800	0	1	354.2	
85.251		1	338.3	
85.848		3	317.3	
86.600		1	290.9	
86.896	1	5	280.5	$a^5D_3-x^5F^o_2$(D)
87.057	1	5	274.8	$a^5D_4-x^5F^o_5$
87.596	0		255.9	
87.788		1	249.1	$a^3P_1-{}^314^o_2$
87.848		2	247.0	
88.296	2	3	231.3	
88.681	1	2	217.8	
89.027		3	205.7	
91.310	2	4	125.8	$a^5D_3-x^5F^o_4$
92.650		2	079.0	
93.330	1	3	055.2	$a^5F_5-y^3D^o_4$
93.393		3	053.0	
93.816	1		59038.3	
94.072	0		58029.4	
95.894	1		965.9	
96.962		3	928.8	
97.630	0		905.7	
98.128	1	1	888.4	
1699.343	0		846.3	
1700.487		1	806.7	$a^5F_3-z^5P^o_2$(P)
00.621	0	1	802.0	
02.603	1		733.6	
02.916	0		722.8	
03.821	1		691.6	Cu
05.643	0	1	629.0	
06.062		3	614.5	
06.794	1	5	589.4	
06.878		1	586.5	
07.563	2	5	563.0	
07.775	1	4	555.7	
09.553	2	3	495.5	
11.101		3	444.1	
12.128		1	406.	
12.373		1	398.5	
12.614		1	390.3	$b^3F_4-a^3G^o_5$
13.379	10w		364.2	
13.426		2	362.6	
15.053		2	307.2	
15.873	1	3	279.4	
16.163	1w		269.5	
17.106	3w		237.5	
18.280	0		197.7	
18.464	0		191.5	
20.168	2	2	133.9	
23.013		4	037.9	$a^5F_5-y^5D^o_4$(P)
23.324	0		027.4	
23.726	0	2	013.9	
23.981	2w		58005.3	
1725.223	2	3	57963.5	

λ vac	HST	SPK	ν	
1725.679	3w		57948.2	
26.802	20w		910.5	
27.806	1	3	876.9	$a^3P_1-{}^313^o_0$
29.899	0	1	807.2	
30.815	2w	1	776.3	
32.763		1	711.3	
33.354		1	692.3	
34.125		4	666.0	
34.550	0		651.8	
35.210	0		629.9	
35.392	0		623.9	
36.225		2	596.2	$a^3P_2-{}^312^o_1$
38.692	0		514.5	
38847	10	7	509.4	
39.483	0		488.3	
39.709		3	480.9	
40.555	1		452.3	
41.358	0		426.4	
41.894		2	408.8	
43.381	0	3	359.8	$a^5F_4-y^5D^o_4$(P)
43.571		1	353.6	
43.791		1	346.3	
46.297		2	264.0	$a^3P_0-{}^312^o_1$
47.119	10		237.1	
47.882		5	212.1	$a^5F_4-y^5D^o_3$(P)
48.343		3	197.0	$a^3P_2-{}^310^o_2$
48.613	1	4	188.2	
48.772	0	3	183.0	
49.962	0		144.1	
54.217		7	57005.5	$a^3P_2-{}^39^o_2$
57.382	0		56902.8	
57.767	2	4	890.4	
58.642		6	862.1	$a^3P_1-{}^39^o_2$
59.085		1	847.7	
59.834	1		823.5	
61.676	1	2	764.1	
61.883	0	3	757.5	
62.056		2	751.9	
63.675		5	699.8	$a^5F_3-y^5D^o_2$(P)
63.889	0	.	692.9	
64.279		4	680.4	$a^5F_3-y^5D^o_3$(P)
72.451	0		419.0	
73.040	1	4	400.3	$a^5F_2-y^5D^o_1$(P)
73.872	0		373.9	
75.867		3	310.5	$a^5F_2-y^5D^o_2$(P)
77.658		3	253.8	$a^5F_1-y^5D^o_0$(P)
78.318		4	232.9	
81.068	1	2	146.1	$a^5F_1-y^5D^o_1$(P)
81.553	0		130.8	
83.909		2	056.7	$a^5F_1-y^5D^o_2$(P)
84.801	0		56028.7	
87.349	3w		55948.8	
87.952		2	929.9	
88.458	0		914.1	
93.499	1		756.9	
93.920	1		743.8	
95.608	1	.	691.4	
96.660	12		658.8	
98.786		1	593.0	
99.271	0	'	578.1	
99.554	0w		569.3	
1802.128	1		490.0	
1804.947	8	12	403.3	
07.267	1	4	332.2	
07.956	0		311.1	
08.276		7	301.3	
08.912	6		281.8	
12.167	2	3	182.6	
13.138	1		153.0	
15.330	0		086.4	
16.608	1		047.6	
16.881	1		039.4	
17.459	1		55021.9	
18.315	1w		54996.0	
18.542	2	1	989.1	
18.649	1		985.9	
20.310		4	935.7	
21.595	2		896.9	
21.793	3w		890.9	
23.891	0		827.8	
24.049	1	3	823.1	
25.328	8		784.7	
25.657	1w		774.8	
1826.098	3	3	54761.6	

λ vac	HST	SPK	ν	
1826.394		4	54752.7	
27.096	1		731.7	
27.919	1		707.0	
28.274		1	696.4	
28.409	2w		692.4	
29.399	1		662.8	
32.471	0	1	571.1	CoI
33.271		1	547.3	$b^3F_4-y^3F^o_3$
33.475	3		541.2	
33.665		1	535.6	
34.251	1		518.2	
35.940	0		468.0	
36.647	6		447.0	
37.556	0		420.1	
37.993	6		407.2	
38.844		2	382.0	
39.263	68.2 5w	4	369.6	
39.356		12	366.9	
40.209	6	10	341.7	
42.350	4	4	278.5	CoI
42.811		9	264.9	
44.009	0		229.7	
45.106	1		197.4	
45.916	5	14	173.6	
48.459	8	4	099.1	
49.814	0		057.5	
51.641		4	54006.1	
52.528		3	53980.3	CoI
52.693	3	4	976.0	CoI
53.715	2	4	945.7	
55.037	2	2	907.3	(CoI) $b^3F_3-y^3D^o_2$
56.144	1	2	875.1	
59.625		2	774.3	$b^3F_4-y^3D^o_3$
60.209	0w	5	757.4	
61.420	1	3	722.4	
61.855		8	709.9	
62.353		6	695.5	$b^3F_2-y^3F^o_2$
63.862	0		652.0	
65.868	0w		594.4	
67.008	1	9	561.6	
68.322		1	524.0	
69.211	8		498.5	Hg
71.720	0		425.4	
74.150	2		357.5	
75.726	2		312.7	
77.332	1		267.1	
85.530		1	035.5	
86.664	0w		53003.6	
90.076		2	52907.9	
91.028	0w		881.3	
91.919	0w		856.4	
95.477	0	8	757.2	
1896.474		1	729.4	
1900.399	0		620.5	
03.600		2	532.1	
08.518	0	6	396.7	$a^3P_2-{}^36^o_1$
08.738	0		390.6	
12.563	0		285.9	
13.756		2	253.3	$a^3P_1-{}^36^o_1$
17.627	1	7	147.8	$a^3P_2-{}^35^o_2$
18.947	10		111.9	
20.706		3	064.2	$a^3P_0-{}^36^o_1$
21.457	0		043.8	
22.561		3	014.2	
22.927		5	52004.1	$a^3P_1-{}^35^o_2$
24.526	0		51960.8	
27.040	4	1	893.1	
28.498	0w		853.8	
28.956	1		841.5	
29.388	0w		829.9	
33.624		1	716.4	
35.963		1	653.9	$a^3P_2-{}^33^o_2$
36.571		3	637.7	CoI
36.770		1	632.4	
37.069		4	624.4	$a^3P_1-{}^34^o_1$
37.394		1	615.7	
40.69		50F	512.3	FAINT $a^5F_4-z^3D^o_3$(F)
44.188		3	435.4	$a^3P_0-{}^34^o_1$
50.098		25F	279.5	$a^3F_3-z^3D^o_2$ (F)
50.424		1	270.9	
51.889		2	232.4	CoI
53.071		3	201.4	$a^3P_1-{}^32^o_0$ -718
55.148		2	149.6	
1957.424		30	51087.6	$a^3F_2-z^3D^o_1$ (F)

λ vac	HST	SPK	ν	
1962.486		1	50955.8	
63.537		1	928.5	CoI
64.010		1	916.2	CoI
68.692		3	795.1	
69.680		5	769.7	
70.731		2	742.6	CoI
71.158		1	731.6	CoI
72.530		2	696.3	CoI
73.855		1	662.3	CoI
75.008		4	632.7	$a^3F_2-z^3D^o_2$ (F)
75.647		2	616.3	CoI
77.304		1	573.9	
77.549		4	567.6	
78.334		1	547.6	CoI
80.251		1	498.6	
80.415		3	494.5	
80.854		1	483.3	CoI
81.601		2	464.2	
81.736		2	460.8	$a^3P_1-y^3D_1$
82.259		3	447.5	
82.530		1	440.6	CoI
83.953		4	404.4	~~$a^3P_2-{}^3P^o$~~
84.843		3	381.8	$a^3F_4-z^3F^o_3$ (F)
87.030		4	326.4	$a^3P_2-y^3D^o_3$
87.651		1	310.6	CoI
89.429		1	265.7	
89.803		1	256.2	CoI
90.356		1	242.3	CoI
91.567		3	211.7	$a^3P_1-y^3D^o_2$
93.880		3	153.5	
94.602		1	135.3	
95.733		2	106.9	$a^3P_2-z^5P^o_2$
97.135		3	071.7	~~$a^3P_2-{}^3P$~~
1998.549		1	50036.3	$a^3F_4-z^3G^o_3$(F)

λ VAC	λ NST	NST	ARC	SPX	ν	NST-NEON SCHULER TUBE
2001.445				7	49963.9	$a^3F_3-z^3F^o_2$ (F)
05	556	0w			845.27	
05	718	0			841.25	
07.636				3	809.8	
08.134				3	797.5	
08.877				4	779.1	$a^3G_5-z^3H^o_6$
12.199	11.583	0	1	16	692.18	$a^3F_4-z^3F^o_4$ (F)
14.169				1	648.3	
16.195				2	598.4	
16.343				2	594.7	
18.950				2	530.7	
18	460	1			526.63	
18	639	1w			522.26	
20.981				1	480.9	
21.956				3	457.1	
22.344				1	447.6	
23.019	22.374	0	1	15	430.84	$a^3F_3-z^3F^o_3$ (M)
23.630				2	416.1	
24	357	0			382.4	
25.702				2	365.6	
26.138				13	355.0	
26.424	25.780		0	13	347.73	$a^3F_4-z^3G^o_4$ (M)
27.057				3	332.6	
27.703	066	0	1	14	316.42	$a^3F_2-z^3F^o_2$ (M)
27.931				1	311.3	
29.703				1	268.3	
30.180				1	256.7	
30.462				1	249.9	
31.746				2	218.6	
32.189				1	208.0	
32.299				1	205.5	
33.379				10	179.2	$a^3P_2-z^3S^o_1$
36.502				1	103.6	
37.244				11	085.9	$a^3F_3-z^3G^o_3$ (M)
39.333				9	49035.6	$a^3P_1-z^3S^o_1$
40	662	0			48987.88	
42.628				1	956.5	
43.996				1	923.8	
44.460				1	912.7	
47.223				3	846.7	$a^3P_0-z^3S^o_1$
48.131				6	825.0	
49.831				5 / 10	784.5 / 746.8	$a^3F_2-z^3F^o_3$ (M) / $a^3F_3-z^3F^o_4$ (F)
51.999				3	733.0	$b^3P_0-{}^3K_1$
–				3M	693.5	
54.830				6	665.8	
55.324				1	654.1	
55.644				1	646.6	
55	094	0			643.88	
55	462	0			635.22	CoI?
56	019	0			621.57	
				1M	619.6	
58.606				6	576.6	
59.480				11	555.9	$a^3F_4-z^3G^o_5$ (M)
59.708				1	550.6	
62.669				10	480.9	
63.576				1	459.6	
64.453				10	439.0	$a^3F_2-z^3G^o_3$ (M)
64.892				3	428.7	
65	328	0	0		402.9	
65 / 65	510 / 775	0	1	10	398.2	$a^3F_3-z^3G^o_4$ (M)
66	003	0			387.11	
68	342	0	0		332.4	
69.673				2	316.8	
69	065	0			315.51	
69	173	0			313.00	
69	467	0w			306.13	
70.352				1	301.0	
72.209				3	257.7	$c^3P^o_2-{}^316^o_1$
73	550	0			210.84	
73	764	0			206.05	
78.480				3	112.1	
79.189				1	095.7	
79.485				1	088.8	$a^3P_2-y^5D^o_1$
–				1M	086.5	
80.556				2	064.1	
82	277	0w			008.99	
82	464	0w			48004.68	
83.358	82.664	0w		10	47999.70	$a^3P_2-y^5D^o_2$
85	444	3			936.72	
–				4M	866.2	
89.569				3	856.8	
90.252				4	841.1	
2090.889				1	826.5	$c^3P_1-{}^316^o_1$
---				2M	47822.0	

λ VAC	λ NST	NST	ARC	SPX	ν	
2091.577				2	47810.8	
91.738				4	8021	$a^5F_5-z^5G^o_4$ (M)
91	324	0			801.33	
91	641	4			795.00	
				5M	769.2	
94.083				1	753.6	
94.931				2	734.3	$a^5F_2-z^5D^o_1$ (M)
96.450				2	699.7	
96	111	5			692.18	
96	241	0			689.23	
96.969				1	687.9	
97.809				3	668.8	$a^5F_3-z^5D^o_2$ (M)
98.180				3	660.4	CoI
99.230				2	636.5	$a^5P_3-{}^5S_2$
98	710	0			633.13	
2099.627	98.751	3		3	627.50	CoI
2100.618				4	605.0	
00	921	3w			583.01	
01.778				4	578.8	
05.419				4	496.5	
06	823	5			494.90	CoI
06.019				3	483.0	$a^5F_4-z^5D^o_3$ (M)
06.162				3	479.7	$a^5F_1-z^5D^o_0$ (M)
07.504				3	449.5	
07	904	0			425.35	
09.676				2	400.6	
10.271				8	387.3	
10	570	0			365.42	
11	422	1			346.38	CoI
12.140				7	345.3	$a^3F_3-z^5G^o_4$ (M)
12.540				1	336.4	$c^3P_1-{}^314^o_2$
12.789				1	330.8	
13.335				2	318.1	$a^5P_1-{}^36^o_1$
14.211				1	299.0	CoI
14.666				3	288.8	
14.966	292	0		4	282.10	$c^3P_0-{}^316^o_1$
15.088				2	279.4	$a^5F_2-z^3D^o_2$ (M)
16.025				3	258.4	
–				1M	221.0	
18.226				1	209.3	
18.644				4	200.0	$a^3F_3-z^5G^o_3$ (M)
20.116				1	167.2	
23.677				1	088.1	
24.524				2	069.4	$a^5P_1-{}^5S^o_2$
25.697	011	0		9	043.65	
26.532				3	47024.9	$a^5F_1-z^3D^o_2$ (M)
28	153	0			46974.20	
–				6M	961.2	$a^5F_3-z^3D^o_3$ (M)
30.318				1 / 4	951.3 / 941.3	
30.492				3	937.5	
–				3M	906.8	
33.453	32.774	8		4	872.44	CoI
33.960				5	861.2	
34.174				4	856.5	$a^5F_3-{}^5G^o_4$ (M)
35.216				5	833.7	
36.680				4	801.6	
37.178				3	790.7	$a^5F_2-z^5G^o_2$ (M)
38.371				1	764.6	
39.269				6	744.9	
40.108				3	726.6	
45.064				3	618.7	
				5M	599.5	
46.932				6	561.8	$a^5F_2-z^3D^o_1$ (M) / $a^5F_2-z^5G^o_3$ (M)
49.217				3 / 5	533.6 / 528.6	
49.673				1	518.7	
50.778				1	494.8	
50	848	12			478.60	
51.731				2	474.2	
–				1M	465.6	
51	523	12			464.03	
54.012				3	425.0	$a^5F_3-z^3F^o_2$ (M) / $a^5F_4-z^5F^o_3$ (M)
57.381				4M	352.5	
57.635				4M	347.0	$a^5F_5-z^5F^o_4$ (M)
57.723				3	345.2	
58.862				1	320.7	$a^3F_4-z^5D^o_4$ (M)
59.651				2	303.8	
60.088				1	294.4	
61.995				2	253.6	
				2M	239.1	$a^3D_1-{}^31^o_2$
62	702	0		2	223.83	
64.158				2	207.3	
63	585	8			205.02	CoI
				1M	201.3	
2165.123				2	46186.8	

λ	λ NST	NST	ARC	SPX	ν	
2166.262				3	46162.5	Ni?
66.625				4	154.7	
66	787	0			136.75	
68	918	0			091.43	
69.766	014	0		3	087.90	$a^5F_5-z^5D^o_4$
–				1M	061.4	
72.532				1	029.2	
73.573				3	46007.2	$a^5F_4-z^5G^o_3$ (M)
74.008	73.365	1		9	45998.40	$a^5F_5-z^5G^o_6$ (M) / [illegible]
74.686	73.986	1		8	983.79	
74	592	15			971.48	$c^1P_2-{}^312^o_2$?
75.614				2	964.0	$a^5F_2-z^5F^o_3$ (M) / [illegible]
76.132				2	953.1	
76.376				6	947.9	
76.874	75.819	1		6	945.3	
–				5M	919.1	
–				5M	913.2	
79.256				6	887.2	
79	193	0			874.2	
80.078				6	869.9	
80.803				7	854.7	
80.955				6	851.5	-
–				3M	847.9	
81.299				6	844.3	$a^5P_3-y^3D^o_2$
80	861	4			839.05	
81.613				2	837.6	
82.414				4	820.8	$a^5F_3-z^3F^o_3$ (F)
82.679				7	815.3	$a^5P_3-y^3D^o_3$
86.174	85.497	0	0	3	741.8	
87.465				6	715.0	
87.730				25M	709.5	$a^5F_1-z^3F^o_2$ (M)
88.219				2	699.3	
88.460				3	694.2	
–				2M	689.5	
89.243				1	677.9	
89.686				25M	668.6	$a^5F_4-z^5F^o_4$ (M)
91.183				3	637.4	
–				75M	634.2	$a^5P_2-z^5P_1$ (M)
91.638				7	628.0	$a^3D_3-{}^315^o$
–				2M	624.2	
91.933				3	621.8	
92.561				3	608.8	
92.957				4	600.5	
93.180				11	595.9	$a^5P_3-z^5P^o_2$ (M)
–				3M	580.8	
94.293	93.601	3w		12	572.85	$a^5P_3-z^5P^o_3$ (M)
94.783				2	562.6	
94.934				1	559.5	
95.216				2	553.6	
95.520	94.833	0		4	547.28	
–				3M	545.7	
95.756				1	542.4	
–				1M	539.7	$c^3P_1-{}^312^o_2$
96.035				1	536.6	
96.207				1	533.0	
96.515			0	4	526.56	$a^5P_1-y^3D^o$ / $a^3D_1-{}^315^o$
96.856				1	519.6	
–				0M	514.0	
97.527				3	505.7	
97.838				5	499.3	
98.045	97.362	0		4	494.78	
98.171	97.473	0		4	492.56	
98.678				1	481.9	
98.803				4	479.3	
2198.968				6	475.9	$a^5F_3-z^3G^o_3$ (M)
2200.085				4	452.8	
00.869				5	436.6	
01.101	00.413	0		25M	431.79	$a^5F_2-z^3F^o_3$ (M)
01	557	0			408.18	
02.323				1	406.6	
02.454				2	403.9	
03.288				1	386.7	
03.617				11	379.9	$c^3P_2-{}^39^o_2$ / $a^5F_3-z^5F^o_2$ (M)
03.870				1	374.7	
04.106				3	369.9	$a^5F_3-z^5D^o_2$ (M)
04.213				1	367.7	
04.649				3	358.7	
05.269				3	345.9	
05.481				3	341.6	
05.750				8	336.1	$a^5P_2-z^5P^o_2$
05	400	10			329.06	
06.205				9	326.7	$a^5P_1-z^5P^o_1$ (M)
2106.576				9	319.1	$a^5F_4-z^3G^o_4$ (M)
06	182	4w		75M	45312.99	$a^5P_2-z^5P^o_3$ (M)

λ	λ NST	NST	ARC	SPX	ν	
2206.903				12	45312.3	$a^5P_2-z^5P^o_3$
06	714	0			302.07	
07.663				3	296.8	
07	854	8		5M	278.69 / 277.2	CoI
09.075				1	267.8	
08	515	2			265.13	
09.518				6	258.7	
09.729				2	254.4	
10.184				6	245.1	
10.956				1	229.3	
11.018				1	228.0	
11.283				2	222.6	
11.667				9	214.8	
12.102				10	205.9	$a^5F_5-z^3G^o_5$ (M)
12.902	12.223	0		2	189.27	$a^5F_5-z^5F^o_5$
13.000				2	187.5	
12	518	0w			182.84	
13.724	13.018	1		!	173.02	
13.825				7	170.1	$a^3D_3-{}^314^o_2$
13.926				4	168.6	
14.542	13.867	2w		6	156.13	CoI
15.026	14.337	1		7	146.13	
15.191				7	142.8	
15.456	14.780	1		20M	137.11	$a^5F_5-z^5F^o_4$ (M)
16.118				3	124.0	
16.158				1	123.1	
16.535				4	115.5	
17.045	16.351	2		11	105.11	
17.601	16.915	2		4	093.64	
17.968	17.284	3w		10	086.10	$a^5F_2-z^3G^o_3$ (M)
–				5M	083.8	
18.390	17.696	1w		8	077.77	
18.798				4	069.4	
19.295				1	059.4	
19.473				1	055.7	CoI
19.734				4	050.4	
20.189				4	041.2	
20.594	19.930	1	0	8	032.41	$a^3D_2-{}^316^o_1$
20.775	20.183	2	1	10	028.89	$a^5P_1-z^5P^o_2$ (M)
21.171	20.501	0w		4	020.83	$a^5F_3-z^5F^o_3$
20	751	0			015.76	
20	887	0			013.21	
21.900	21.331	1		8	006.03	
22.123	21.458	1		9	45001.44	$a^3D_2-{}^315^o_1$
22.422	21.763	2		9	44995.54	$c^3P_0-{}^312^o_1$
22.915				4	986.0	$b^3P_2-{}^37^o_3$
22	413	0w			982.10	
23.582				1	972.5	
23.700	23.032	0		1	969.68	
23.927	23.240	0w		3	965.25	
24.378	23.704	0		4	955.99	
24.745	24.075	1	0	6	948.49	$c^3P_1-{}^39^o_2$
24	298	0			943.98	
24	421	0			941.50	
25.238				1	939.0	
25.545				2	932.8	
24	552	0			930.78	
25	054	0			928.67	
26.194	25.535	0		7	919.20	
26.611				6	911.3	
26.835	26.152	0		6	906.36	CoI
27	072	0w			888.02	
27	349	0			882.43	
2228.183	27.535	1		5	44878.68	

↑ END OF VACUUM SPARK MEASUREMENTS FROM PRINCETON

M- MEGGERS' INTENSITY ESTIMATE

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44878

NST λ (AIR) / SPK λ AIR	NST	ARC	SPK	ν	
2227.83			2M	44872.7	
2228.561	0			858.02	
29.114	0			846.89	
30.429 .49	4	0	100w	820.45	
31.079	0			807.39	
31.354	1			801.87	
31.899	1			790.93	
32.065 .05	3	3	50	787.60	$a^5F_3-z^3G_4^o$ (M*)
32.384	1			782.70	
32.460 .46	1	1	30	779.69	CoI
33.090	1	1		767.04	CoI
33.91			2	750.6	
34.009	0			748.63	
34.735 .78	8w	3w	50w	734.10	CoI
35.003 .09	4		40w	728.74	
35.704	0			714.71	
36.063 .15	0w		2w	707.53	
37.03			5	688.2	
37.315 .42	2		2w	682.52	
37.853	0			671.78	
39.807 .77	0		10	632.81	
40.027 .11	1		15w	628.43	
40.237	0w			624.25	
41.178 .22	4		30w	605.51	
41.646 .58	5		5	596.21	CoI
42.808 .90	1w		10w	573.10	
43.747	0			554.45	
43.842 .87	0		30w	552.56	
45.120 .11	15	15	100	527.20	$a^5F_4-z^3G_5^o$ (M*)
45.647	1			516.86	
45.735 .78	0		2w	515.01	
46.13			10w	507.2	
46.264	0			504.53	
47.323	0			483.56	
47.602	0			478.04	
47.745	0w			475.21	
48.004	2			470.08	
48.074 .15	1		8w	468.70	
48.236	0			465.50	
48.66			8	457.1	$a^5F_5-z^5G_4^o$ (M*)
48.896	0			452.45	
48.975	1	1		450.89	
49.202	0			446.40	
49.460	0			441.30	
49.687	0			436.82	
49.921 .96	1w		20w	432.20	
50.314 .36	3		2	424.44	
50.606 .54	0		10d	418.68	
51.10			10	408.9	$a^5P_2-z^3S_1^o$
51.323 .31	0		4	404.53	
51.63			2	398.5	$a^5D_3-y^5P_2^o$
51.981	0			391.38	
52.277 .35	2		6w	385.72	
52.79			7w	375.6	
53.132	2w			368.98	
53.336	0			364.86	
53.473 .46	1w	0	15	362.17	
54.181 .13	0		1	348.13	$a^5D_4-y^5P_3^o$
54.610	1			339.80	
54.982 .97	1		10	332.48	Cu
55.645 .63	0		8	319.45	
55.935 .602	2		20w	313.76	
56.582	4	2w		301.05	CoI
56.743 .74	6	3w	75	297.89	
56.854	0			295.71	
57.253	0			287.88	
57.594	1			281.19	CoI
57.649	1			280.11	
57.779 .84	1		25w	277.56	
57.921	0			274.78	
58.140	0			270.49	
58.483 .58	1		6w	263.87	
59.495	1			243.94	
59.852	1			236.96	
60.000 .05	12	8	50w	234.06	
60.286	1w			228.46	
60.432	1			225.61	
60.815	2			218.12	
60.971	2			215.06	
61.32			3w	208.3	
61.419	0			206.31	
61.549 .55	0		10	203.96	
61.803	1			198.80	
2261.938	1			44196.16	

λ	NST	ARC	SPK	ν	
2262.046 .03	1		3w	44194.05	
63.467	8w			166.31	
63.702	0			161.73	
63.893	2			158.00	CoI
64.077].16	1		3w	154.42	
64.196	1			152.09	
64.622	0			143.79	
65.248 .33	1		5w	131.59	
65.96			6	121.7	$a^5F_4-z^5G_3^o$ (M*)
66.013	15			116.69	
66.541 .54	6w	3w	40	106.42	
66.795 .82	1w	1w	10	101.47	$a^5P_1-z^3S_1^o$
67.381	2			090.07	
67.731	0			083.27	
67.90			2d	080.0	
68.184	4w	4w		074.47	CoI
68.465	0			069.01	
68.525	0			067.85	
69.122	0			056.25	
69.301	0			052.78	
69.509	0			048.74	
69.737	0			044.31	
69.905].94	3		10w	041.06	
70.217	2			035.00	
70.303	1			033.34	
70.540	3			029.74	
70.722	0			025.21	
70.893	0			021.89	
71.117 .20	3		20w	017.56	
71.791	0			44004.50	
72.265 .26	0	3	20	43995.42	$a^5F_5-z^5G_5^o$ (M*)
72.427	0			992.19	
72.682	3			987.25	
72.862	0			983.76	
73.047	0			980.18	
73.588	6	0		969.72	
73.73			100	966.9	
73.814	0			965.35	
73.997	0			961.81	
74.507	6w	3w		951.96	CoI
75.070	0			941.08	
75.312	1			936.41	
75.423 .41	0w	0	10	934.27	
75.609	0			930.68	
75.701 .70	0		1	928.90	
76.163	2			920.08	
76.793 .88	2		3w	907.83	
77.416	2			895.82	
77.905	1			886.40	
78.082	0			882.99	
78.307	0			878.66	Cu
78.456 .47	1		5	875.79	
78.578	0			873.44	
79.033	0w			864.68	
79.595	0			853.86	
79.30			2	859.5	
80.018	0			845.73	
80.146	0			843.27	
80.359 .44	8	0	50w	839.17	
80.853	3			829.78	
80.938 .95	0	0	7	828.05	$a^5F_3-z^5G_2^o$ (M*)
81.572	2			815.86	
81.704	0			813.34	
81.889 .89	4	3	25	809.77	
82.348 .36	0		10	800.97	
82.440	0			799.21	
82.583	1			796.45	
82.701	0			794.20	
83.062	6			787.28	
83.265	0w			785.30	
83.511 .53	3w	5w	20	778.77	$a^5F_4-z^5G_4^o$ (M*)
83.841	1w			772.25	
84.092	1w			767.53	
84.839	1w	1w		753.23	CoI
85.630	1			738.09	
85.795	0	0		734.93	
86.147 .17	50	25w	150	728.20	$a^5F_5-z^5G_6^o$ (M*)
86.877	0			714.24	
87.418	0			703.90	
87.82			4	696.2	CoI $a^3D_1-{}^3B_0^o$
88.101	4			690.86	
88.431	0			684.56	
88.549 .53	0		2	682.31	
2288.663	0			43680.42	

λ	NST	ARC	SPK	ν	
2288.887 .905	1w		5w	43675.86	
89.223	3			669.45	
89.638	0			661.54	
89.970	4	3		655.21	
90.192	0			651.00	
90.314 .34	1	0	5	648.65	
90.619	3			642.84	
90.982	0			635.93	
91.073	0			634.19	
91.303 .34	8	0	20w	629.81	
91.981 .98	12	8w	40w	616.91	$a^5P_3-y^5D_4^o$ (M*)
92.304	2			610.76	
92.756	2			602.16	
93.102	0			595.58	
93.411 .41	10w	8w	30	589.71	$a^5F_3-z^5G_3^o$ (M*)
94.585	0			567.41	
94.709	0			565.06	
94.890	0			561.63	
95.740	1			545.50	
95.871 .91	2		5	543.02	
96.550	0			530.14	
97.138	0			519.00	
97.274	0			516.42	
97.345 .36	0		4	515.08	
97.482	0			512.48	
97.742	0w			507.56	
98.625	0			490.85	
98.727 .75	0	0w	10	488.92	$a^5P_3-y^5D_2^o$ (M*)
98.880	0			486.02	
99.024	0			483.30	
2299.252	0			478.99	
2299.76			25	469.4	$a^5P_3-y^5D_3^o$ (M*)
2300.46			1	456.2	
2300.795 .81	2	2	8	449.83	
00.987	3			446.21	
01.401 .41	2	5	15	438.39	$a^5F_2-z^5G_2^o$ (M*)
04.24			4	384.8	
04.941	3			371.68	
06.12			3w	349.5	
06.79			2	337.0	
06.997 .01	0		3	333.02	
07.507 .49	0		2	323.46	$a^5P_2-y^5D_1^o$ (M*)
07.854 .84	25	15w	75	317.04	$a^5F_4-z^5G_5^o$ (M*)
08.724	2			300.62	
10.239	0			272.22	
10.328	1	1		270.56	
10.85			2	260.9	
11.459	3			249.38	Sb
11.596 .60	25	15w	50	246.81	$a^5F_3-z^5G_4^o$ (M*)
12.249	0w			234.61	
12.548 .56	6	6w	10	229.02	$a^5P_2-y^5D_1^o$ (M*)
12.790	6			224.49	
12.913	0			222.20	
13.094	1			218.80	
13.218	1			216.51	
13.341	1			214.20	
13.619 .62	3w	3w	8	209.02	$a^5P_2-y^5D_3^o$ (M*)
14.053 .04	25	15w	40	200.91	$a^5F_2-z^5G_3^o$ (M*)
14.646 .67	1	0	1	189.84	$a^3D_1-{}^3I_1^o$
14.969 .97	40	50w	30	183.81	$a^5F_1-z^5G_2^o$ (M*)
15.393	1w			175.90	
15.747 .76	0w	0	3	169.31	
17.065 .08	8	4	15	144.76	
17.596	0			134.87	
17.721	1w			132.55	
18.420 .44	2w	3w	8	119.21	$a^5P_1-y^5D_0^o$ (M*)
18.538	2w			117.35	
18.698	0			114.37	
18.996	1			108.83	
19.268 .28	0		4	103.78	
19.384	15			101.62	
19.825 .86	2	0	6	093.43	
20.034	15	4w		089.65	
20.227	0			085.97	
20.307	1			084.49	
20.519	0			080.55	
21.219].33	12		8w	067.56	
21.371	3	3w		064.74	
21.578	1			060.90	
21.999 .01	2w		5	053.13	
22.168	0			049.96	
22.342	0			046.73	
22.442	0			044.88	
2322.677	0			43040.52	

λ	NST	ARC	SPK	ν	
2322.911	0			43036.19	
23.656	0			022.39	
23.849	1			018.82	$a^5P_1-y^5D_1^o$ (M*)
24.310 .32	10	25	40	010.29	$a^5F_4-z^5D_3^o$ (M*)
24.646	0			004.08	
24.803	1			43001.17	
26.103 .15	35	50	20	42977.14	$a^5F_3-z^5D_2^o$ (M*)
26.458 .49	30	40	25	970.59	$a^5F_5-z^5D_4^o$ (M*)
26.711	0			964.81	
27.663 .68	5	5	10	948.34	
28.008	6			941.98	
28.329	0			935.14	
28.845	3	1w		926.55	CoI
29.094 .13	8w	10w	10	921.96	$a^5P_1-y^5D_2^o$ (M*)
29.230	0			919.45	
29.637	0			911.95	
29.952	6	2		906.15	
30.071	0			903.96	
30.351	15	20	30	898.81	$a^5F_2-z^5D_1^o$ (M*)
30.539	2			895.35	
31.502	1w			877.63	
31.689	1w			874.19	
31.808	6			872.00	
32.082	20	15		866.98	
32.330	6			862.41	Sm
32.581	0			857.81	
32.666	2			856.24	
32.95			3w	851.3	
33.417	5			842.45	
33.722	4w			836.85	
34.000	4w			831.74	
34.092 .08	4w	4	9	830.06	
34.324	1w			825.80	
34.578	5w			821.14	
34.91			3	815.1	
35.050	0w			812.49	
35.185	1			810.01	
35.495	0w			804.33	
35.618	0w			802.08	
35.828	2			798.23	
36.223 .24	15	15	20	790.99	$a^5F_1-z^5D_0^o$ (M*); $a^3G_3-y^3F_2^o$
36.473	2			786.41	
36.694	1w			782.37	
36.986 .01	8w	6	9	777.02	
37.142	1			774.17	
37.315	5			771.00	
37.480	5	0		767.98	CoI
37.685	0			764.23	
37.834 .808	4		1w	761.51	
37.924 .94	50	25w	30	759.86	CoI
38.574	3w			747.98	
38.72			6	745.2	$a^3D_2-{}^3I_2^o$
39.046 .06	15w	6w	10	739.35	CoI
39.201	0			736.52	
39.286 .28	1			734.96	
40.044	4w			721.12	
40.342	0w			715.68	
40.679	0			709.53	
40.814	4w			707.07	
41.112 .15	15	8w	40	701.64	$a^3D_3-{}^3\delta_3^o$
41.607	4w			692.61	
42.005	1w			685.36	
42.247 .2	0w		2	680.95	$a^3D_1-{}^3g_2^o$
42.428	1w			677.65	
43.310	15	0		661.75	
43.652	0			655.37	
43.830	0w			652.13	
44.109	1			647.05	
44.254 .29	15	25	25	644.42	$a^5F_1-z^5D_1^o$ (M*)
44.424	0			641.32	
44.621 .66	5	5w	12	637.74	
44.691	2			636.47	
44.771	2			635.02	
44.987	1w			631.10	
45.270	1			625.95	
45.515 .52	15w	12w	15	621.49	
45.877	1w			614.92	
46.551 .58	10	8w	20	602.68	
46.613	1			601.64	
46.807	1			598.03	
47.108 .13	5	4	2	592.56	
47.382 .41	25	30	30	587.60	$a^5F_2-z^5D_2^o$ (M*)
2347.496	1			42585.54	

↑ SPARK INTENSITIES BY MEGGERS

λ	Sm λ	NST	MAC	SPK	ν	
2347.798	.33	6	5		42580.06	
48.343		6	0		570.17	
48.711	.79	2w	0	0	563.50	
49.148	.1	1w		1	555.58	
49.443	.57	1w	0	0w	550.24	
49.698		2w	0		545.63	
49.912		5			541.74	
50.056		1			539.14	
50.192		0			536.69	
50.701		1			527.47	
50.851		0			524.76	
51.114		8			520.00	
51.163	.17	2w	0	8	519.11	
51.728		1			508.89	
51.810	.85	6w	2	7	507.41	
52.117		1w			501.86	
52.190	.23	1	0	4	500.54	
52.917		2			496.45	
53.120		6			483.75	
53.386	.44	75	100	60	478.95	$a^5F_3-z^5D^o_3$ (M*)
53.735		0	0		472.65	
53.840		0	0		470.76	
53.983		0			468.17	
54.095		0w			466.15	
54.266		0w			463.07	
54.551		0			457.93	
55.207		0			446.11	
55.308		0			444.29	
55.583		6	4		439.33	CoI
55.862		0			434.30	
55.932		0			433.05	
56.046		1w			431.00	
56.346		0			425.59	
56.431	.43	1		0	424.06	
56.670		4			419.76	Cu
56.856		1			416.41	
56.963		1			414.49	
57.036		0			413.18	
57.198		1w			410.26	
57.294		1			410.33	
57.476		6w	6		405.26	CoI
57.692		0w			401.37	
57.776		5			399.86	
57.865	.92	1		0	398.26	
58.191	.24	35	50	12	392.40	CoI
58.727		0			382.77	
58.851		1			380.54	
59	.11			2w	375.9	
59.251		0w			373.36	
59.452		1			369.75	
59.550		10			367.99	
59.798		0w			363.53	
60.397		0w			352.78	
60.508	.54	25	30	20	350.80	$a^3G_4-y^3F^o_3$
60.784	.82	20	20	8	345.84	$a^3D_2-{}^3D^o_2$
60.967		0			342.56	
61.127	.16	2w		3	339.69	
61.510	.54	8	15	10	332.83	$a^5F_1-z^5D^o_2$ (M*)
61.574		0w			331.68	
62.066		0			322.86	
62.242		0w			319.71	
62.857		1			308.70	
63.115		5			304.08	
63.226		2			302.09	
63.532		0			296.62	
63.802	.84	100	100	90	291.78	$a^5F_4-z^5D^o_4$ (M)
64.022		0			287.85	
64.229		1			284.15	
64.515		0			279.03	
65.397		0w			263.27	
65.527		0			260.95	
65.690		0			258.03	
65.743		0			257.09	
66.118		0			250.39	
66.453	.63	0		0w	244.41	
66.572		12			242.28	
67.053		1w			233.70	
67.218	.19	1	0	3	230.76	
67.456		8	0		226.51	
68.031		0			216.26	
68.853		0			201.61	
69.115		1			196.95	
69.230		0			194.90	
2369.391		0			42192.03	

2370.297		2			42175.90	
70.838	.79	3		6	166.29	
71.095		3			161.72	
71.596	.62	0	0	1	152.81	
71.739		0	0		150.27	
71.845	.86	20	12w	15	148.38	CoI
72.380		4			138.88	
72.632		0			134.40	
73.083	.09	4w	2	3	126.40	
74.181		0			106.91	
74.537		6			100.60	
74.736		0	1		097.08	
75.190	.20	15	20	15	089.05	$a^5F_2-z^5D^o_3$ (M)
75.642		0			081.02	
76.023		0			074.28	$a^3D_2-{}^38^o_3$
76.817		0			060.22	
76.877		1			059.15	
77.301		0			051.66	
77.792		3			042.97	
78.162		3			036.43	
78.378		0			032.61	
78.620	..	100	100	100	028.35	$a^5F_5-z^5F^o_4$ (M)
78.986		1			021.65	
79.584		0w			011.31	
79.736		0w			008.63	
79.997		6			42004.02	
80.51				4	41995.02	
80.964	.97	0		2	986.98	
81.173		1			983.29	
81.435		4			978.67	
81.763	.78	50	50	40	972.89	
82.322	.33	10	6	5	963.04	
82.876		0			953.29	
83.125		0			948.90	
83.455	.44	100	100	80	943.10	$a^5F_4-z^5F^o_3$ (M)
83.817		0			936.73	
84.102	.11	0w		1	931.71	
85.658		0			904.37	
86.367	.38	75	75	50	891.92	$a^5F_3-z^5F^o_3$ (M)
86.714	.74	75w	75	25	885.83	$a^3G_5-y^3F^o_4$
86.935		3			881.95	
87.135		0			878.44	
88.918	.93	100	100	100	847.19	$a^5F_5-z^5F^o_5$ (M)
89.537	.57	30	30	40	836.35	$a^5F_2-z^5F^o_1$ (M)
90.426		0	0		820.79	CoI
91.374		20	8		804.22	CoI
92.027		15	?		792.80	CoI
92.594	.59	15w	15w	10	782.91	
92.961		1			776.50	
93.273	.29	1		0	771.06	
93.678		0w			763.99	
93.901	.93	10	12	10	760.09	$a^5F_3-z^5D^o_4$ (M)
94.343		2			752.39	
94.516	.54	2	0	5	749.37	
95.393		3			734.10	CoI
95.520	.53	8	3	6	731.87	
95.882		3			725.57	
96.146		2			720.97	
96.451	.58	3		1W	715.66	
96.724		0			710.91	
96.776		4			710.01	CoI
97.029		10	12w		705.60	CoI
97.380	.42	20	25	60	699.50	$b^3F_4-z^3D^o_3$ (M)
98.381	.39	15w	15w	12	682.09	
98.665		0			677.18	
99.463	.59	3		0w	663.30	
2399.984	0.11	8		0w	654.26	
2401.102		8	8		634.86	CoI
01.426	.64	8		6w	629.24	
02.428		0w			611.88	
02.788		3			605.64	
03.248		0w			597.68	
03.663		5w	3w		590.50	
03.784	.81	6	0	4	588.40	
04.000		0			584.67	
04.106		3			582.84	$b^3P_2-{}^3G^o_1$
04.174	.19	25	35	20	581.65	$a^5F_1-z^5F^o_1$ (M)
04.523	.56	10w	5w	10	575.63	$a^3D_3-{}^37^o_3$
04.728		0			572.08	
04.869		4w	3w		569.64	
06.443	.32	0		0	542.45	
06.784		2			536.57	
06.921		0			534.21	
2407.009		0			41532.80	

2407.31				0	41527.4	
2407.442	.46	3		2	525.22	
07.597		2			522.55	$b^3F_3-z^3D^o_3$ (M)
07.664	.68	10	10	20	521.39	
08.409	.42	30	15	20	508.55	
08.544	.57	6	0	0?	506.22	
08.746	.77	15	15	25	502.74	$a^5F_2-z^5F^o_2$ (M)
08.833	.87	3	0	0?	501.24	$a^3G_4-y^3F^o_4$
09.276		0			493.61	
09.383	.51	3		0w	491.77	
11.876		2			448.88	
12.069		0w			445.57	
12.302	.31	0w		0	441.57	
12.767		25	6w		433.58	
14.068	.07	50	50	40	411.26	$a^5F_3-z^5F^o_3$ (M)
15.072		2			394.04	
15.783		0			381.85	
15.992	.601	50	50	25	378.27	
16.214	.24	25	25	15	374.48	$a^3H_5-x^3G^o_4$
16.448		0			370.47	
16.899	.92	30	30	30	362.74	$b^3F_2-z^3D^o_1$ (M)
17.659	.69	75	75	40	349.75	$a^5F_4-z^5F^o_4$ (M)
18.081		0			342.53	
18.227		0			340.04	
18.478	.48	8	8	20	335.74	CoI
18.584		1	0		333.93	$b^3P_2-{}^3S^o_2$
19.124		20	35w		324.71	CoI
19.312		2	1		321.50	CoI
20.732	.74	30	30	50	297.26	
20.928		3			293.92	
22.04				1	274.8	$a^5D_4-y^5F^o_5$
23.626	.64	10	15	10	247.96	$a^5F_1-z^5F^o_2$ (M)
23.756	.77	2	0	3	245.75	$b^3P_0-{}^3G^o_1$
23.809		2	0		244.84	
24.027		0			241.14	
25.056		3			223.64	
26.137	.19	3	0	7	205.27	
27.015		25	25		190.36	CoI
28.015		1			173.40	
28.289	.31	10	15	10	168.77	$a^5F_4-z^5F^o_5$ (M)
28.524		4	?		164.77	
29.144		0			154.27	
29.728		0w			144.37	
29.928	.94	4	3	5	140.99	$b^3P_1-{}^3S^o_2$
30.337		0			134.06	
30.52				1	131.2	
30.962		0			123.49	
31.385		1			116.33	
31.612		0			112.50	
32.517	.54	35	20w	30	097.20	$a^3H_6-x^3G^o_5$
32.940		1			090.06	
33.482		1			081.64	
33.639		1			078.26	
33.750		0			076.39	CoI
34.069		0			071.00	
34.342		10			066.40	
34.653		0			061.15	
35.034		3			054.73	
35.107		15w	15w		053.50	CoI
35.841		20	10		041.13	CoI
36.311	.32	10		3	033.21	
36.445	.43	10	10	3	030.95	
36.983	.99	4		10	021.90	$a^5F_2-z^5F^o_3$ (M)
373.72		4			015.46	MnII?
37.863	.89	3		3	41007.09	
38.303	.42	2		0w	40999.69	
39.503		3	1w		979.53	
39.872		0			973.33	
39.998		0			971.21	
40.749		1w			958.61	
41.839		0w			940.32	
42.623	.63	30	25	50	927.19	CoI
42.887		6	4w		922.76	CoI
43.019		0			920.55	
43.781	.80	15	15	40	907.81	$b^3F_2-z^3D^o_2$ (M)
44.900	.91	0		1	889.07	
46.013	.04	10	12	30	870.47	
47.710	.73	10	10	40	842.14	
47.826	.85	8	6	12	840.20	$b^3P_2-{}^39^o_2$
48.58				0	827.6	
48.905		8			822.21	
49.166	.18	6	15	10	817.86	$a^5F_3-z^5F^o_4$ (M)
50.005	.02	12	25	35	803.88	$b^3F_3-z^3D^o_3$ (M)
2451.499		0			40779.02	

2451.66				0	40776.4	
2452.556	.59	1w	0	2	761.44	$b^3P_1-{}^34^o_1$
53.067		1w			752.95	
53.88				2	739.5	
53.992		1	1		737.59	
54.14				1	735.30	$a^3H_5-x^3G^o_5$
54.214	.22	0		2	733.91	
54.824		0w			723.79	
55.444		1			713.50	
58.484		0			663.16	
59.191		3			651.47	
59.452	.48	10	4	10	647.16	$b^3P_1-{}^33^o_2$
59.910		3			639.59	
60.081		0			636.76	
60.655		1			627.29	
61.667		0			610.59	
62.445	.49	0		0	597.76	
63.020		0			588.28	
63.65				0	577.9	
64.200	.21	20	40	35	568.85	$b^3F_4-z^3F^o_3$ (M)
65.133		1w	3w		553.49	
65.566		0			546.37	
67.051	.07	15	15	20	521.97	$c^3P_2-{}^3S^o_2$
67.354		0			516.99	
68.285		0			501.70	
69.225		0			486.29	
69.354		0			484.18	
69.889		0			475.40	
70.018		0			473.30	
70.274	.29	35	15	2	469.10	CoI
71.197	.16	0w		0	453.98	
71.663	.78	0		0w	446.36	
72.216		0			437.31	
72.326		0	6		435.51	
73.350		15w			418.78	
75.294	.43	8		0w	387.03	
76.340		0	0		369.98	
76.457		0	0		368.07	CoI
76.868		3			361.33	
77.054		0			358.31	
77.298	.32	8	2	7	354.34	
77.474	.49	3	1	8	351.45	
77.609		0			349.25	
77.789		0			346.31	
77.863		0	0		345.11	
78.074		0w			341.72	
78.195	.20	6	3	4	339.75	$c^3P_1-{}^3G^o_1$
78.299	.31	5	3	5	338.06	$b^3P_1-{}^32^o_0$
78.560		75	0		334.18	C
78.938		0			327.67	
79.044	.07	3	0	4	325.94	MnII
79.402		0			320.13	
79.777		4	1		314.02	
79.905		0			311.95	
79.980		1			310.72	
80.412		0			303.71	
80.474		0			302.71	
80.665		0			299.60	
81.005		3			294.08	
81.217		0			289.64	
81.320		0			288.89	
81.534	.53	2		0	285.49	$b^3P_2-y^3F^o_3$
81.272		10	2		257.30	
83.618		25	25w		251.69	CoI
83.929		0w			246.65	
84.187		3			242.47	
84.39				1	239.2	
84.571		2			236.25	
84.84				1	231.84	
85.241		4			225.40	
85.358	.38	8	15	10	223.51	$b^3F_3-z^3G^o_3$
85.949	.98	0		0	213.95	
86.439	.45	15	25w	35	206.02	$b^3F_4-z^3F^o_2$ (M)
86.502		2			205.01	
86.644		1w			202.71	
86.965		6			197.52	Sm
87.150	.17	3	0	5	194.52	$b^3P_0-{}^32^o_0$
87.376	.42	3w	5w	4	190.88	$b^3F_2-z^3D^o_3$ (M)
87.583		0			182.54	
87.899	803	8		0w	182.44	
88.907		0			166.16	
89.743		1			152.67	
90.047		0			147.97	
2490.392	.41	30w	6w	15	40142.16	$c^3P_2-{}^34^o_1$

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ν 40142

λ	SPK λ	NST	ARC	SPARK	ν	
2491.366	.41	0w		0	40126.46	
91.903		0			117.87	
92.386		0			110.11	
92.623		0			106.29	
92.933		0			101.30	
93.572	.60	0		0	091.03	$c^3P_1-{}^3S_2^o$
93.778		0			082.72	
94.963		0			068.68	
95.179		0			065.21	
95.909		0			053.49	
96.900		0			037.59	
97.135		0			033.82	
97.490	.51	6w	2w	10	028.14	$c^3P_2-{}^33_2^o$
97.907		0			021.45	
98.821	.35	12	8	20	40006.81	
99.248		0			39999.98	
2499.983		0			988.20	
2500.616	.64	0		2	978.09	
02.047		3			955.23	
02.368		0			950.11	
03.256		1			935.94	
04.530		50	40		915.62	Bh CoI
04.744		0			912.21	
04.870		0			910.20	
05.002		0w			908.11	
05.197		0			905.09	
05.747		8			896.24	
06.473	.47	75	100	70	884.68	$b^3F_4-z^3F_4^o$ (M)
07.964	.801	5	12	10	860.97	
08.189		0			857.42	
08.626		0			850.49	
09.242		8	3		840.70	
09.558		0w			835.68	
10.072		5	1		827.53	
10.553		10			819.90	
10.850		5			815.19	
11.168	.17	30	35	40	810.15	
12.061	.08	5w	0	3	796.00	$c^3P_0-{}^3G_1^o$
12.406	.40	2w	4w	2	790.54	$b^3P_2-y^3D_1^o$
13.036		0			780.56	
13.521		0			772.89	
16.330		0w			728.46	
17.353	.37	0		2	712.31	
17.439	.45	4	2	3	710.95	$c^3P_1-{}^34_1^o$
17.857		15w	15w		704.36	
18.256		1			698.17	
19.823	.83	40	50	60	673.39	$b^3F_3-z^3F_3^o$ (M)
20.914		2	3		656.22	
21.618		1w			645.15	
22.384	.51	0		0w	633.11	
22.848		15	0		625.84	
22.955	.97	8	4	10	624.16	CoI
23.452		0			616.35	
24.212		1			604.45	$a^5D_4-x^5D_4^o$
24.643	.66	8w	8w	7	597.68	$\{b^3P_1-y^3D_1^o\}$
24.971	5.02	75	100	80	592.58	$b^3F_2-z^3F_2^o$ (M)
26.074	.09	0		2	575.27	
26.185		1			573.53	
26.397		0w			570.21	
26.497		0			568.64	
27.428		10	0		554.07	
27.879		0			547.01	
28.216	.26	8w	12w	5	541.70	$b^3P_2-y^3D_2^o$
28.613	.65	75	75	50	535.49	$b^3F_4-z^3G_4^o$ (M)
30.105	.10	50w	50w	40	512.18	$b^3P_2-y^3D_3^o$
30.890		0			499.2	
31.013		1			498.00	
31.095		1			495.16	
31.485		0			490.74	
31.664		6			487.85	
32.184		30	40		479.74	CoI
32.657		0			472.37	
32.839		0			469.53	
32.903		3w			468.53	Sm
33.063		0			466.04	
33.207		0			463.80	
33.432		0			460.20	
33.821	.84	35w	35	30	454.23	$b^3P_0-y^3D_1^o$
34.025		0			451.06	
34.768		0			439.50	
34.843		0			438.33	
35.50				0	428.1	
35.972	.79	50	60	10	420.78	CoI
2536.228		0			39416.79	
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λ	SPK λ	NST	ARC	SPARK	ν	
2536.521	.53	50	50	8	39412.24	CoI
37.022		0w			404.46	
37.454	.47	1	0	3	397.75	$b^3P_1-z^5P_1^o$
37.570		0			395.95	
37.811		1			392.21	
38.050		0w			388.48	MnII
38.683		0w			378.68	
39.901		2			359.80	
40.621	.65	25	25	20	348.86	$b^3P_1-y^3D_2^o$
41.500		1			335.03	
41.958	.98	30	35	50	327.95	$b^3F_3-z^3G_3^o$ (M)
42.544		0			318.89	
43.752		0			300.22	
43.832		0			298.98	
44.267		75	75		292.26	CoI $b^3P_2-z^5P_2^o$
44.541	.56	2w	0	4	288.03	$c^3P_1-{}^32_0^o$
45.040	.08	2w	5w	5	280.33	$a^3P_1-z^3D_1^o$
45.718	.73	1	0	2	269.87	$b^3P_2-{}^5P_3^o$
46.158	.19	2	4	3	263.08	
46.743	.75	20	15	20	254.06	$b^3P_0-z^5P_1^o$
47.588		1			241.04	
47.997	.92	0	1	0	234.74	
48.399		30	35		229.48	CoI
49.610		3			209.92	
49.723	.91	4		0w	208.19	$z^5F_4^o-e^5F_4$ (F)
50.201		0	0		200.84	
50.534		2			195.72	$z^5F_3^o-e^5F_3$ (F)
51.233		2	4w		184.98	CoI
51.637		0			178.78	
51.695		0			177.88	
52.391	.40	4	0	4	167.20	$c^3P_0-{}^34_1^o$
52.807		2			160.82	
53.408		4w	8w		151.60	
53.938	4.16	3		0w	143.48	$z^5F_2^o-e^5F_2$ (F)
54.393		0			136.50	
55.633		0w			117.52	
56.761	.80	25	35	8	100.26	CoI $b^3P_1-z^5P_2^o$
57.005		0w			096.53	
57.200		0			093.55	
57.341	.38	6	6	8	091.39	$a^3P_0-z^3D_1^o$
57.438		1			089.91	$z^5F_1^o-e^5F_1$
57.528		0			088.54	
57.614		0			087.22	
57.978		0			081.65	
58.091		1			079.93	
58.842		10	12		068.46	
59.034		0	0		065.53	
59.410	.42	60	75	40	059.80	$b^3F_2-z^3F_2^o$ (M)
59.663		0			055.93	MnII
60.032	.05	50	50	30	050.31	CoI
60.674		0w	1w		040.52	
60.825		0			038.22	
61.280		5	10		031.28	CoI
63.059		0			39004.19	
64.044	.05	100	100	75	38989.21	$b^3F_3-z^3F_4^o$ (M)
64.293		0			985.42	$a^5D_3-x^5D_4^o$
64.483		0			982.53	
65.277		1w			970.46	
65.367	.42	2	4	6	969.10	$a^3P_2-z^3D_2^o$
66.437		0w			952.86	
66.612		0w			950.20	
67.113		0w			942.60	
67.602		0			935.19	
67.968		0			929.63	
69.187		0w			911.16	
69.740	.76	4	0	5	902.79	
70.109		0			897.21	
70.659		0			888.88	
71.289		0w			879.34	
71.524		5			875.80	
72.482		0			861.33	
72.605		0			859.47	
73.165		0			851.01	
73.305		0w			848.90	
73.545		20	10		845.28	CoI
73.787		0			841.62	
74.061		0			837.49	
74.274		1			834.27	
74.362		30	25		832.96	CoI
74.603		0			829.32	
74.77				2	826.8	
74.860	.91	8	12	10	825.44	$a^3P_2-z^3D_2^o$
75.084		0			822.06	
2575.155		0			38820.99	

λ	SPK λ	NST	ARC	SPARK	ν	
2575.474	.59	200	0	0w	38816.19	$z^5F_5^o-e^5F_5$ (F)
75.893		1			809.87	$z^5F_2^o-e^5F_1$
76.206		3			805.16	$a^5D_2-x^5D_3^o$
76.861		5			795.29	
77.062		0			792.27	
77.545		0		1	785.00	$c^3P_2-z^5P_1^o$
78.259		1			778.3 774.26	
78.468		1			771.12	
78.530		0			770.19	
78.696		0w			767.69	
79.091		0			761.76	
79.181		0			760.41	
79.256		0			759.28	
79.958		1w			748.73	
80.070		1			747.05	
80.335	.37	50	75	100	743.07	$b^3F_4-z^3G_5^o$ (M)
80.578		0			739.41	
81.211	.24	2w		2w	729.92	$c^3P_2-y^3D_2^o$
81.754		0w			721.77	
81.827		0w			720.68	MnII
82.244	.25	30	40	50	714.42	$b^3F_2-z^3G_3^o$ (M)
82.635		0	0		708.56	
82.773		0			706.49	
82.896		0			704.65	
83.057		5			702.24	
83.170	.19	15	15	15	700.55	$c^3P_2-y^3D_3^o$
83.476		0w			695.97	
83.806		0w			691.03	
83.962		0w			688.69	
84.302		35			683.60	MnII
84.933		0			674.16	
85.163	.18	1		2	670.72	
86.008		0			658.08	
86.279		0			654.03	
86.393		0			652.32	
86.579		1			649.54	
86.846	.86	8	1	0	645.56	
87.072		2	0		642.18	
87.145		2	0		641.09	
87.223	.23	50	60	60	639.93	$b^3F_3-{}^3G_4^o$ (M)
87.521		12			635.48	$z^5F_4^o-e^5F_5$ (F)
87.758		0			631.94	
88.184		0			625.59	MnII
88.381		1			622.65	
88.521		0			620.56	
88.900	9.12	10		0w	614.90	$z^5F_3^o-e^5F_4$ (F)
88.994		0w			613.50	MnII
89.716		10w			602.74	MnII
89.795		0w			601.56	
89.934		0w			599.49	
89.991		12w			598.64	MnII
91.065		0w			582.64	
91.235		0			580.11	CoI
91.306		0			579.05	
92.305		0			564.18	
92.390		0			562.92	
92.709	.82	1		2w	558.18	$z^5D_3^o-e^5F_2$ (F)
92.942		20			554.71	
93.275		0w			549.76	
93.429	.44	0w		2	547.47	$c^3P_1-y^3D_1^o$
93.549		8			545.69	
94.346		1			533.85	
94.705		0w			528.52	
94.839		0w			526.53	
95.650		10			514.49	
95.765		12			512.79	Mn
96.291		0w			504.98	
96.481		0w			502.17	
97.261		0			490.60	
97.344		0			489.37	
97.401		1	3		488.53	CoI
99.020		0			464.55	
2599.879		0			451.85	
2600.020		0			449.76	
00.502		0w			442.63	
01.917	.99	0w		1w	421.73	
02.038		0w			419.94	
02.724		0			409.82	MnII
02.974		0w			406.13	
03.138	.28	10		5w	403.71	
03.982		2			391.26	
04.397	.44	5	6	4	385.14	
05.694	.72	75	5	12	366.03 365.7	Huge MnII
2605.903	.93	10	5	10 5	38362.96	$b^3P_2-z^3S_1^o$

λ	SPK λ	NST	ARC	SPARK	ν	
2606.35				2w	38356.4	
06.95				1	347.6	$c^3P_1-z^5P_3^o$
07.68				0	338.0	$b^3F_4-z^5G_3^o$
08.34				0	327.1	
2608.540	.52	0		0	324.18	
10.22				0	299.6	CoI
10.30				1	298.4	$c^3P_1-y^3D_2^o$
10.782		12w	8		291.28	
11.327		0			283.28	
12.051		6			272.67	
12.499	.64	15		1w	266.11	$z^5D_4^o-e^5F_4$ (F)
12.986		1			258.98	
13.129		0			256.89	
13.419		6			252.64	
13.494	.54	25	25	10	251.54	$a^3P_2-z^3D_3^o$
13.660		0			249.11	
14.353		30w	35w	20	238.97	$a^5P_3-z^5S_2^o$ (M)
14.537		0			236.28	
14.762		0			232.99	
15.121	.12	10		0	227.75	
15.571		0			221.17	
15.705	.72	2w	4w	0	219.21	
15.846		6			217.15	
15.982		0			215.16	
16.882	.99	4w		2w	202.02	
17.310		0w			195.78	
17.542		0			192.39	
18.894	.91	8	4	3	172.68 172.4	$b^3P_1-z^3S_1^o$
19.601		0		20	162.58	
19.797	.82	12		8	159.51	
20.189		0w			153.81	
20.325		0			151.83	
20.836	1.03	12		4w	144.39	
21.089		0			140.71	
21.841		0			129.77	
21.924		8			128.57	$z^5D_3^o-e^5F_3$ (F)
22.059	.07	50	50	1w	126.60	CoI
22.639	.68	0w		2w	118.67	
23.101		1			111.46	
24.257	.38	4w		2w	094.67	
24.792		20	4		086.90	
25.141		0			081.84	
26.014		0			069.18	
26.728	.89	8		2w	058.83	$z^5D_2^o-e^5F_2$ (F)
26.927		0w			055.95	
27.030		7	12		054.46	
28.776	.83	25w	2w	6	029.193	$b^3P_0-z^3S_1^o$
28.886		2		8	028.4 027.60	$z^5D_1^o-e^5F_1$ (F)
29.742		0w			015.22	
29.883		0			013.18	
30.272	.29	0w		8	007.56	$c^3P_0-y^3D_1^o$
30.744		0w		3	003.7 38000.74	
31.787		2			37985.68	
32.239	.26	20w	20w	30	979.16	$a^5P_2-z^5S_2$ (M)
32.538		2			977.73	
32.847		1w			970.39	
33.246		0			964.63	
33.424		1			962.07	
33.624		1w			959.19	
33.947		0			954.53	
34.305		15	1		949.38	
35.209		0			936.36	
35.308		0			934.93	
35.867	.88	1		1	926.88	
36.070	.09	12w	0w	6	923.96	$a^3D_3-{}^3S_2^o$
36.388		4	4		919.39	
36.608		0			916.23	
36.833		0			912.99	
36.985		1			910.80	
37.179		0w			908.01	
37.366	.36	2		1	905.76	
37.840		0w			898.52	
38.342		2			891.31	
39.081	.28	3		1w	880.69	$z^5D_0^o-e^5F_1$ (F)
40.193	.22	3	3w	0	864.74	
40.33				0w	862.9	
40.51				1w	860.3	
41.087		10			851.92	
43.11				2	823.0	$a^3D_1-{}^3S_2^o$
43.520		3			817.09	
43.968	.98	1w	2w	0	810.68	
44.106		2			808.72	
44.464	.46	0w		1	803.59	$c^3P_0-z^5P_1^o$
2644.617		1			37801.41	

37801

λ	SPK λ	NST	ARC	SPARK	ν	
2645.143		0			37793.89	
45.263		0			792.17	
45.668		1w			786.38	
45.832		0			784.05	Mm
45.993	6.15	4		5w	781.75	
46.269		0			777.80	
46.647		0w			772.42	
46.847		0w			769.57	
47.374		0			762.05	
47.477		1			760.59	
47.726		0w			757.03	
47.822		1			755.66	
48.118		0w			751.44	
48.407		3			747.32	$z^5D_1^o - e^5F_2$
48.700	.64	100	100	25	743.15	
49.307		1			734.50	
49.508		1			731.64	
49.694		0			728.98	
49.812		0			727.31	
50.078		4			723.52	
50.488		0			717.69	
50.578		0			716.41	
50.884		1			711.21	
51.08				0w	709.3	
51.255		0w			706.78	
51.359	.32	0		0	705.30	
51.652		0			701.13	
52.041		1			695.60	
52.193	.39	8		5w	693.44	$z^5D_4^o - e^5F_5$ (F)
52.429		1			690.09	
52.780	.80	4	0	1	685.10	
52.995		0			682.05	
53.095		0		1	680.63	$b^3F_3 - z^5G_2^o$ (M)
53.219		2			678.87	
53.713	.72	12w	15w	15	671.85	$a^5P_1 - z^5S_2^o$ (M)
53.913		2	0		669.01	
54.091		1w			666.49	
54.235		0			664.44	
54.679		1w			658.14	
54.937		2w			654.49	
				0	6529	$a^3P_2 - z^3F_2^o$
55.153		0w			651.42	
55.297		1			649.38	
55.412		1			647.75	
55.513		1			646.32	
55.678		2			643.98	
55.782		1			642.50	
56.225		10			636.23	
56.359	.57	6		1w	634.33	
56.641		3w			630.33	$z^5D_2^o - e^5F_3$
57.001		0			625.25	
57.122		0			622.11	
57.330		2			620.58	CoI
57.595		1			616.82	
57.813		0w			613.74	
57.928		0	0		612.11	
58.155		0			608.90	
58.246		0			607.61	
58.420		0			605.15	
58.547		8			603.36	
59.176		0			594.66	
59.365		0			591.79	
59.507		3			589.78	
59.834		0			585.16	
60.091		1			581.53	
60.224		1			579.65	
60.400		6			577.17	
60.625		6	0		573.99	
60.851		0w			570.80	
60.987		0			568.87	
61.515		0			561.43	
61.717		15	8		558.58	
				1	553.9	$c^3P_2 - z^3S_1^o$
62.482		4			547.78	$z^5D_3^o - e^5F_4$ (F)
62.640	.67	0		1	545.55	$a^3D_2 - {}^3G_1^o$
62.906		1	0		541.81	
63.058		0			539.66	
63.161		0	0		538.21	
63.250		0			536.95	
63.534	.55	30	50	60	532.95	$b^3F_4 - z^5G_5^o$ (M)
64.344		0			521.54	
64.486		1			519.54	
64.943		1			513.11	
65.203		0w		4	509.45	$a^3P_1 - z^3F_2^o$
2665.344		0			37507.46	

2665.492		0w			37505.38	
65.659		0			503.03	
65.848		2w			500.37	
65.952		0			498.91	
66.163	.17	12	3	2	495.94	a^3D_1-
66.437		5	5		492.09	
66.495		1w			491.27	
66.728		5		5w	488.00	$z^5G_2^o - e^5F_1$ (F)
67.804		3			472.89	
67.915		4			471.32	
68.059		3			469.30	
68.434		0			464.03	
68.631		0w			461.27	
68.866		0w			457.96	
69.351		0w			451.16	
69.773	.92	20	0	4w	445.24	$z^5G_3^o - e^5F_2$ (F)
69.900	.92	0			443.47	
70.074		0			441.02	
70.248		0			438.59	
70.831	.85	2w		2w	430.42	$a^3D_3 - {}^33_2^o$
71.428		0	3		422.05	
71.991		15			414.16	
72.825		1			402.49	
72.999		0			400.05	
73.110		0			398.51	
73.212		1			392.08	
73.691		0			390.37	
74.277		0			382.19	
74.608		1			377.56	
74.752		1			375.55	MnII
75.116		0			370.47	
75.344		0			367.28	
75.546		1w	3w		364.44	
75.762		1			361.34	
75.856		20		15w	360.13	$z^5G_4^o - e^5F_3$
76.182		0			355.58	
76.324		0			353.60	
76.647		0			349.09	
76.783		0			347.19	
77.135		0			342.28	
77.260		0			340.54	
77.648		0			335.13	
77.921	8.07	100w		2w	331.32	
78.189		0			327.58	
78.299		1			326.05	
78.693		50			320.56	
78.856		0			318.29	
79.342		0			311.52	
79.438		0			310.19	
80.028		0			301.98	
80.325		0			297.84	
80.435	.43	0	0	1	296.35	$a^3D_2 - {}^3S_2^o$
80.677		0	0		292.94	
81.331		1			283.95	
81.711		1	0		278.57	
81.903	.93	0		1w	275.90	$b^3P_2 - z^5D_1^o$
82.000		1			274.55	
82.146	.16	1		1	272.52	
82.664		5			265.33	
83.009		1			260.54	
83.316		2			256.27	
83.431		1			254.68	
83.729		0			250.54	
83.975		0			247.12	
84.188		0			244.18	
84.421		20	0	6w	240.94	$z^5G_5^o - e^5F_4$ (F)
84.528		0			239.46	
84.969		1			233.34	
85.271		1			229.15	
85.776		1			222.15	
85.887		1			220.75	Mm
86.105		5			217.59	
86.344		0			214.42	
86.506		0			212.04	
86.606		1			210.65	
86.758		1			208.54	
86.812		1			207.80	$z^5G_2^o - e^5F_2$ (F)
87.832		0			193.68	
88.355		1			186.45	
				0	181.[illegible]	$b^3P_2 - y^5D_2^o$
89.427		1			171.62	
89.83				2	166.1	$b^3P_2 - y^5D_3^o$
2690.189		0			161.10	
90.65				0	154.7	
2690.99				0	37150.0	

2691.153		0			37142.78	
91.74				0	139.6	
91.976	200	0		0	136.43	
92.147		0			134.07	
92.25				2	132.6	
92.462		3	0		129.72	CoI
92.727		1	1		126.07	
92.982	.99	1	0	1	122.55	$c^3P_1 - z^3S_1^o$
93.090	.13	1	2	2	121.06	$a^3P_2 - z^3F_3^o$
93.356		0w			117.40	
93.701		0			112.65	
93.796		0			111.34	
94.205		2w			105.71	
94.680	.70	25	20w	30	099.16	$b^3F_3 - z^5G_4^o$ (M)
95.270		5		5	091.04	$b^3P_1 - y^5D_1^o$
					082.9	
96.202		1			078.22	
96.481		1			074.38	
97.07				8	066.3	$b^3F_2 - z^5G_2^o$ (M)
97.204		0			064.45	
97.303		0w			063.09	
97.483		1w			060.61	
97.867	.88	0w		3	055.34	
98.272	.47	6		1w	049.78	
98.622		0			044.97	
98.720		0			043.63	
2699.831		1			028.38	
2700.415	.42	0		2	020.38	$a^3D_1 - {}^32_0^o$
00.686		1			37016.66	$z^5G_3^o - e^5F_3$
02.019	.20	8		2w	36998.41	$z^3G_4^o - e^3F_3$ (F)
02.424	.43	0	4		992.86	$b^3P_1 - y^5D_2^o$
03.332	.53	1		0w	980.44	
04.170	.36	1		0w	968.97	
06.110		0			942.48	
06.241		0			940.79	$b^3P_0 - y^5D_1^o$
06.507	.77	30	5	10w	937.06	$z^5G_6^o - e^5F_5$ (F)
06.605		8w	0w		935.72	
06.780		1			933.33	
07.348	.53	20	0	8w	925.58	$z^3G_5^o - e^3F_4$ (F)
07.853		0			918.69	
08.002	.02	2	0	8	916.67	$a^3D_2 - {}^34_1^o$
08.095		0			915.39	
08.229		0			913.57	
08.943	9.13	8		1w	903.84	$z^3G_3^o - e^3F_2$ (F)
09.208		0			900.23	
09.313		5			898.80	
09.595		0			894.95	
10.062	.23	5		0w	888.60	
11.045		0			875.23	
11.303		0			871.72	
11.461		0			869.57	
11.683		2w			866.55	
11.922		0			863.31	
12.592		0			854.19	
12.732		0			852.30	
12.950		4			849.33	
13.210	.39	8		1w	845.81	
13.985		8			835.28	
14.206		2			832.29	
14.349		0	2w		830.34	$b^3F_3 - z^5D_4^o$ (M)
14.437	.47	6w	10w	20	829.15	$b^3F_2 - z^5G_3^o$ (M)
15.176		0			819.12	
15.325		0			817.11	
15.822		0			810.37	
16.280		1	1w		804.16	
16.380	.39	0		5	802.80	$a^3D_2 - {}^33_2^o$
16.478		0			801.47	
16.954		0w			795.03	
17.172	.18	0		0	792.08	
17.374		0w			789.34	
17.905		0			782.16	
18.111		1			779.37	$z^5G_4^o - e^5F_4$
18.282		0			777.05	
18.42				0	775.2	$a^3P_2 - z^3G_3^o$
19.025		20	8		767.01	
19.91				0	755.1	
20.050		0			753.16	
20.19				0	751.3	
20.700		10			744.38	
20.897		10	2		741.71	
22.844	3.06	1		0w	715.44	
23.424		0w			707.63	
23.706		0			703.83	
24.226		0			696.82	
2726.502		0w			36666.19	

2726.615		0			36664.67	
27.200		0			656.81	
27.773	.99	10		10w	649.10	$z^3F_4^o - e^3F_3$ (F)
27.901		0			647.39	
29.059		12			631.84	
29.818		0			621.66	
31.20				1	603.1	
31.922		0w			593.43	
32.046		0w			591.79	
32.306		0w			588.31	
32.848	.87	4	6	0	581.05	CoI
33.009	.03	0		6	578.90	$c^3P_0 - z^3S_1^o$
33.247		0			575.72	
34.539	.74	8		5w	558.44	$z^3F_3^o - e^3F_2$ (F)
34.984		0		2	552.49	$b^3F_2 - z^5D_3^o$ (M)
					526.8	
38.32				4	507.80	$b^3F_4 - z^5D_4^o$ (F)
38.971	.99	1w		10	499.28	
39.767		10			488.68	
40.917		0			473.37	
41.452		0			466.29	
41.66				0	463.5	$c^3P_2 - y^5D_1^o$
42.10				2	457.6	
42.678		0			449.56	
45.007		3			419.03	
47.957		0			379.94	
48.43				1	373.6	$c^3P_2 - y^5D_2^o$
49.917	.91	8	0	3	355.33	$c^3P_2 - y^5D_3^o$
					334.1	
51.69				0	330.6	$b^3F_3 - z^5D_3^o$
52.22				0	323.6	
52.625		1			318.34	
53.216	.30	6		2w	310.45	$z^3G_3^o - e^3F_3$ (F)
54.42				0	294.1	
54.601		0			292.19	
54.792		0			289.67	
55.511	.54	0		0	280.21	$a^3D_1 - y^3D_1^o$
56.614		10			265.69	
58.793		0w			237.04	
59.022		0			234.04	
59.586		0			226.63	
59.718		0			224.90	
60.075		0w			220.21	
60.443	.46	0		0	215.39	$b^3F_2 - z^5D_2^o$
60.769		0			211.11	
61.792		75	0		197.70	Sm
61.957	2.18	2		0w	195.54	
62.746	.97	3		0w	185.20	
62.920		8			182.92	
63.389		0			176.78	
63.647		0			173.41	
63.696		0			172.76	
63.792		0			171.51	
63.955		0w			169.37	
64.605		1			160.87	
64.721	.74	1		0	159.35	$b^3F_4 - z^5F_3^o$ (F)
65.854		1			144.54	
65.992		0w			142.74	
66.151		1			140.66	
66.719	.90	15		8w	133.24	$z^3G_4^o - e^3F_4$ (F)
67.318		0			125.42	
67.997		0			116.56	
69.072	.09	1w		10	102.54	$a^3D_3 - y^3D_3^o$
70.378		0			085.52	
70.577		1			082.93	
70.82				0	079.8	$a^3D_1 - z^5P_1^o$
71.076	.27	3		0w	076.43	
72.536		4	0w		057.44	
72.689	.71	10	1w	0	055.45	CoI
72.863		1			053.19	
73.369		0w			046.61	
73.80				0	041.0	
74.254		0			035.11	
74.452		0			032.54	
74.578	.60	0		0	030.90	$a^3D_1 - y^3D_2^o$; $z^5G_5^o - e^5F_4$
74.647		0			030.05	
74.964	5.17	15	15w	2w	025.89	$z^3F_2^o - e^3F_2$ (F)
75.173		8	8w		023.18	
75.844		1			014.42	
75.923		1	0w		013.44	
76.206	.23	10	1	15	009.77	
76.841		0			36001.54	
77.234		0			35996.44	
77.624		12			991.39	
78.398		1			981.36	
2778.817	.92	35	35w	1w	35975.94	

37793

35975

λ					
2779.660 .89	5		5w	35965.03	$z^3F_3^o - e^3F_3$(F)
79.743	2			963.96	
79.894	1			962.01	
81.087	0w			946.58	
81.40			0	9425	$c^3P_1 - y^5D_2^o$
81.603	0w			939.91	
81.856	0			936.64	
82.995	2w			921.83	
84.454	0w			903.11	
84.606	0w			901.15	
85.275	3w			892.53	
85.820	1			885.51	
86.05			3	8826	$a^3D_3 - z^5P_2^o$
86.141	0w			881.37	
86.472	0w			877.11	
86.835	0			872.44	
87.415	0w			864.98	
87.693	8			861.41	
87.83			1	859.6	$a^3D_3 - z^5P_3^o$
88.347	0w			852.99	
89.203	6			841.99	MnI
89.544	0w			837.60	
90.274 .30	5	1w	0	828.23	CoI
90.772	0			821.84	
91.430	4	1w		813.39	
92.022	20			805.80	MnII
92.324	0			801.93	
92.659	0			797.64	
92.826	0			788.20	
93.726 .94	15	0	5w	783.99	$z^3F_4^o - e^3F_4$(F)
93.949	0w			781.11	
94.103	1			779.13	
94.226	12			777.56	
94.404	0			765.28	
94.542	0			763.52	
95.63		2		759.7 757.1	$a^3D_2 - y^3D_1^o$
96.560	0w			747.71	
96.84			3	744.2	$b^3F_3 - z^3F_2^o$(F)
97.261	0w			738.75	
97.990	0			729.44	
98.653 .67	1	0	0	720.97	
98.949 .96	0w	0	3w	717.19	$b^3F_2 - z^5D_1^o$(F)
99.162	0w	0		714.48	
99.503	0			710.12	
2799.841	15			705.81	
2800.125	0			702.19	
00.307	1			699.87	
00.643	1w			695.59	
00.808	0			693.49	
01.362	0			686.42	
01.598	0w			683.42	
01.733	0			681.70	
02.011 .19	8	4w	3w	678.16	
02.165	2			676.20	
02.448	4			672.70	
02.701 .72	1		3	669.38	
02.806	1w			668.04	
02.970	0			665.95	
03.065	0			664.84	
03.487	1w			659.37	
03.624	3			657.64	
04.094	8	2w		651.65	CoI
04.360	3			648.27	
04.628	0w			644.87	
04.791	0w			642.79	
05.459	0			634.31	
05.69			0	631.4	
06.135	6			625.73	Mn
06.929	3			615.65	
07.173 .19	1	3	10	612.55	$b^3F_3 - z^5D_4^o$(M)
07.361	0			610.17	
07.517 .54	0w		0	608.19	
07.678	0			606.14	
07.785	0			604.79	
07.894	0			603.42	
08.013 .06	6		0	601.90	
08.500	0w			595.73	
08.672	1			593.54	
09.026	0			589.06	
09.400	0			584.33	
09.487	25			583.22	
09.675	0			580.84	
09.766	0			579.69	
2809.872	0			35577.08	

λ					
2810.076	0			35575.76	
10.268 .32	0w	0	0	573.33	
10.535	0w			569.96	
10.689	0			568.00	
10.760	0			567.10	
10.853 .88	8	10	12	565.93	$b^3F_4 - z^5F_4^o$(M)
11.513 .79	8	8w	0w	557.79	CoI
11.796	1			553.99	
12.018	6w			551.20	
12.178	0w			549.17	
12.655	0			543.15	
12.760	0			541.82	
12.835	4			540.87	
13.022	1			538.51	
13.162	0			536.75	
13.921	0			527.16	
13.980	1			526.41	
14.133	0			524.48	
14.465	1			520.29	
15.312	6w			509.61	$a^3D_2 - y^3D_2^o$
15.745 .76	0		3	504.14	
15.952 6.21	10		4w	501.53	
16.133	1			499.25	
16.391	0w			496.00	
16.592	0w			493.47	
16.748	1			491.50	
16.878	1		0	489.87	$c^3P_0 - y^3D_1^o$
17.012 .97	0w		0	488.18	
17.213	0			485.65	
17.569	1			481.17	
17.653	0			480.00	
17.851	0			477.61	
18.07			0	474.8	$a^3D_2 - y^3D_3^o$
18.282	0			472.18	
18.900 .91	1w	0w	5	464.41	$b^3F_2 - z^5F_1^o$(M)
19.003	0			463.12	
19.382	0w			458.34	$z^3G_5^o - e^5F_5$
19.522	0w			456.59	
19.690	0w			454.47	
19.791	2			453.20	
20.333	0			446.39	
20.402	0			445.53	$z^3G_5^o - e^3F_4$
20.932	0			438.87	
21.038	0w			437.54	
21.196	0			435.54	
21.369	1			433.38	
21.449 .65	5		1w	432.37	$z^3F_2^o - e^3F_3$(F)
21.638	0			430.00	
21.734	4			428.80	CoI
21.992	1			425.55	
22.192	1			423.04	
22.251	0			422.30	
22.363	0			420.90	
22.427	1			420.10	
22.545	6			418.61	MnII
22.684	2			416.87	
22.890	1			414.28	
22.985 3.20	6		1w	413.09	
23.418 .68	0		0w	407.67	
23.519	0			406.40	
23.860	1			402.12	
23.939	0			401.13	
24.694 .67	0		0	391.67	
25.235 .27	2	2w	15	384.89	$b^3F_4 - z^5F_5^o$(M)
25.57			0	380.7	
25.830	1			377.44	
26.039	0			374.83	
26.319	1			371.32	
26.390	0			370.43	
26.481	1			369.29	
26.566	0			368.23	
26.670	0			367.01	
27.069	0w			361.94	
27.180	0			360.55	
27.273	1			359.46	
27.401	1			357.79	
27.522	0			356.28	
27.647	0			354.72	
27.94			0	351.1	
27.997	0w			350.34	
28.035 .09	0		0	349.86	
28.241	0			347.28	
28.335	0			346.11	
2828.684	0w			35341.75	

λ					
2829.085 .10	0		1	35336.74	
29.199	0			335.32	
29.331	0			333.67	
29.544	0w			331.01	
29.721	0			328.80	
29.870	1			326.94	
30.112	1			323.92	
30.320	0w			321.33	
30.527	0			318.74	
30.788	5			316.48	
30.986	0w			313.02	
31.263	0			309.56	
31.337	0			308.64	
31.811	0w			302.73	
31.965	0			300.81	
32.211	0			298.99	
32.721	0			291.39	
33.180	0			285.68	
34.295	3			281.82	
34.942 .96	2	4	10	263.74	$a^3F_3 - z^5F_3^o$ (M)
35.052	1			262.38	
36.312	1			246.71	
37.365	5			233.83	
37.48			0	232.2	$a^3D_2 - z^5P_3^o$
38.670	0w			217.43	
38.937	0w			214.12	
39.221	0w			210.60	
39.541	0w			206.63	
39.695	1			204.72	
40.08			0	200.0	
40.246	0			197.90	
40.491	0			194.87	
40.720	1			192.02	
41.051	0w			187.93	
41.320	0			184.59	
41.469	0			182.75	
41.623	0w			180.83	
41.798	1			178.67	
42.642	1			168.23	
42.811	1			166.14	
42.930	0			164.67	
43.294 .28	1		0	160.17	
43.418	2			158.63	bh
44.587	0			144.19	
44.788	0w			141.70	
44.915	0			140.13	
45.097	0			137.89	
45.186 .38	3		0w	136.79	
45.69			5	130.6	$b^3F_2 - z^5F_2^o$ (F)
45.890	0			128.10	$a^3P_2 - z^5G_2^o$
46.062	0w			125.97	
46.465	1			121.00	
46.663	1			118.56	
47.037	0w			113.94	
47.349	0w			110.09	
47.672	4			106.11	
47.764	1			104.98	
48.167 .41	6		2w	100.01	$z^3F_3^o - e^3F_4$ (F)
48.330	1			098.00	
48.504	0			095.86	
48.760	0			092.70	
49.594	0w			082.43	
49.714	0			080.96	
50.194	0			075.05	
50.327	0			073.41	
51.351	0			060.82	
51.448	1			059.80	
52.551	0			046.07	
52.663	0w			044.69	
52.940	2	0		041.29	
53.352	1	0w		036.23	
53.470	0			034.78	
53.535	1	0w		034.08	
53.989	1			028.41	
54.183	0w			026.03	
54.321 .38	0w		0w	024.34	
54.468	0w			022.53	
54.933	0			016.83	
55.112	0w			014.63	
55.458	0w			010.39	
55.722	1			007.15	
55.844	0			35005.66	
56.330	1			34999.70	
2857.290	0			34987.94	

λ					
2857.413	0			34986.44	
57.585	0			984.33	$a^3P_1 - z^5G_2^o$
57.746	0			982.36	
59.115	0			965.61	
59.381	0			962.35	
59.999 0.05	0w		0w	954.80	
60.614	0			947.29	
60.708	0			946.14	
62.033	0w			929.16	
62.270	0			927.07	
62.894	0			919.45	
63.025	1			917.86	
64.434	0w			900.68	
64.690	0			897.56	
65.193	0w			891.43	
65.293	0			890.21	$a^3P_2 - z^5G_3^o$
65.378 .59	3		1w	889.18	$z^3F_4^o - e^5F_4$
65501	0			887.69	
65.659	0			885.76	
65.938	0			882.37	
66.026	0			881.30	
66.199	0w			879.19	
66.617 .83	6w		0w	874.11	
66.726	20w			872.78	
68.21			0	854.7	
68.765	0w			848.00	
69.036	1			844.71	
69.876 0.08	6		1w	834.51	$z^3D_3^o - e^3F_3$ (F)
69.942	0w			833.71	
70.332	0w			828.98	
71.215 .25	10	5	20	818.27	
71.976	0w			809.04	
73.799	0			786.95	
73.833	1			785.92	$z^3F_3^o - e^5F_3$
74.450	0			779.08	
74.739	0			775.58	
75.786 .83	2	0w	0	762.92	
76.007 .01	2	0w	0	760.26	
76.332	3			756.32	
76.469	3			754.66	
76.706	0w			751.81	
78.120	0			734.73	
78.390	0			731.47	
78.759	0w			727.02	
78.927	0w			725.00	
79.385 .57	2w		3w	719.47	
79.518 .57	8w		3w	717.87	MnII
80.134 .31	5		4w	710.45	$z^3D_2^o - e^3F_2$(F)
82.504	0			681.91	$z^3F_2^o - e^5F_2$
82.932	8			676.59	Mn
83.146	1			674.19	
83.240	0			673.06	
83.464 .47	0		2	670.36	$b^3F_3 - z^5F_4^o$ (F)
84.464	1			658.34	
84.694	2	0		655.58	
84.819	1			654.08	
85.17			0	649.9	$b^3F_2 - z^5F_3^o$
85.921	0w			640.85	
86.035	0			639.48	
87.632	1			620.33	
88.232	0			613.14	
88.318 .33	0		1	612.10	
88.426	1			610.81	
88.726	0			607.22	
89.839 .99	2		0w	593.89	CoI
89.954	1	0w		592.48	
90.424 .45	12	0	20	586.89	
90.558	0			585.29	
90.683	0			583.79	
91.206	6			577.53	
91.547	0			573.46	
92.244 .26 .40	30	25w	1w 0	564.12	CoI
92.648	1			560.30	
92.762	0			558.94	
93.102	0			554.87	
93.171	0			554.05	
93.480	0w			550.36	
93.595	2			548.99	
94.609	0			536.88	
94.721	0	0		553.55	
95.619	0			524.84	
95.795	0w			522.74	
96.031	4			519.93	
2896.570	0			34513.50	

λ	λ spk	NST	ARC	SPK	ν cm⁻¹	
2896.714		0			34511.79	
96.886		0			509.74	
97.011		0			508.25	
97.221		0W			505.75	
97.424		0			503.23	
97.553		0			501.79	
97.680		0			500.28	
97.754	.93	6		3W	499.37	
97.875		2	1w		497.96	
98.037		1	0w		496.03	
2898.967		0			484.97	
2900.515		0W			466.56	
00.870		0			462.34	
00.974		0			461.11	
01.783		0w			451.50	
02.197	.44	0		0w	446.59	
02.301		0			445.35	
02.746		0w			440.07	
02.882		0w			438.37	
03.456		0			431.65	
03.598		0			429.96	
03.741		0w			428.27	
04.052		0w			424.58	
04.707		0w			416.82	
05.088	.17	0w		0w	412.31	
05.137		1	1w		411.73	CaI
05.374		0			408.92	
05.899		2w			402.70	
06.087		0			400.48	
06.286		0			398.12	
06.584		0W			394.59	
06.827		2w			391.72	
07.000	.96	1		10	389.68	
07.059		0w	0w		389.00	
08.143		0w			376.16	
08.351		0w			373.70	
08.508	.57	0w		0	371.85	
08.782	.81	0		0	368.60	
09.174		0			363.97	
09.731		0			357.40	
10.064		8			353.46	
10.411		8			349.37	
10.907		0W			343.52	
11.145		2			340.71	
11.761		0			333.45	
12.158		6W	0		328.77	
12.284		0w			327.28	Fe
12.503		0			324.70	
12.769		1			321.57	
13.575		35	0		312.07	Sm
14.041		0W			306.59	
14.442		0			301.87	
15.117	.28	1		0w	293.92	
15.236		0			292.52	
15.396		1			290.64	
15.785		0w			286.07	
16.209		0w			282.26	
16.576	.62	0		0	276.77	
16.868		0W			273.34	
17.573		0			265.05	
17.823		0			262.12	
17.883		0			261.41	
18.387	.62	15		?	255.50	$z^3D^o_1 - e^3F_2$
19.777		5			239.19	
20.483		0			230.91	
20.877		0			226.30	
21.123		2			223.42	
21.334		0			220.95	
21.413	.65	2		0w	220.02	
21.619		0			217.61	
21.820	.87	0		0	215.25	
21.958		0			213.63	
22.029		0			212.81	
	22.37			0	208.8	
22.466		3			207.69	
22.672		1			205.28	$z^3F^o_3 - e^5F_4$
22.790		0w			203.89	
23.064		0			200.69	
23.148		0			199.71	
23.201	.29	0		0w	199.09	
23.654		0			193.79	
23.712		0			193.11	
24.080		0W	0w		188.81	
2924.201		0			34187.40	

λ	λ spk	NST	ARC	SPK	ν cm⁻¹	
2924.381		0W			34185.29	
24.873		0w			179.54	
25.283		0			174.75	
25.400		0w			173.39	
25.786		0W			168.88	
26.035		0			165.97	
26.150		0w			164.63	
26.347		0			162.33	
26.911	.93	3w		0w	155.74	
	28.89			1	132.7	
30.239	.48	12		20w	116.95	$z^3D^o_2 - e^3F_3$(F)
30.661		3			112.04	
30.773		0w			110.73	
30.954		0			108.63	
31.312		1w			104.47	
31.666		0			100.34	
31.830		2w			098.44	
32.102		1			095.28	
32.373		1			092.12	
32.623		0			089.22	
32.740		1W			087.86	
33.355	.33	0		0	080.72	
33.416		0			080.01	
33.711		0			076.58	
33.772		0			075.87	
33.949		0			073.82	
34.326		1			069.44	
34.520		0			067.19	
34.640		0			065.79	
34.786		0			064.10	
35.020		1			061.38	
35.373		0			057.29	
35.437		0			056.54	
35.565		0			055.06	
35.634		0			054.16	
35.777		1			052.60	
36.051		0w			049.42	
36.157		6			048.19	
36.480		1			044.45	
37.041	.01	0		0	037.95	
37.161		0			036.55	
	37.36			0	034.3	?
37.474		0w			032.93	
37.663		0w			030.74	
38.090		1			025.80	
38.212		0			024.38	
38.343		0			022.87	
38.452		0W			021.61	
38.693		0			018.82	
38.781		0			017.80	
39.604		0			008.27	
39.723		0			34006.89	
40.336		20			33999.81	
41.489		0			986.48	
41.718		0W			983.83	
42.117		1			979.22	
42.268		0w			977.48	
42.460	.47	0w		0	975.27	
42.968	3.18	25	0	15W	969.40	$z^3D^o_3 - e^3F_4$(F)
43.317		0			965.37	
44.118	.44	0w		0W	956.13	
44.492		0			951.82	
44.928		0			946.79	
45.159		0			944.13	
45.277		1W			942.77	
45.436		0w			940.94	
45.585		0			939.22	
46.123		0			933.02	
46.229		0W			931.80	
46.487		0w			928.83	
46.620		0			927.30	
46.740		1			925.92	
46.910		1			923.96	
47.063		1			922.20	
47.245		0			920.10	
	47.48			0	917.5	
	47.98			0	911.6	
48.798		0			902.25	
48.979		0			900.16	
49.488		0			894.31	
49.568		0			893.39	
	49.74			0	891.4	$a^5P_1 - z^3D^o_2$
49.980		1			888.66	
2950.288		0			33885.12	

λ	λ spk	NST	ARC	SPK	ν cm⁻¹	
2950.774		0			33879.54	
50.960		1			877.40	
51.396		0			872.40	$a^3D_1 - y^5D^o_0$
51.551		3			870.62	
51.782	.80	0		0	867.97	
52.062	.09	3		0	864.76	
52.323		0w			861.76	
52.440		0			860.42	
52.603		2w			858.55	
52.814		0			856.13	
53.004		0			853.96	
53.139	.30	1		0w	852.41	
53.295		0			850.62	
53.419		0			849.20	
53.650		4			846.55	
54.180		2			840.48	
54.462		1			837.25	
54.727	.75	25	12	20	834.21	
55.037		1			830.66	
55.385		30	30		826.68	
55.534		1			824.98	
55.725		75	0		822.79	Mn
56.262	.25	1	0	0	816.64	
56.575		2w			813.06	
56.741		0w			811.17	
56.170		1w			806.26	
57.286		1			804.93	
57.480		0			802.72	
57.811		0			798.94	
58.985		0			785.52	
58.148		1			795.09	
58.214		1			794.33	
58.338		0			792.92	
58.554		0w			790.45	
58.728		1			788.46	
58.890		1w			786.61	
59.284		1w			782.11	
59.431		1			780.44	
59.589	.65	0w		5	778.63	$a^3P_2 - z^5D^o_3$
59.745		0w			776.85	
60.085		0			772.97	
60.278		0W			770.77	
60.484		0w			768.42	
60.644		0			766.60	
	60.80			0	764.9	$a^3D_1 - y^5D^o_1$
61.443		1			757.48	
61.548	.57	1		0w	756.29	$a^3D_3 - y^5D^o_3$
61.761		0			753.86	
61.914	.89	0W		0	752.12	
62.085	.11	0		0	750.16	
62.209		0			748.76	
62.305		1			747.67	
62.386		0			746.73	
62.484		0			745.62	
62.727		1			742.86	
62.863		1			741.31	
63.014		0w			739.59	
63.237		30	0		737.05	
63.348		0w			735.79	
63.483		0			734.25	
63.729		0			731.45	
63.833		1			730.27	
63.923		1			729.24	
64.075		1w			727.51	
64.181		0w			726.31	
64.340		1w			724.50	
64.420		0w			723.59	
64.514		0			722.52	
64.875		4W			718.41	
65.103	.16	0		0	715.82	
65.414		1			712.29	
65.494		1			711.37	
65.564		1			710.58	
65.654		1			709.66	
65.839		1			707.45	
66.057		2w			704.98	
66.172		0			703.67	
66.240		0			702.90	
66.355		1			701.59	
66.490		1			700.06	
66.701		0			697.66	
67.179		12			692.23	
67.281		6			691.07	
2967.563		0			33687.87	

λ	λ spk	NST	ARC	SPK	ν cm⁻¹	
2967.654		1			33686.84	
67.732		1			685.95	
67.924		0			683.78	
68.034		0			682.53	
68.295		0W			679.56	
68.459		2			677.70	
68.580		0w			676.33	
68.688		0			675.10	$a^3D_1 - y^5D^o_2$
68.772		0			674.15	
68.982		2w			671.77	
70.388		8			655.85	
70.517		2			654.37	
70.592		0			653.52	
70.660		1			652.75	
72.093		0			636.52	
72.212		1			635.19	
72.438		0			632.62	
72.605		0			630.74	
72.817		0w			628.34	
73.005		2w			626.21	
73.336	.34	0		0?	622.57	
73.409		0			621.64	
73.609	].73	1		0	619.38	
73.873		0w			616.40	
74.058		0w			614.31	
74.202		0			612.68	
74.324		0			611.30	
75.135		0w			602.14	
75.743		0w			595.27	
75.956		0w			592.87	
76.349		0W			588.44	
76.553		1			586.13	
76.638		0			585.17	
77.189		0			578.96	
77.303		0			577.67	
77.377		0			576.84	
77.602		0			574.30	
77.839		0			571.63	
78.270		0w			566.77	
79.448		1w			553.50	
80.035		2			546.89	
80.182		0			545.23	
80.425		0			542.50	
	81.76			0	527.5	
81.962		0			525.21	
82.994		0w			513.61	
83.124		0w			512.15	
83.294		0			510.24	
83.429		1			508.73	
83.953		0w			502.84	
84.484		0w			496.88	
84.717		1	0w		494.27	
84.942		6	2		491.74	
85.367		2			486.97	
86.583		0W	0		473.34	
86.710		0			471.92	
86.834		0w			470.53	
87.602	.65	0w	0W	0	461.93	
88.162	.07	0		0w	455.66	
88.298		0			454.13	
88.698		1			449.66	
88.783		1			448.70	
89.145		0			444.66	
89.287		0			443.07	
89.878		0			436.46	
90.142		0			433.51	
90.321		0			431.50	
90.992		1			424.01	
92.015	1.969	0		2W	412.58	
93.141		0			400.01	
93.387		0			397.27	
93.661	.71	1	0	0	394.21	
94.013		0w			390.28	
94.824		0			381.24	
95.570		0			372.93	
95.813		0			370.22	
96.057		0w			367.50	
97.187		0			354.92	
97.615		0			350.16	
98.961		0w			335.19	
2999.112	.13	0	0	0	333.51	
3000.023		0			323.39	
01.119		0w			311.22	
3001.944		0			33302.07	

λ	λ vac	INT	ARC	SPK	ν	
3002.047		0			33300.92	
03.116		0			289.07	
04.870	5.08	2		0w	269.64	
05.011		0			268.08	
05.155		0			266.48	
05.974	6.02	8	8W	0w	257.42	CoI
06.125		0			255.75	
02833		0			236.87	
08.049		0			234.58	
08.267		0			232.07	
08.589		0			228.51	
08.688		1			227.98	
08.837	.88	1W		1w	225.78	
09.687		0			216.39	
10.228		0			210.42	
11.704		0			194.15	
11.821		0			192.78	
13.155		0			178.16	
13.268		0			176.92	
15.156		0			156.14	
16.55				4	148.8	
16.996		0			135.92	
17.101		0			134.78	
17.830		0			126.77	
18.686		0			117.38	
20.330		0			099.35	
20.647		10	10		095.88	
21.076		6	6		091.18	
21.502		5			086.51	
22.091	.13	0	0	0	080.06	
22.746	.85	10		2w	072.90	Mn
23.302		0w			066.82	
23.478		0w			064.89	
23.950		1			059.73	
26.668				0w	33030.1	
32.507				0	32966.5	
34.696				30	942.7	
35.380				0w	935.3	
40.957				0	874.9	
45.143				0	829.7	
45.577				0	825.0	
45.855				0	822.0	
47.081				0w	808.8	
50.945				3	767.2	
52.878				0	746.5	
53.551				0	739.3	
54.162				0	732.7	
61.458				0?	654.7	
62.671				0	641.8	CoI
63.262				1	636.5	CoI
63.431				0	633.7	
63.581				0?	632.1	
63.731				0	630.5	
63.965				0w	627.9	
64.250				0	625.0	
67.264				5	592.9	
62946				0	585.7	
68.187				0	583.1	
70.026				0w	563.6	
72.990				0	532.2	
75.288				0	508.42	
78.660				0	472.3	
82.170				0	435.3	
83.297				0	423.5	
83.971				0w	416.3	
85.234				0	403.1	
85.670				0w	398.5	
88.035				0	373.7	
92.732				1	324.5	
94.646				0	305.6	
3095.361				0	297.1	
3107.794				0	167.9	
09.389				0	151.4	
10.627				0	138.6	CoI
14.962				0	32093.8	
24.971				0w	31991.1	
30.866				15w	930.8	
30.335				0	936.2	$b^3P_2-z^5S_2^o$
31.329				0w	926.1	$a^5P_3-z^5F_4^o$
32.745				0w	911.7	
36.332				0w	875.2	
50.686				0	730.0	
58.104				0	655.4	
3165.988				0	31577.6	

λ	Int	ν	Classification	λ	Int	ν	Classification
3211.457	0	31129.6		3803.986	1?	26280.8	
12.019	3	31124.1	$c^3P_2-z^5S_2^o$	13.35	3?	26216.7	
32.149	0	30930.3		53.53	1?	25942.8	
35.790	0	895.4		62.362	2?	883.6	
36.587	0	887.8		3890.166	1?	698.6	
41.981	0	836.5		3905.76	1	595.9	
42.278	0	833.7		24.14	1	476.1	
52.931	0	737.7		32.00	1	425.2	
56.807	0w	696.1		39.90	10*	374.2	
59.697	5	668.9		59.75	2	246.9	
61.597	0	651.0		83.040	10	099.4	$a^3D_1-z^3D_1^o$
3290.761	0	379.4	$a^5P_3-z^5G_3^o$	84.606	1	089.5	
3301.897	0w	277.4		3994.90	25*	25024.9	
05.390	3w	244.9		4001.90	10*	24986.1	
22.846	2	086.1		16.02	10*	893.3	
28.380	0	036.0	$a^5P_3-z^5G_4^o$	16.729	5?	888.9	
31.908	0	30004.2		40.057	3?	745.16	$a^3D_2-z^3D_2^o$
44.023	2	29895.5		81.462	0	494.1	
52.786	30	817.4	$a^5P_2-z^5D_1^o$ (m)	4096.566	5?	403.8	
58.608	10	765.7	$a^5P_3-z^5D_2^o$ (m)	4114.62	10*	296.8	
70.933	50	656.5	$a^5P_1-z^5D_0^o$ (m)	14.80	10*	295.7	
72.806	0	640.4	CoI	17.17	12*	281.7	
79.900	1	578.2		18.30	10*	275.0	
87.698	60	510.1	$a^5P_1-z^5D_1^o$ (m)	22.88	10*	248.1	
	35	505.8	$a^5P_2-z^5D_2^o$ (m)	23.20	15*	246.2	
89.333	0w	495.9		25.40	10*	233.3	
91.558	0	476.6		31.10	1	199.8	
96.695	0	432.0		38.950	1	153.9	
3399.161	2w	410.6		45.153	15	117.8	$a^3D_2-z^3D_2^o$
3407.531	0	340.4		60.672	50	24027.8	$a^3D_3-z^3D_3^o$
15.785	75	262.8	$a^5P_3-z^5D_3^o$ (m)	71.916	1?	23963.1	
23.846	40	198.6	$a^5P_1-z^5D_2^o$ (m)	4244.194	10	555.0	
30.862	3	138.9	CoI	69.384	6	416.0	
37.31	20?	084.2		72.202	3	400.6	$a^3D_2-z^3D_3^o$
42.006	0	044.5		80.652	2	354.4	
44.857	0	020.5		81.062	0	352.2	
46.401	50	29007.5	$a^5P_2-z^5D_3^o$ (m)	83.655	2	338.0	
47.436	0	28998.8		4285.36	1h	23329.2	$a^3D_1-z^3F_2^o$
60.178	0	892.0		4353.99	5?	22961.0	$b^3P_2-z^3D_3^o$
63.264	0	866.3		4384.25	2?	802.5	$a^3D_2-z^3F_2^o$
65.387	0	848.6		4413.864	30	649.5	$a^5D_4-z^5P_3^o$
88.673	0	656.0		35.31	2	540.0	
97.300	15	585.3		82.707	5h	301.7	$a^5D_3-y^3D_2^o$
3499.90	1	564.1		89.12	2	269.9	$a^3D_2-z^3F_3^o$
3501.708	200	549.4	$a^5P_3-z^5D_4^o$ (m)	91.20	2	259.5	
07.799	100	499.8		4497.44	4	228.7	
10.583	0	477.2		4500.54	10	213.4	
14.219	2	447.7	$a^5P_1-z^5F_1^o$ (m)	16.432	10	135.2	$a^3D_3-z^3F_4^o$
15.235	0	439.5		16.65	20	134.1	
17.503	10	421.2	$a^5P_2-z^5F_2^o$ (m)	33.206	10	22053.3	$a^5D_3-z^5P_2^o$
17.988	0	417.2	$b^3P_1-z^3D_1^o$	37.971	10	22030.1	$a^5D_3-z^5P_3^o$
22.220	0	383.1		59.28	8	21927.2	$a^5D_2-z^5P_1^o$
22.468	0	381.1	$a^3G_4-z^3F^o$	69.27	25	879.2	$a^3H_5-z^3G_4^o$
35.940	15	272.9	$b^3P_0-z^3D_1^o$	4574.238	10	855.5	
36.90	1	265.3		4616.234	5	656.6	$a^5D_1-z^5P_1^o$
40.034	0	240.3		22.011	2h	629.6	$a^5D_2-z^5P_2^o$
45.032	25	200.5	$a^5P_3-z^5F_3^o$ (m)	34.731	0	570.2	
45.53	2	196.5		59.999	15	453.2	
47.571	0w	180.3		60.66	25	450.2	$a^3H_6-z^3G_5^o$
55.925	6	114.1	$a^5P_1-z^5F_2^o$ (m)	4680.72	0	358.3	$a^5D_1-z^5P_2^o$
61.123	50	073.0	$a^3G_5-z^3F_4^o$	4721.50	15*	173.8	
66.977	5	026.9	$a^3G_4-z^3G_3^o$	4757.40	8	21014.0	
68.760	6	28013.1		64.75	2h	20981.6	
73.077	1	27979.1		4772.68	2	946.7	
74.598	2	967.2		4821.07	2	736.5	
76.780	2	950.2		29.06	5	702.2	
78.022	30	940.5	$a^5P_2-z^5F_3^o$ (m)	30.68	1	695.3	
83.62	1w	896.8		31.16	10h	693.2	$a^5D_4-y^5D_4^o$
3598.50	1?	781.4		49.98	2	612.9	
3606.003	30	723.7		65.83	1h	545.8	$a^5D_4-y^5D_3^o$
10.60	3	688.4	$a^3G_4-z^3F_4^o$	4872.97	3	515.7	
21.177	100	607.5	$a^5P_3-z^5F_4^o$ (m)	4915.405	2h	338.5	
43.589	6	437.7	$b^3P_2-z^3D_3^o$	23.906	3	303.4	
56.18	2	343.2	$c^3P_2-z^3D_2^o$	39.649	5	238.7	
56.845	2	338.2	$a^3G_4-z^3G_4^o$	56.50	4?	169.9	
81.398	40	155.9		57.88	2	164.3	
85.16	2	128.2		59.405	4	158.12	
94.442	5	27060.0		60.025	3	155.58	
3695.328	5	27053.5		4980.113	3	20074.3	$a^5D_3-y^5D_4^o$
3714.709	3	26912.4	$c^3P_1-z^3D_2^o$	5012.082	5	19946.2	$a^5D_3-y^5D_2^o$
27.316	6w	821.4		17.025	3	926.6	$a^5D_3-y^5D_3^o$
45.61	10?	688.9	$c^3P_2-z^3D_3^o$	17.725	1	923.8	
54.700	30	625.8		18.395	1	921.2	
3800.45	1w	26305.2		5097.445	1	612.2	$a^5D_2-y^5D_1^o$
				5120.757	3	522.2	$a^5D_2-y^5D_2^o$
				27.994	3	495.4	
				40.114	3	449.4	a^5D_1-
				5192.947	3	19251.5	$a^5D_1-y^5D$

* Indicates Lines Observed from Exner & Haschek

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λ	NST	ν cm^{-1} REMARKS										
5186.506	6	19275.45	5251.818	3w	19035.74	5450.525	0w	18341.77		5515.275	1w	18126.44
86.681	0	274.80	52.061	1w	19034.86	53.690	0w	331.13		17.464	8w	119.25
87.450	0w	271.94	52.584	6W	032.97	61.127	1w	306.17		17.758	4W	118.28
87.594	1w	271.41	53.325	1W	030.28	61.437	1W	305.13		18.088	3w	117.20
88.401	3w	268.41	54.926	0W	024.48	61.663	0W	304.37		18.791	2w	114.89
89.019	3w	266.12	56.618	8w	018.36	62.487	0	301.61		19.007	0W	114.18
89.999	1w	262.47	57.173	30w	016.35	65.029	1	293.09		19.371	0w	112.99
90.507	2w?	260.59	58.354	1w	012.58	65.151	0	292.69		20.067	10w	110.70
91.920	8w	255.35	59.029	5w	009.64	65.331	0	292.08		20.485	0w	109.33
92.786	0w	252.14	59.443	25	008.14	65.511	0	291.48		20.676	0W	107.80
92.959	0w	251.50	60.251	2	005.23	66.857	0	286.97		21.279	0	106.40
93.415	0w	249.84	60.711	0W	19003.56	67.220	0w	285.76		21.561	8w	105.80
93.605	0w	249.10	70.164	8w	18969.48	67.587	0w	284.53		22.008	0w	104.34
93.831	0w	248.27	71.963	0w	963.10	67.779	0w	283.89		22.909	10w	101.38
93.958	0w	248.23	72.190	2W	962.37	68.542	1w	281.34		23.875	4w	098.22
94.709	0	245.01	75.000	0w	952.09	70.027	1w	276.38		24.290	1w	096.86
94.777	0	244.76	75.195	5w	951.39	71.237	1w	272.33		24.465	2w	096.28
95.943	0w	240.44	78.249	0w	940.07	72.125	1w	269.37		25.981	8w	091.32
96.233	4w	239.37	79.628	0w	935.48	72.416	0w	268.40		26.542	4w	089.48
96.480	3w	238.45	81.586	0w	928.46	72.984	0w	266.50		27.511	0	086.31
96.777	1w	237.35	91.503	0w	892.98	73.359	1w	265.25		27.832	0w	085.26
97.198	0w	235.80	95.824	0w	877.57	73.748	1w	263.95		28.012	0w	084.67
97.415	0w	234.99	99.153	0w	865.71	74.427	0w	261.69		28.499	4w-0w	083.08
97.846	0w	233.40	5299.586	0w	864.27	75.569	1w	257.89		29.314	4w	080.42
98.082	0w	232.53	5301.684	0w	856.70	75.763	1w	257.24		31.774	3w	072.38
98.171	6w	232.20	06.629	0w	839.13	77.588	4w	251.16	$a^5F_5 - n^5D_4^o$	32.856	3w	068.85
5199.523	75	227.19	09.067	6w?	830.47	78.140	0w	249.32		33.430	0	066.97
5201.506	2w	219.87	09.986	0w	827.21	78.348	0w	248.62		33.568	0	066.52
02.177	0w	217.39	11.986	0w	820.62	78.920	1w	246.72		33.728	0	065.99
03.533	0	212.38	12.120	0w	819.65	79.850	1w?	243.62		34.349	1w	063.97
03.671	4w	211.87	14.862	0w	809.88	81.330	1W	238.69		34.741	2w	062.69
04.595	2w	208.46	17.231	0w	801.56	81.731	1w	237.36		35.481	12w	060.28
05.854	5w	203.81	17.693	0w	799.93	81.901	0w	236.79		35.821	0w	059.17
06.029	1w	203.17	20.588	0w	789.70	82.325	3w	235.38		36.062	0W	058.38
08.115	7w	195.47	21.102	0w	787.89	85.011	2w	226.45		36.679	4W	056.37
08.424	1w	194.34	22.817	0w	781.83	85.554	0w	224.65		36.907	0	055.67
09.180	0w	191.55	24.747	1w	775.02	86.630	1w	221.08		37.200	2w	054.67
09.812	0	189.22	26.993	10w	761.11	89.151	1w	212.71		38.706	0w	049.76
09.878	1	189.00	30.544	2w	754.61	91.020	1w	206.51		39.038	0w	049.68
11.353	2w	183.55	32.300	12	748.43	92.882	1w	200.34		39.749	0w	046.36
12.416	15	179.63	37.806	0w	729.09	93.247	0	199.13		40.055	1W	045.37
12.958	1w	177.64	39.062	0w	724.69	93.343	0	198.81		40.469	1w	044.03
15.934	1W	166.70	39.930	50	721.14	93.482	1	198.35		40.711	3W	043.23
16.857	0w	163.31	45.048	0w	703.72	94.566	0	194.76		41.434	0w	040.87
17.043	0w	162.63	46.336	0w	699.21	96.295	3w	189.03		41.750	0w	039.85
17.680	0w	160.28	46.840	5w	697.45	96.711	1w	187.66		41.956	0w	039.34
19.268	2w	154.46	48.041	0w	693.25	97.725	5	184.30		42.144	0w	038.56
20.550	0w	149.75	48.708	10w	690.92	97.906	1w	183.70		42.604	1w	037.06
21.558	1w	146.05	49.442	0w	688.35	98.619	3w	181.15		42.875	6w	036.19
23.423	0w	139.22	51.018	0w	682.85	99.760	2w	177.58		44.585	1w	030.62
23.975	10w	137.20	54.623	0w	670.27	5499.962	2W	176.91		45.002	2W	029.26
24.816	0w	134.12	55.715	0w	666.47	5500.271	6w	175.89		46.517	0W	024.34
25.388	0w	132.02	56.559	0w	663.53	00.453	0w	175.29		46.967	2W	022.88
25.776	0?	130.60	57.438	0W-1W	660.46	00.678	0W	174.54		47.336	0w	021.68
27.450	1w	124.47	60.619	1w	649.39	00.954	0w	173.63		48.192	1w	018.90
28.419	2w	120.93	65.562	1w-6w	632.21	01.159	1w	172.95		48.790	3w	016.9[illegible]
28.642	0w	120.12	68.590	10	621.71	01.548	4w	171.67	$a^5F_4 - n^5D_3^o$	49.347	0w	015.65
29.091	0w	118.48	75.981	0w	596.10	01.616	1w	171.24		49.538	2W	014.53
30.470	8w	113.44	77.030	1w	592.58	02.097	2w	169.19		51.523	0W	008.09
31.113	50	111.09	77.189	1w	591.93	03.236	1w	166.09		51.818	0W	007.13
33.596	1	102.02	77.669	15	590.27	03.670	1w	164.66		52.075	0	006.30
33.845	0w	101.11	80.330	3w	581.07	03.837	1w	164.11		52.498	1w	004.28
34.147	0	100.01	82.608	1w	573.20	04.476	1w	162.00		53.564	1	18001.47
35.610	3w	094.63	84.051	0	568.23	04.685	1w	161.31		54.229	2w	17999.31
35.834	2w	093.86	84.350	5w	567.20	04.885	0w	160.65		54.358	1w	998.90
36.342	0w	092.00	85.250	1w	564.09	05.222	1w	159.54		55.446	0w	995.37
38.179	0W	085.31	87.042	0w	557.92	05.481	0w	158.69		55.617	0w	994.82
38.882	1w	082.75	88.488	1w	552.94	06.019	0w	156.91		56.195	0w	992.95
39.494	50	080.52	5396.724	12	524.62	06.323	2w	155.91		56.474	0w	992.04
41.010	4w	075.00	5405.153	0w	495.74	06.620	2w	154.93		56.754	0w	991.14
42.756	0w	068.65	11.811	2	472.98	07.959	1W	150.52		57.358	0w	989.18
42.895	1w	068.14	14.825	3w	462.70	08.190	0w	149.76		57.481	0w	988.78
43.130	1w	067.29	16.595	0w	456.67	09.291	0w	146.13		58.095	6w	986.80
44.477	2w	062.39	16.878	0w	455.71	09.427	3w	145.68		59.241	1w	983.09
45.539	0w	058.53	17.978	10-1W	451.96	09.925	1W	144.04		59.590	0w	981.96
45.631	0w	058.20	23.836	1	432.03	10.321	1w	142.74		60.329	0w	979.57
46.426	0w	055.31	26.579	0w	422.71	10.591	0w	141.85		60.673	0w	978.46
47.098	1W	052.87	30.169	0w	410.54	10.842	0w	141.02		61.020	0w	977.33
47.343	0w	051.98	41.443	1w	372.05	11.076	6w	140.25		61.292	2w	976.46
47.579	12w	051.12	41.713	0w	371.47	12.247	3w	136.40		64.495	1w	966.11
48.533	0w	047.66	44.120	4W	363.35	12.438	0w	135.77		64.669	0w	965.55
48.784	0w	046.75	48.188	0w	349.65	12.960	6w	134.05		65.076	0w	964.23
49.366	25	044.63	49.529	0w	345.13	13.933	0W	130.85		67.900	2w	955.12
5251.215	2w	19032.93	5449.835	0w	18344.11	5515.092	5w	18127.04		5568.160	2w	17954.28

19275

17954

λ	INT	ν									
5569.997	2w	17948.36	5611.071	8w	17816.97	5728.987	0W	17450.26	6052.811	1w	16516.69
70.162	0w	947.83	11.672	0w	815.07	29.952	0w	447.32	54.811	0w	511.23
70.608	0w	946.39	12.038	0w	813.90	33.620	0	436.16	57.767	1w	503.18
70.794	0w	945.79	12.340	1w	812.95	34.352	0W	433.94	59.722	1w	497.85
71.179	0w	944.55	12.655	1w	811.95	34.799	0w	432.57	61.413	2w	493.25
71.451	0w	943.68	14.027	0w	807.59	35.457	0w	430.58	62.169	3w	491.19
72.134	0w	941.48	14.245	0w	806.90	38.267	1w	422.05	68.258	1w	474.64
72.523	1w	940.22	14.396	0w	806.42	42.030	1w	410.63	68.490	0w	474.01
74.749	1w	933.06	14.756	0	805.28	45.471	0w	400.20	69.111	0w	472.33
75.075	0w	932.01	16.106	30	801.00	46.904	0w	395.86	72.072	5W	464.30
76.365	0w	927.86	16.418	10	800.01	52.008	0w	380.42	77.623	5w	449.26
76.640	1w	926.98	18.054	0w	794.83	56.894	0w	365.67	79.768	2w	443.25
76.803	0w	926.46	19.446	1w	790.42	57.339	0W	364.33	80.398	1w	441.75
77.638	1w	923.77	19.643	1w	789.80	64.072	8w	344.05	83.964	3w	432.11 $\ell^5F_4-n^5F_3^o$
78.494	1W	921.02	20.989	1w	785.55	66.581	0w	336.50	86.496	1w	425.28 $\ell^5F_5-n^5F_4^o$?
78.734	1W	920.25	22.181	1w	779.87	69.581	0w	327.49	88.017	1w-R	421.17 $^3 7_3^o-e^3F_4$
79.009	0w	919.37	23.078	1w	778.93	71.476	2w	321.80	89.898	1w	418.26
79.934	0w	916.40	23.369	0w	778.01	71.850	2w	320.68	90.079	2w	415.61
80.507	1w	914.56	24.180	0w	775.44	73.944	0w	314.39 $\ell^5F_5-w^5D_4^o$	6099.152	2w	391.19
81.302	0w	912.00	25.575	0w	771.04	80.159	1w	294.78	6102.265	3w	383.37
81.725	0	910.65	25.837	0w	770.21	81.366	5w	292.17	08.359	4w	366.49
81.828	0	910.32	29.076	0w	759.98	81.561	0w	291.58	10.564	4w	360.58
82.282	0	908.86	29.570	0w	758.43	93.424	1w	256.18	12.544	6w	355.28
82.384	0	908.53	30.086	0w	756.81	98.554	5w	240.91	17.377	1w	342.36
83.017	0w	906.50	30.266	0w	756.24	98.856	20w	240.01	18.029	3w	340.63
83.412	0w	905.24	30.853	1	754.39	5799.752	0W	237.35	18.719	1w	338.78
83.580	0w	904.70	31.172	1	753.37	5800.201	0w	236.01	22.220	2w	329.43
84.122	2w	902.96	32.030	0w	750.67	02.413	0W	229.44	23.636	1w-R	325.66
84.712	1w	901.07	32.743	0w	748.42	03.789	0w	225.36	30.775	5w	306.64
85.187	1w	899.55	33.202	1W	746.98	05.194	0w	221.19	36.933	2w	290.28
85.292	1w	899.21	33.419	0w	746.30	05.423	0w	220.51	41.933	2w	277.02
85.480	0w	898.61	34.975	0w	742.97	09.216	0w	209.27	42.139	2w	276.48
85.714	0w	897.86	35.191	2w	740.71	10.318	0w	206.00	42.461	5W	275.63
87.502	1w	892.13	35.325	1w	740.29	11.008	3w	203.96	44.159	1w	271.13
87.995	1w	890.55	35.482	0w	739.79	11.667	25	202.01	49.199	15w	257.80
88.794	50	887.99	36.992	0	735.05	13.747	1	195.85	49.596	1w	256.75
89.169	1w	886.79	37.138	0	734.59	16.029	2w	189.10	51.244	1w	252.39
89.523	0w	885.66	38.409	0w	730.59	16.696	10w	187.13	55.347	20w	241.55
90.365	0w	882.97	38.916	2w	729.00	16.807	1w	186.81	57.427	0w	236.07
91.910	6w	878.02	39.240	0w	727.98	17.844	0w	183.74	61.502	0w	225.33
93.048	0w	874.39	42.199	0w	718.68	18.507	5w	181.79	62.161	10w	223.60
93.248	0w	873.75	46.120	0w	706.38	20.925	1w	174.65	62.661	0w	222.84
93.447	1w	873.11	51.311	1w	690.11	26.849	1w	157.19	69.757	1W	203.62
93.807	2w	871.96	55.522	0w	676.94	28.966	1w	150.95	69.989	0w	203.01
94.478	10w	869.82	55.801	1w	676.07	40.334	0w	117.57	75.924	2w	187.44
94.994	0w	868.17	56.154	0w	674.97	40.783	35	116.55	77.096	1w	184.37
95.694	0w	865.94	56.862	0w	672.75	46.254	0w	100.24	86.663	6w	159.42
95.872	0w	865.37	58.392	0w	667.98	46.845	0w	098.51	6187.877	30	156.17
96.029	0w	864.87	59.367	0w	664.09	47.491	0w	096.63	6201.034	1w	121.89 $\ell^5F_3-n^5F_2^o$
96.265	3w	864.11	63.967	0w	650.59	47.688	0w	096.05	03.025	10?	116.72
96.745	3w	862.58	64.686	0w	647.72	47.852	0w	095.57	05.711	20w	109.74
97.536	0w	860.06	65.195	0w	646.76	57.472	1w	067.49	06.806	1w	106.90
98.338	1W	857.50	65.688	0w	645.22	58.352	50	064.93	09.263	1w	100.53
98.644	0w	856.52	66.484	0w	642.75	63.616	0w	049.62	11.953	1w	093.55
98.822	0w	855.96	68.603	1W	636.15	64.203	30	047.90	14.252	2W	087.60
98.975	0w	855.47	69.881	0w	632.18	70.081	5W	17030.83	15.269	3w	084.97
99.478	0w	853.86	70.343	0W	630.74	87.805	1w	16979.56	18.158	1w	077.49
5599.958	0w	852.33	73.619	0w	620.56	93.669	1w	962.67	21.050	1w	070.02
5600.444	0w	850.46	73.771	1w	620.09	94.072	0w	971.51	24.736	1w	060.50
00.491	0w	850.00	78.061	2W	616.08	5896.209	0w	955.36	25.411	1W	058.76
00.918	0w	849.27	82.195	0w	593.96	5902.112	1w	938.40	29.417	15w	048.44
01.011	0w	848.98	83.165	1w	590.96 $\ell^5F_3-w^5D_3^o$	02.791	2w	936.45	32.910	1w	039.44
01.271	5w	848.15	86.086	0w	581.92	14.800	0w	902.07	32.392	2w	027.91
01.505	0w	847.40	86.536	0w	580.53	30.566	1w	857.13	38.267	0W	025.67
02.099	0w	845.51	89.312	20	571.95	32.944	4w	850.38	41.119	0w	018.35
02.263	0w	844.99	92.858	0	561.01	34.252	1w	846.66 $\ell^5F_3-w^5D_3^o$	42.139	1w	015.73
03.279	1w	841.75	95.859	0w	551.76	38.506	1w	834.60	44.118	1w	010.15
03.804	0w	840.08	5696.981	0w	548.30	38.905	1w	833.47	44.958	0w	008.50
04.008	0w	839.43	5702.825	0w	530.32	46.824	1w	805.40	45.204	0w	007.87
04.583	1w	837.60	06.615	0w	518.67	50.789	6w	802.68	47.717	1w	001.43
05.132	0w	835.85	07.100	0w	517.19	54.715	0w	788.71	48.218	1W	16000.15
05.357	0w	835.14	07.672	0w	515.43	56.725	5w	783.11	49.133	1w	15997.80
05.633	0w	834.26	12.543	0w	500.49	71.149	6w	742.57	50.798	0W	993.54
05.894	1w	833.43	13.033	0w	498.99	5972.981	0w	737.43	52.822	0w	988.37
06.668	0W	830.97	13.477	0w	497.63	6009.799	0W	634.95	55.109	0w	982.52
07.521	0w	828.26	15.054	1w	492.80	10.251	0W	633.64	55.361	0w	981.88
07.831	0w	827.27	15.314	0w	492.01	12.122	0W	628.47	55.633	0w	981.18
08.153	2w	826.24	17.972	0w	483.88	12.402	0w	627.69	56.600	1w	978.71
08.277	2w	825.85	22.193	0w	470.98	19.481	1w	608.14	60.235	2w	969.43
08.519	0w	825.08	22.822	0w	469.06	28.375	1w	583.63	60.540	2w	968.66
09.028	0w	823.46	23.563	0w	466.80	31.833	6	574.11	61.221	0w	966.92
09.636	0w	821.53	23.980	0w	465.52	36.041	1w	562.57	61.396	0w	966.48
09.992	0w	820.40	25.205	0w	461.79	36.942	0W	560.10	63.842	0w	960.24
5610.541	0w	17818.66	5727.805	0w	17453.86	6037.423	0w	16558.78	6265.561	1w	15955.86 $\ell^5F_5-n^5F_5^o$

λ	INT	ν	
6267.616	1w	15950.63	
69.454	0w	945.95	
69.945	0w	944.70	
70.877	2w	942.33	
71.076	2w	941.83	
72.746	1w	937.58	
74.914	0w	932.08	
75.835	0w	929.74	
76.350	1w	928.43	
79.033	2w	921.63	
79.229	0w	921.14	
82.976	1w	911.64	
83.835	1w	909.46	
84.911	0W	906.73	
86.321	0w	903.17	
88.215	0w	898.38	
88.791	2w	897.05	
89.934	2w	894.03	
92.156	0w	888.42	$^{3}1O^{o}_{2}-e^{3}F_{3}$
93.742	5w	884.42	
95.203	0W	880.73	
95.609	0w	879.70	
97.139	0w	875.85	
6299.456	0w	870.01	
6305.768	1w	854.12	$a^{5}F_{4}-n^{5}F^{o}_{4}$
06.655	0W	851.89	$a^{5}F_{3}-n^{5}F^{o}_{3}$
11.119	1W	840.68	
12.480	0w	837.26	
21.744	2w	814.06	
24.125	0w	808.10	
24.490	1w	807.19	
28.961	0W	796.02	
33.226	1W	785.39	
33.479	1w	784.75	
35.563	0w	779.56	
38.831	0w	771.43	
46.075	0w	753.42	
46.455	0w	752.48	
46.580	0w	752.17	
47.102	6w	750.88	
48.529	1w	747.33	
50.072	35	743.51	
51.849	0w	739.11	
56.972	0w	726.42	
57.707	4w	724.60	
62.687	0w	712.29	
64.239	10-10w	708.47	CoI
70.218	1w	693.72	$a^{5}F_{2}-n^{5}F^{o}_{2}$
71.241	0w	691.20	
71.796	5w	689.84	
73.789	30	684.93	
84.156	0w	659.46	
86.901	6w	652.73	
88.189	25	649.58	
89.406	5W	646.59	
90.751	3w	643.30	
95.799	2W	630.96	
6397.180	4	627.58	
6401.287	0w	15617.55	

Appendix IV.

VITA

Nathaniel Ellmaker Hager, Jr. was born on June 3, 1922 in Lancaster, Pennsylvania, the son of Nathaniel Ellmaker and Ruth Mayer Hager.

He graduated from Franklin and Marshall Academy in June 1940 with honors in science and literature, and then attended Franklin and Marshall College. He graduated in November of 1943 with the degree of Bachelor of Science with Departmental Honors in Physics, and while at Franklin and Marshall he was elected to Phi Beta Kappa and Sigma Pi Sigma honorary fraternities.

He was commissioned as an Ensign in the United States Naval Reserve in January 1944, and served with the United States Submarine Forces until July 1946, when he retired from active duty with the rank of Lieutenant Junior Grade.

He entered Lehigh University in March 1947, and received the degree of Master of Science in June 1948. While at Lehigh he became an associate member of Sigma Xi honorary fraternity. He has served at Lehigh as a graduate assistant and as an instructor in the physics department.