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SPECTRA OF BRIGHT STARS

PHOTOGRAPHED WITH THE 11-INCH DRAPER TELESCOPE

AS A PART OF

THE HENRY DRAPER MEMORIAL

AND DISCUSSED BY

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UNDER THE DIRECTION OF

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PREFACE.

ONE of the first investigations undertaken as a part of the Henry Draper Memorial was the detailed study of the spectra of the bright stars north of declination —30°. This work was assigned to Miss Antonia C. Maury in 1888, and she is alone responsible for the classification contained in Part I. of this volume. A large part of the work of determining wave lengths, and of preparing the volume for publication, has been done by several of the other officers of the Observatory.

As the investigations were made several years ago, they could not take account of the recent discoveries respecting the spectrum of helium, which, if known at the time, might have had an important influence upon some of the conclusions. Such modifications could not now be introduced without practically rewriting the treatise, which is therefore published without change. A discussion of the relation of the spectra of stars of the Orion type to that of helium has, however, been made, and is contained in the "Supplementary Notes," pages 122 to 128.

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CAMBRIDGE, U. S., *February 18, 1897.*

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SPECTRA OF BRIGHT STARS.

CHAPTER I.

Outline of Classification.

The following pages contain the results of an examination of about forty-eight hundred photographs representing the spectra of six hundred and eighty-one of the brightest stars north of declination —30°. The photographs were taken with the apparatus described in Volume XXVI. of these Annals (p. xv). The telescope employed was one originally constructed for visual use by Dr. Draper, but provided with an additional lens to adapt it to photographic purposes. It has an aperture of 11 inches, and a focal length of about 153 inches. Four prisms, each having a refracting angle of about 15°, a deviation of 8°, and a clear aperture of 11 inches, may be placed singly or together in front of the object-glass. The telescope is mounted as an equatorial, and the clockwork driving it is controlled electrically by an auxiliary clock in the photographic laboratory, the rate of which is varied at pleasure by adding or removing weights placed upon the pendulum. The spectrum photographed is accordingly made to traverse the plate in the direction of the spectral lines with any desired speed, in order to widen it sufficiently to make the lines distinct. The rate of this movement was regulated in accordance with the brightness of the star under observation, its color, and the dispersion employed. The time of exposure was usually one hour, but sometimes more. The length of the photographed spectrum between $H\epsilon$ 3970 and $H\beta$ 4861, was 8.0 cm. when four prisms were used together, and 2.0 cm. with one prism only.

Since only the brighter spectra could be photographed when four prisms were employed, a number, selected as typical, were photographed also with two prisms and with one, in order that they might be satisfactorily compared with those of fainter stars, which had not in any case been photographed with the entire number of prisms. The classification of stellar spectra which will be described below depends chiefly upon the comparison of spectra photographed with one prism. Remarks upon the details of the brighter spectra are of course frequently derived from the photographs exhibiting a greater degree of dispersion.

The comparisons themselves were made by placing the photographic films in contact, with the spectra to be compared side by side. The identification of particular lines as common to the two spectra largely depended upon the similarity in intensity, as well as in position, of the great majority of the neighboring lines in the two photographs.

In order to determine the wave lengths of many of the lines in the typical spectra, the solar spectrum was photographed with the 11-inch telescope above described, combined with the Draper 15-inch reflector, used as a collimator in the manner explained on page xvi of Volume XXVI. of these Annals. The relative distances of lines in the solar spectrum, and in various stellar spectra, were determined by means of the measuring apparatus described on page 42 of Volume VIII. of these Annals. This apparatus is provided with two screws placed perpendicular to each other, by means of which the photograph to be measured can be moved under a microscope. One revolution of either screw advances the photograph one twenty-fourth of an inch. The heads of the screws carry graduated circles six inches in diameter, by means of which one thousandth of a revolution may be readily observed.

By means of this instrument, the stellar spectra photographed with four prisms could be compared with the solar spectrum photographed with the same dispersion. In the spectra of the same stars, photographed with a smaller number of prisms, the corresponding lines could readily be identified and compared with those found in the spectra of the fainter stars, in order to determine the place of each star in the system of classification which was finally adopted.

This classification depends, to some extent, as will be seen below, upon the appearance, as well as upon the position of the spectral lines. Care was necessary, therefore, not to confound appearances due to the want of an accurate focal adjustment with those characteristic of particular stars. When the focal adjustment is unsatisfactory, the edges of the lines are ill defined; but when it is improved, while these edges become more definite, the line itself often remains comparatively indistinct, and having relatively little contrast with the remainder of the spectrum. Such lines, in the course of the present treatise, will be described as "hazy."

Care was also required, in deciding upon the character of a photographed spectrum, to make the proper allowance for the degree of density of the silver precipitate. In a photograph somewhat over exposed, the unusual density of the image makes all the lines narrower than they would otherwise be, and may even obliterate fine lines and faint bands. The opposite effect, resulting from insufficient exposure, exaggerates the relative importance of the fainter bands and increases the apparent width of well marked lines.

The comparison of a considerable number of photographs, of apparently good quality, was therefore often requisite to obtain a satisfactory decision with regard to the proper classification of some stars. It was likewise necessary to conduct the investigation systematically, by successively comparing each typical star with those most nearly resembling it in the nature of their spectra, in order to avoid errors in the identification of the lines. Without these precautions many of the finer gradations of the classification would have escaped notice.

In the present treatise, particular lines are designated by their wave lengths, the unit of wave length being the ten-millionth of a millimeter. The extent of a group or of a band of lines is indicated by the statement of the wave lengths of its extreme limits.

The principal terms here to be employed in describing certain well marked classes of lines may require some explanation. The lines of hydrogen form, as is generally known, one of the most important of these classes, and are often mentioned collectively as hydrogen lines. They are mentioned individually, according to the nomenclature of Vogel, as $H\beta$, $H\gamma$, $H\delta$, $H\epsilon$, $H\zeta$, $H\eta$, $H\theta$, $H\iota$, $H\kappa$, $H\lambda$, $H\mu$, $H\nu$, $H\xi$, Ho, $H\pi$, $H\rho$, $H\sigma$, $H\tau$, $H\upsilon$. With these are often associated the lines or bands of calcium, known as H and K, the letter H in this case not referring to hydrogen. The portion of the spectrum containing the line $H\alpha$, due to hydrogen, is not contained in these photographs.

Another class of lines frequently mentioned comprises those which are characteristic of the solar spectrum, excluding the lines of hydrogen and calcium. They are called "solar" lines, except when referring to lines not contained in the solar spectrum, in which case they are called metallic lines.

A third class of lines includes those known as "Orion lines," from the fact that they are conspicuous in the spectra of many stars belonging to the constellation Orion. They are often strongly marked, and generally appear to be single, and not separable into two or more lines by increased dispersion, as is frequently the case with the solar lines.

Certain stars, such as α Cygni and δ Canis Majoris, have spectra in which the majority of the lines, though probably identical in position with lines belonging to the solar spectrum, differ greatly in intensity, while others apparently are not represented in the solar spectrum. The characteristic lines of such stars should perhaps be regarded as forming a class distinct from those already described.

It has long been known that stellar spectra could readily be classified in large groups, ordinarily described as types; and further, that, as is generally the case in natural systems of classification, intermediate varieties could be found between the groups, so that the entire number of spectra observed could be arranged in a series, which has usually been regarded as exhibiting more or less distinctly a course or plan of development. In some parts of this series large numbers of almost identical spectra are found, even when several hundred lines appear in each. The transition of type shown in this series proceeds, as a rule, by barely perceptible degrees, but at times it is more abrupt, the intermediate varieties being fewer.

The method of detailed classification which resulted from the present investigation will now be explained. As usual, the stars were arranged in an apparently progressive series, which in the present case was made to include twenty-two groups, excluding composite spectra, that is, spectra which seemed in reality to result from the combination of the spectra of two or more close components of different spectral characters, and excluding also those in which bright lines were the most important feature. But it also appeared that a single series was inadequate to represent the peculiarities which presented themselves in certain cases, and that it would be more satisfactory to assume the existence of collateral series. These are called "Divisions" in the following pages. They pursue parallel courses of development through at least many of the groups employed, as above stated, to represent stages of progress. The features peculiar to each of these divisions must now be described, before passing to the distinctions made between the various groups.

The chief division, including 355 of the 681 stars examined, was called "Division *a*." In the spectra of this division, none of the single lines, that is, lines which cannot be resolved into pairs or groups by increasing the dispersion, are relatively wide, except those of hydrogen and calcium; and all are clear, that is, as explained above, they are well contrasted with the bright portions of the spectrum, in distinction to the lines which have been called hazy. Good examples of stars belonging to Division *a* are α Lyræ, α Canis Minoris, the Sun, α Boötis, and, among stars remarkable for Orion lines, γ Orionis.

Division *b* comprises stars in the spectra of which all the lines are relatively wide and hazy. As already remarked, this description does not signify any want of definition in the edges of the lines, as compared with those in the spectra of the other divisions, but refers to the appearance of the lines themselves. Owing to this haziness, the fainter lines become altogether imperceptible, and the total number of lines which can be seen is therefore often comparatively small. The relative intensity of those which are visible, however, remains about the same as in spectra of Division *a*, so that there appears to be no decided difference in the constitution of the stars belonging respectively to these two divisions. Indeed, the spectra of the close binary stars, ζ Ursæ Majoris and β Aurigæ, which, when they appear single, belong to Division *a*, pass into Division *b* by the widening of the lines before they become distinctly resolved into pairs. As further examples of stars belonging to Division *b* may be mentioned α Aquilæ, and, among stars containing Orion lines, δ Orionis and α Leonis.

The principal characteristics of Division *c* are, first, the lines of hydrogen are narrow and well defined, and their maximum intensity does not exceed eight tenths of that attained by stars of Divisions *a* and *b*; secondly, the Orion lines are likewise narrow and well defined, and are still discernible in this division in some groups early in the series from which they have disappeared in Divisions *a* and *b*; thirdly, the lines of calcium (except in a single group), are more intense than in the corresponding groups of the other divisions; fourthly, the system of metallic lines contains some apparently not coincident with any lines of the solar spectrum, many of these metallic lines are unusually intense, and the relative intensity of the different lines does not correspond with that observed in the solar spectrum. It has already been mentioned that this system of lines should perhaps be regarded as forming a separate class, as in the case of the Orion lines, and should not be described as "metallic," as has just been done in the absence of any more distinctive name. In general, Division *c* is distinguished by the strongly defined character of its lines, and it seems that stars of this division must differ more decidedly in constitution from those of Division *a* than is the case with those of Division *b*.

As happens with successive groups, it is also found in attempting to assign stars to a particular division, that spectra of intermediate forms occur. A spectrum intermediate between those of two divisions is briefly described by the combination of the two corresponding letters, *ab*, for example, or *ac*. When the spectrum cannot be assigned with certainty to either division, owing to the faintness of the star, or the imperfection of the photographs representing its spectrum, two letters separated by a comma are employed; thus *a*, *b* denotes that the star may belong to either of the divisions *a* or *b*.

Spectra intermediate between Divisions *a* and *c* are almost as numerous as those belonging strictly to Division *c*, and the gradation from the most marked characteristics of Division *c* to spectra closely resembling those typical of Division *a* is particularly apparent in the thirteenth group. The intermediate forms of spectra are valuable aids in determining the groups of Division *c*, which best corresponded to similar groups already formed from spectra of Division *a*.

Before proceeding to the minute description of the peculiarities of the successive groups, a general sketch of the principles according to which they have been formed may be desirable. The first five groups have been formed from stars in the spectra of which the Orion lines are particularly prominent, and which may be called stars of the Orion type. The sixth group contains stars intermediate between this Orion type and the first type of Secchi, to which belong the stars in the seventh to the eleventh groups inclusive. The twelfth group lies between the first and second types of Secchi, and the stars in the thirteenth to the sixteenth groups inclusive belong to this second type. Secchi's third type includes the stars of the seventeenth to the twentieth groups inclusive. The twenty-first and twenty-second groups are respectively coincident with the fourth and fifth types of stellar spectra.

The general course of development traceable through the series is as follows. In the Orion type, the system of hydrogen lines is comparatively faint, and terminates with Hξ, the more refrangible hydrogen lines being absent or invisible. The Orion lines are, as has been said, particularly numerous and well marked, while the solar lines, except perhaps those at 4144 and 4481, are absent. Of the calcium lines only K is present and is very faint. In the transition from the Orion type to Secchi's first type, the Orion lines gradually become fainter and less numerous, until in the spectrum of α Canis Majoris, a good example of the first type, all but two or three are wanting. Meanwhile, the solar lines have begun to make their appearance, and in the group containing α Canis Majoris more than one hundred such lines are found, although they are inconspicuous. At this part of the series the hydrogen lines have acquired their maximum intensity, and form the most prominent feature of the spectrum. The system can be traced at least as far as Hπ or Hρ. Both the calcium lines are present, and the intensity of the K line has increased.

Stars of the second and third types, as is well known, have spectra in which the solar lines become much more prominent than before. In the spectrum of α Orionis, for example, their number exceeds three hundred in the portion of the spectrum lying between 3970 and 4861, while the region between 4861 and 5900, which is studied by means of plates stained with erythrosin, contains more than one hundred and fifty. The latter region in the early first type stars appears to be almost destitute of lines. Among these earlier groups of third type stars, the collective intensity of the solar lines is at a maximum. In the last two groups of the series, distinct lines give place to extensive bands and flutings.

The relative intensity of the solar lines, as we pass onward from the group of α Canis Majoris, undergoes a change so gradual as to be in general almost imperceptible. It is, however, well marked in the transition from the first to the second type. Certain lines are specially affected. Thus, a marked increase in the group of lines extending from 4299 to 4315 gives rise to the conspicuous band seen in the solar spectrum, and called by Fraunhofer G. Similarly, a compound line having its centre at 4227 becomes a distinguishing feature of third type stars.

The intensity of the calcium lines continues to increase, at first slowly, but with a great and sudden rise as the first type passes into the second. In the early groups of second type stars these lines thus become wide bands having more than twice the intensity of the hydrogen lines of α Canis Majoris. This is well shown in α Aurigæ and the Sun. In the later groups of second type stars the calcium bands attain their maximum intensity. They show no increase and a possible slight decrease in the third type.

The hydrogen lines, on the other hand, after remaining nearly constant in the two groups following that of α Canis Majoris, begin to decrease rapidly in the transition from the first to the second type. Their intensity in stars like α Aurigæ and the Sun is little more than a tenth of that shown in α Canis Majoris. These lines continue to decrease, though less rapidly, down to the third type stars, where they are inconspicuous among the faint solar lines.

The nearly constant relation of the decreasing intensity of the lines of hydrogen to the increasing intensity of the lines of calcium and solar lines is probably the most important law in the sequence of stellar types.

Another important feature of the series is the manifestation of extensive absorption in the later groups of second type stars, and its marked increase in those of the third type. In second type spectra it affects only rays having shorter wave-length than 4307; in those of the third type, it is so conspicuous in the region between 4760 and 5900, as to constitute the distinctive feature of the type. This absorption, spreading unequally over wide areas of the spectrum, causes variations, abrupt or gradual, in the intensity of the light.

The absorption in the region having shorter wave length than 4307 begins generally in the group following the Sun, though, by exception, it occurs in the Sun itself; and, widening from one or two centres, covers at length the entire region.

This, in combination with three bands of increased brightness, having wave lengths approximately from 4614 to 4648, 4470 to 4525, and 4315 to 4368, respectively, causes the second type spectra of the later groups to appear as though they consisted of faint and bright portions separated by the strong band at 4307. The apparent bright bands just mentioned begin to appear in the earliest group of second type spectra, become gradually stronger, and reach their highest intensity in the last group of the second type. They are best seen under small dispersion, since a greater dispersion renders the contrast less marked.

A strong absorption in the ultra-violet causes, in spectra of the group following that of the Sun, an abrupt diminution in the intensity of the light at wave length 3889. This, in transition to the third type, spreads to 3934, and finally to 3970, so that all rays of shorter wave length are difficult to photograph. The fading, however, is here no longer abrupt, but gradual.

The absorption in the region between 4760 and 5900 begins in the first group of third type stars, and becomes more marked in each succeeding group. It shows itself as four strong bands, having their limits of shorter wave length at 4762, 4954, 5168, and 5445, respectively. A fifth, less marked band appears in the last group of the series, having its limit of shorter wave length at 4586. Each of these bands is abrupt and strong on the edge of shorter wave length, and fades gradually toward the succeeding one, so that no definite limit of greater wave length can be given. Each is bordered by a distinct bright band on the edge of shorter wave length. As the absorption bands develop, the bright borders increase in brightness in the successive groups of third type stars. These bands are well shown in α Herculis and in variable stars like o Ceti.

The three bright bands in the region between 4315 and 4648, mentioned as conspicuous in the later groups of second type stars, fade gradually in the successive groups of third type stars. With the fading of these, the contrast in intensity of light in the portions of the spectrum separated by the band at 4307 diminishes, and in the last group disappears. It may be noted, however, that a bright band 4556 to 4586 develops in third type stars.

The foregoing statement describes the series of spectral types so far as it has been possible to establish it. If, as we are led to conjecture from their color and from the prevalence of extensive absorption in their spectra, stars of the fourth type follow those of the third, the conjecture cannot become a satisfactory theory in the absence of any connecting links indicating the transition from one type to the other. For the present, therefore, we may regard the series as ending with spectra of the third type, and, in particular, with the system of dark lines contained in the spectra of such variables of long periods as o Ceti.

In the detailed description of the groups, to be given later, some of the spectra are regarded as intermediate between two groups. In such cases, new groups might, of course, have been established in order to provide for these intermediate spectra. When, however, two groups were closely allied, the intermediate spectra did not seem to require the introduction of such an additional group. But when, between successive groups greatly differing from each other, spectra were found of an intermediate character, they were combined in a new group, even when these spectra themselves presented considerable variety.

Table I. gives a general view of the system of classification above described. Stars, which in the detailed account of the groups, to be given hereafter, are placed between two groups, as just explained, are here assigned to that group which they most closely resemble. In the first column, O., I., II., III., IV., V., C., and L. are used to denote respectively spectra of the Orion type, spectra of the five usual types, composite spectra (apparently to be resolved into two or more), and spectra which are mainly of the Orion type, but contain bright lines. The second column contains the numbers of the groups. The succeeding columns give the numbers of stars belonging to each division in each group, and the total numbers. As Division *c* is distinguished by very narrow, and Division *b* by very wide lines, while those of Division *a* are intermediate, the first of these columns relates to Division *c*; the next to spectra intermediate between Divisions *c* and *a*; those which follow relate respectively to spectra of Division *a*, to spectra which might be assigned either to Division *a* or to Division *b*, to spectra clearly intermediate between these divisions, to spectra of Division *b*, to spectra which might be placed under either of the headings *a*, *b*, or *ac*, and to peculiar spectra, under the heading *p*. The distinction between the use of two letters in juxtaposition and the separation of the same letters by a comma, has been already stated on page 5, where it is also explained that the latter symbol indicates that the photographs employed were inadequate to the satisfactory determination of the division.

It will be observed that stars following the twentieth group are not assigned to particular divisions, and are not considered as having a place in the series exhibiting the gradual development of stellar spectra.

The final column contains letters corresponding to those used in the classification adopted for the Draper Catalogue, in Volume XXVII. of these Annals. A position in the series intermediate between two groups of the Draper Catalogue is indicated by the use of both the letters designating these groups. Small letters following the letters denoting the groups refer to subdivisions of the groups.

It appears from Table I. that spectra of Division *c* are not found in groups following the thirteenth, nor are those placed under the heading *ac* after the fourteenth group, which is that containing the Sun. Spectra of Division *b* disappear still earlier, so that the series tends to become more uniform as it progresses. But this, in so far as it relates to Divisions *a* and *b*, may partly be due to the circumstance that in groups following the eleventh many stars occur not sufficiently bright to allow the use of more than one prism in photographing their spectra. Accordingly, some of these stars may have been assigned to Division *a* merely because the dispersion was insufficient to exhibit the true character of the lines in their spectra.

TABLE I.

CLASSIFICATION OF SPECTRA.

Type.	Group	Division.								Total.	D. C.
		c	*ac*	*a*	*a, b*	*ab*	*b*	*a, b, ac*	*p*		
O.	I.	. .	. .	. .	. .	. .	7	. .	. .	7	B
O.	II.	. .	. .	4	5	. .	5	. .	2	16	B
O.	III.	1	. .	5	7	. .	5	. .	1	19	B
O.	IV.	. .	. .	11	22	3	14	. .	. .	50	B
O.	V.	3	. .	9	8	. .	5	. .	. .	25	A B
O. I.	VI.	6	. .	4	9	3	9	. .	. .	31	A B
I.	VII.	1	. .	13	13	. .	17	. .	1	45	A
I.	VIII.	1	1	23	6	3	17	. .	7	58	A
I.	IX.	. .	. .	?	17	3	9	5	. .	34	A F
I.	X.	. .	. .	2	12	2	3	. .	. .	19	A F
I.	XI.	. .	5	?	11	5	. .	7	1	29	F
I. II	XII.	2	3	29	. .	1	. .	. .	. .	35	F G
II.	XIII.	4	1	22	. .	. .	. .	. .	. .	27	G
II.	XIV.	. .	7	40	. .	. .	. .	. .	3	50	G
II.	XV.	. .	. .	117	. .	. .	. .	. .	1	118	K
II.	XVI.	. .	. .	23	. .	. .	. .	. .	. .	23	K
III.	XVII.	. .	. .	19	. .	. .	. .	. .	. .	19	Ma
III.	XVIII.	. .	. .	20	. .	. .	. .	. .	. .	20	Mb
III.	XIX.	. .	. .	10	. .	. .	. .	. .	. .	10	Mb
III.	XX.	. .	. .	4	. .	. .	. .	. .	2	6	Md
IV.	XXI.	. .	. .	. .	. .	. .	. .	. .	. .	4	Na
V.	XXII.	. .	. .	. .	. .	. .	. .	. .	. .	4	O
C.	—	. .	. .	. .	. .	. .	. .	. .	. .	18	. .
L.	—	. .	. .	. .	. .	. .	. .	. .	. .	14	. .
Totals . . .		18	17	355	110	20	91	12	18	681	

Still, sixty-six stars of these later groups were photographed with more than one prism, and among these no instance was found of a spectrum exhibiting the wide lines of Division *b*, and only one, in the twelfth group, which could properly be placed under the heading *ab*. It is therefore probable that spectra distinctly belonging to Division *b* are confined to stars of the Orion type and of Secchi's first type. Minor peculiarities of individual spectra also suggested the same tendency to an increasing uniformity as the series progressed.

It will also be observed that the peculiar spectra enumerated under the heading *p* occur most frequently in the eighth group, which follows that to which α Canis Majoris belongs, and that only two such spectra occur later than the fourteenth group. Slight variations, affecting only the intensity of a very few lines, were common from the sixth to the fourteenth group inclusive, while beyond this point the spectra of each group, although often containing from 200 to 300 lines, were practically indistinguishable from each other.

While it will be generally admitted that the series represents successive stages in stellar evolution, it may still be doubted whether the arrangement beginning with the Orion type, and here adopted, is in fact the natural order. It is strongly indicated, however, by the gradual falling off of the more refrangible rays in the successive groups, by the corresponding increase in the less refrangible rays, and by the occurrence of marked absorption at the close of the series. The comparative simplicity of the Orion spectra and the increasing complexity shown throughout the series lend additional weight to the argument. Finally, the prevalence of the Orion type in great nebulous regions, as in Orion and the Pleiades, indicates very emphatically that stars of this type are in an early stage of development.

The question whether spectra of the fifth type do not form a connecting link between the Orion spectra and those of the nebulæ was considered in an article entitled "A Fifth Type of Stellar Spectra," published in the Astronomische Nachrichten, Vol. 127, p. 1, and also in a paper on "The Constitution of the Stars," read at the Congress of Astronomy and Astrophysics at Chicago in 1893.

Brief allusion should be made to four classes of stars which, as stated above, are excluded from the general series. The first to be mentioned are those which combine features of widely differing types, and are designated by the letter C in Table I. In these stars it is most common to find the spectrum of the second or third type associated with a hydrogen spectrum that is characteristic of the first type. Some stars of this class, like γ Andromedæ and 31 Cygni, are known doubles, and the strong resemblance which most of the stars in question bear to them suggests that stars with these anomalous spectra may in general be close doubles. In spectra of this class, including those belonging to known doubles, the K line appears either unduly narrow, or overspread with a peculiar haziness. This appears to be due to the presence of an additional star, having a spectrum which belongs to some group earlier in the series. It is also significant that in such spectra the first type characteristics predominate in the ultra-violet, the second or third type features in the green and blue. This is exactly what would happen if two spectra of the first and second type were superposed. Perhaps the most beautiful examples of the composite type found among stars not known doubles are ζ Aurigæ and δ Sagittæ, which combine the second and Orion types, and the third and first types, respectively.

The fourth type stars show a wide band of complete absorption having its edge of greater wave length approximately in the position of the line $H\beta$. A second absorption band having greater wave length is commonly shown when the photographic spectra are prolonged toward the red by means of plates stained with erythrosin. These absorption bands, unlike those of the third type stars, are abrupt on the edge of greater wave length and fade toward the violet. The spectra of fourth type stars commonly extend but a short way beyond the line $H\beta$ in the direction of shorter wave length. They are, however, prolonged toward the red as far as or beyond the D line, and show several well marked lines near the end of greatest wave length. These have not as yet been identified with lines of other stars. The spectra exhibiting bright lines bear singular relations to the general series. They are naturally divided into three classes. Those of the fifth type, as has been said, possibly form a link between the nebulæ and stars of the Orion type. They show on a faint continuous spectrum ten or twelve wide fuzzy bright bands, most of which coincide with hydrogen lines and important Orion lines of Group I. The strongest of these bright bands, 4688, is probably present also in the spectra of gaseous nebulæ. These coincidences were first noted by Mrs. Fleming in a study of the plates taken with the 8-inch telescope, and they are confirmed by the plates of higher dispersion studied in this investigation. The second class of bright line stars is formed of those having a more or less normal Orion spectrum, in which, however, many of the lines are accompanied by bright bands. The lines thus reversed are generally one or more of the hydrogen lines and of the strong Orion lines. A double reversal is seen in the lines of hydrogen in γ Cassiopeiæ. The intensity of the bright bands is generally greatest in the line $H\beta$, and decreases with the wave length. In one or two of these stars, notably in β Lyræ, the bright bands cross over the dark ones periodically. This is discussed in the Remarks on Individual Stars.

The third class of bright line stars consists of the long period variables. The system of dark lines in the spectrum of these has been regarded above as showing the last phase in the series. They have the hydrogen lines wholly bright, the maximum brightness being in the line $H\delta$ and decreasing in either direction. The line $H\beta$, which was brightest among the Orion bright line stars, is often faint or invisible.

It is thus a matter of great interest that the bright line stars are found at the beginning and at the end of the series, and that one class of them probably connects the series with the nebulæ.

CHAPTER II.

Detailed Description of the Classification.

The following pages contain a more detailed description of the groups into which the series has been divided. The division was at first based on barely perceptible differences, but the number of groups thus became inconveniently great, and was accordingly reduced. Since the progressive changes shown in the series consist for the most part in gradual alterations in intensity, all distinctions made in describing the groups must be more or less arbitrary. The attempt has been made, however, to select the most constant and obvious features as a means of separating, as clearly as may be, each group from the two adjacent ones.

In describing each group, the typical star or stars have been given in paragraph I., the distinguishing features of the group in II., and the further description in III.

The descriptions relate generally to stars of Division *a*. They have, however, been supplemented by statements of the differences shown in Divisions *b* and *c* as compared with Division *a*. Stars intermediate between Divisions *a* and *b* or *a* and *c*, occurring in some groups, are denoted by the designations *ab* and *ac* respectively, and described in supplementary statements. The peculiarities of individual stars have been considered in the series of remarks at the end of this treatise. Tables IX., X., and XI. contain lists of stars belonging to the successive groups.

In all the descriptions and estimates of what is called the intensity of the lines, the width of each line, as well as the contrast between it and the adjacent portions of the spectrum, has been considered as a mark of intensity.

Before passing to the descriptions, it may be noted that, in dividing the Orion stars into groups, it has been found convenient to consider the distribution and relative intensity of certain lines grouped about Hδ, whose wave lengths are 4069.4, 4072.0, 4075.9, 4089.2, 4096.9, 4116.2, 4120.5, 4128.5, 4131.4, and 4144.0. The relative intensities of the Orion line 4471.8 and the line 4481.4, which latter may be common to the Orion and solar systems, and increases in intensity as we advance in the series, have also been employed as a basis of classification. The Orion line 4026.4, as being the most constant and as a rule the strongest of the Orion lines, has in many cases been used as a standard for comparing intensities. The hydrogen lines attain their greatest intensity in the group of which α Canis Majoris is the typical star. This intensity has therefore similarly been adopted as a standard of comparison for hydrogen lines. The discussion of the groups is preceded by a tabulation showing their relation to the established spectral types, and the constant features of these types.

Tabulation of Groups in Regard to Type.

Groups I.—V. Stars of Orion Type.

Orion lines strong, numerous, declining in the later groups. Hydrogen lines of moderate intensity, increasing toward the first type. Solar lines absent, unless the lines 4144.0 and 4481.4 are common to the two systems. K line faint; the calcium line, H, absent except in some stars of Division *c*.

Group VI. Stars intermediate between the Orion and First Types.

Groups VII.—XI. Stars of Secchi's First Type.

Orion lines in general absent, except two. Hydrogen lines at maximum intensity, declining in the last two groups. Solar and calcium lines increasing toward the second type.

Group XII. Stars intermediate between First and Second Types.

Groups XIII.—XVI. Stars of Secchi's Second Type.

Hydrogen lines not very strong and growing fainter. Solar lines extremely numerous and increasing. Calcium lines seen as bands, which are strong and gradually increasing.

Groups XVII.—XX. Stars of Secchi's Third Type.

Hydrogen lines weak, bright in Group XX. Solar lines slightly increasing, then declining. Calcium lines strong, slightly decreasing. Bands and flutings replacing lines. The former fading in the direction of greater wave length.

Group XXI. Stars of Secchi's Fourth Type.

Two absorption bands present. Line absorption slight. Blue portion of the spectrum generally very faint.

Group XXII. Stars of Fifth Type.

Wide bright bands superposed on a faint continuous spectrum, the strongest one of these probably coincident with a bright band in the spectrum of the gaseous nebulæ, and most of the others probably coincident with hydrogen lines and prominent Orion lines.

Remaining Classes of Spectra: —

1. Composite spectra, probably of double stars.
2. Stars of Orion type having bright lines.

Group I. Oe 5

I. Typical stars, ι Orionis, S Monocerotis.

II. Distinguishing features of the group.

1. Lines 4200.3, 4542.7, and 4685.4 have great intensity, being about half as strong as line 4026.4.

2. Among the lines grouped on either side of Hδ the collective intensity is greater on the side of shorter wave length. Line 4089.2 is very strong, and 4096.9 is of considerable intensity, and stronger than in the following groups. Lines 4069.4, 4075.9, 4116.2, and 4120.5 are weak, and often absent or indistinctly visible.

III. Further description.

1. All the stars which have as yet been found in this group are of Division *b*, having wide and hazy lines.

2. In this group, as in Division *b* of most other Orion groups, lines 3964.6 and 4641.1 are absent.

The entire number of Orion lines, however, is nearly the same as in Division *b* of Group II. These lines are given in Table IV. In relative intensity they resemble the lines of Group II., except in the case of the lines described above, and in that of lines 4009.5, 4387.8, and 4649.2, which are much less intense in this group.

3. Except line 4144.0, which is perhaps common to the Orion and solar classes, no solar lines are present.

4. The hydrogen lines, as frequently happens in Division *b*, are strong and very wide. As in the next group, the system terminates with line Hξ, which has greater intensity than line Hν, thus forming an exception to the rule that at the close of the system each successive hydrogen line of shorter wave length declines in intensity.

5. Of the calcium lines K alone is present, and is very faint.

6. The space between the hydrogen lines Hκ and Hλ appears almost like a bright band. A similar but less marked increase of brightness is visible in the region of Hδ, and as far as 4026 or beyond.

This group of Orion stars is of special interest, as being that which appears to be most closely related to the fifth type stars, and through them to the planetary nebulæ. The three lines 4200.3, 4542.7, and 4685.4, described above as characteristically strong in this group, are probably identical with three important bright bands seen in the fifth type stars. A reference to the description of Group XXII. will show that all but two of the lines of the fifth type stars studied in this investigation are probably coincident with lines of Group I.

The system of dark lines in the spectrum of θ Orionis, H. P. 1023, on which the spectrum of the nebula of Orion is superposed, belongs to this group.

Group II. B0

I. Typical stars, ϵ and κ Orionis.

II. Distinguishing features of the group.

1. Among the lines grouped about Hδ, the aggregate intensities are about the same on either side of this line. Line 4089.2 is the strongest, and has as great intensity as line 4026.4. Line 4116.2 is the second in intensity. The lines 4069.4, 4072.0, 4075.9, 4096.9, 4120.5, and 4144.0 are present, as in the preceding group, but have greater intensity.

2. In the region between Hβ and Hγ, lines 4471.8 and 4649.2 are very prominent. The former is about as strong as line 4026.4; the latter is stronger than line 4026.4, and often as wide as Hβ. Other lines in this region are comparatively weak.

III. Further description.

1. The complete list of Orion lines found in Division *a* of this group, together with rough estimates of their intensities, is given in Table IV. They number about seventy. The presence of the extreme ultra-violet lines 3584 and 3634 is of interest.

2. Except the lines 4144.0 and 4481.4, which may be common to the Orion and solar types, no solar lines are present. The faintness of 4481.4 is noteworthy.

3. The hydrogen lines, as shown in Division *a* of this group, have an average intensity of about two tenths that of the hydrogen lines of α Canis Majoris. As in Group I., the system ends with Hξ which is stronger than Hν.

4. Of the calcium lines K alone is present, and is very faint.

5. The space between the hydrogen lines Hκ and Hλ is nearly as bright as in the preceding group, and so also is the region from 4026.4 to 4144.0.

Of the stars ϵ and κ Orionis, which were selected as typical of Division *a* in this group, it should be stated that their more prominent lines show in a slight degree the haziness so conspicuous in stars of Division *b*. Whether this is true in general of stars in Group II. cannot be decided, as no other stars of Division *a* have been photographed with four prisms.

Group II. — Division *b*. B0

I. Typical star, δ Orionis.

II. Differences as compared with Division *a*.

1. All lines are wide and hazy.

2. This is especially marked in the lines of hydrogen. Owing to the increase of width, their intensity is greater than in Division *a*, and is about three or four tenths that shown in α Canis Majoris.

3. The faint lines of Division *a* appear fainter in Division *b*, and the faintest are lost. The number of lines is therefore much reduced, being only about thirty-three. These are given in Table IV. Lines 3964.6 and 4641.1, well marked in Division *a*, are absent.

4. The intensity of line 4685.4, and in a less degree that of 4200.3, exceeds that given in the table for Division *a*. On the other hand, the intensity of line 4009.5 is less than in Division *a*. It will be noticed that in these respects Division *b* of Group II. approaches Group I.

Group III. β1

I. Typical star, β Canis Majoris.

II. Distinguishing features of the group.

1. Among the lines grouped about Hδ the aggregate intensity is greater on the side of greater wave length. Lines 4120.5 and 4144.0, which have at least double the intensity shown in the preceding group, are now the strongest lines in this region. They are approximately equal in intensity. All the remaining lines near Hδ have become rather fine. These include all those found near Hδ in the preceding group, and several new faint ones.

2. Line 4649.2, though still conspicuous, has little more than half its former intensity, and is about six tenths as strong as line 4026.4. Line 4387.8, formerly weak, has now more than half the intensity of line 4026.4.

III. Further description.

1. The Orion lines found in this group are about eighty in number. They include nearly all those of the preceding group, and several new ones. These lines with their estimated intensities are given in Table IV.

2. The only lines of this group which may be solar are 4144.0 and 4481.4. Line 4481.4 is still very faint.

3. The hydrogen lines are a little stronger than in the preceding group. They have from three to four tenths the intensity of those of α Canis Majoris. The system still terminates with Hξ, which is stronger than Hν.

4. The K line is faint, as in the preceding groups, and the calcium line H is absent.

5. The increased brilliancy seen in the preceding groups between Hκ and Hλ, and about Hδ, has not been observed in this group, except in one or two stars of Division *b*.

GROUP III. — DIVISION *b*. B2

I. Typical star, α Virginis.

II. Differences as compared with Division *a*.

1. The lines are hazy, and more or less wide. The principal lines sometimes appear with a ragged and hazy border on one side. (See Remark 18 on α Virginis, in which star this appearance is probably due to the lines of a rapidly moving companion.)

In general, the lines are not as wide as in Division *b* of other Orion groups.

2. In some at least of the stars of this division, nearly all the lines of Division *a* are present. The number of lines lost, however, probably varies with the degree of widening of the lines.

Several additional lines were found in the region between 4861 and 5900 on plates of α Virginis stained with erythrosin. For the lines of Group III., Division *b*, see Table IV.

GROUP III. — DIVISION *c*. B2

I. Typical star, χ^2 Orionis.

II. Differences as compared with Division *a*.

1. All lines are exceedingly narrow and sharp.

2. The lines of hydrogen have barely one tenth the intensity of those of α Canis Majoris.

3. The K line, as generally happens in Orion stars of Division *c*, is much stronger than in Division *a*. Here it has more than half the intensity of the line 4026.4.

4. Lines 3805.1, 3856.2, 3994.9, and 4154.7 have also a comparatively great intensity. This also is common among Orion stars of Division *c*.

The above named star is the only one so far found in this group belonging to Division *c*. As this star is faint, and the photographs consequently imperfect, the exact relations of the lines grouped about Hδ could not be determined. The lines observed are given in Table IV.

GROUP IV. B2

I. Typical star, γ Orionis.

II. Distinguishing features of the group.

1. Of the lines which in the preceding groups were found near Hδ on the side of shorter wave length, the triple line 4069.4, 4072.0, 4075.9, is alone clearly visible. It appears as three fine lines. On the side of greater wave length, lines 4120.5 and 4144.0 are still conspicuous, but the former has now only half the intensity of the latter. The line 4116.2 of the preceding group is absent.

2. Line 4367.4 is characteristically strong among the fainter lines.

III. Further description.

1. The Orion lines present are about seventy in number, and for the most part the same as in the two preceding groups. These lines with their intensities are given in Table IV. The presence of the extreme ultra-violet lines 3584 and 3684 is of interest.

2. Lines of this group which may also appear in the solar spectrum are 4144.0 and 4481.4. A slight increase in the intensity of 4481.4 indicates an advance toward stars of the first type.

3. The hydrogen lines have an average intensity from four to five tenths of that in *α* Canis Majoris. The line $H\xi$ is still stronger than $H\nu$, and Ho has not been distinctly seen.

4. The K line is a little stronger than in the preceding groups.

Group IV. — Division *b*. B3

I. Typical star, *η* Ursæ Majoris.

II. Differences as compared with Division *a*.

1. All lines are wide and hazy.

2. The hydrogen lines in particular are very wide, and nearly as strong as those of *α* Canis Majoris. Their haziness is slight.

3. All the fainter lines of Division *a* are lost. Next to those of Group VI., Division *b*, the stars here described have the smallest number of lines of any stars in the series. These lines are given in Table IV.

4. The difference between the intensity of the hydrogen lines and that of the remaining lines of the spectrum is greater than in Division *a*.

Stars Intermediate between Groups IV. and V.

Stars are found both in Divisions *a* and *b* whose characteristics are intermediate between Groups IV. and V. In such stars the lines 4128.5, 4131.4, and 4481.4, transitional between the Orion and first types, are stronger than in Group IV. proper, and can be seen even in plates taken with only one prism. The first two then appear as a single line. In typical stars of Group IV. the pair of lines 4128.5 and 4131.4 are faintly seen under the highest dispersion, but neither they nor 4481.4 are commonly seen in plates taken with one prism. When these intermediate stars are of Division *b*, the lines in question, and also the triple line 4069.4, 4072.0, and 4075.9

are commonly seen as hazy and broken lines only, and one or other of them may not be visible.

A few of these stars lying between Groups IV. and V. are of Division *ab*, since their lines are but slightly hazy.

GROUP V.

I. Typical star, η Tauri.

II. Distinguishing features of the group.

1. Among the lines grouped near Hδ on the side of greater wave length, the nearly equal pair 4128.5 and 4131.4 have a combined intensity greater than that of line 4120.5, but less than that of 4144.0. The lines seen in the preceding groups near Hδ on the side of shorter wave length have not been seen in stars of this group.

2. The line 4481.4, probably solar, has upwards of five tenths or more of the intensity of the Orion line 4471.8, but is never equal to that line.

III. Further description.

1. The Orion lines are greatly reduced in number, and with but few exceptions have much less intensity than in the preceding groups. Line 3856.2 has now become the strongest line between Hζ and Hη. These with their estimated intensities are given in Table IV.

2. The lines of this group which may be coincident with solar lines are 4144.0 and 4481.4.

3. The intensity of the lines of hydrogen has greatly increased. It averages nine tenths that shown in α Canis Majoris. The line Ho is now present, and the more refrangible lines of the system show gradual decrease.

4. The K line is stronger than in the preceding group, but, except in Division *c*, the other calcium line is probably absent.

Most of the stars in the Pleiades belong to this or the following group.

GROUP V. — DIVISION *b*.

I. Typical star, τ Orionis.

II. Differences as compared with Division *a*.

The hydrogen lines are wider, and the Orion lines are hazy.

All the lines of Division *a* are found in these stars.

GROUP V. — DIVISION *c*.

I. Typical star, η Canis Majoris.

II. Differences as compared with Division *a*.

1. The lines of hydrogen are sharp and narrow. Their intensity is about four or five tenths of that shown in α Canis Majoris.

2. The K line is much stronger than in Division *a*. It is nearly equal to that of α Canis Majoris. The other calcium line is probably present, though it could not be separated from Hε.

3. The Orion lines have as a rule greater intensity than in Division *a*. Their wave lengths are given in Table IV.

This increased intensity of Orion and calcium lines is characteristic of stars of Division *c* in all the Orion groups, as well as in the group of α Canis Majoris.

The lines 3856.2 and 3863.2, so conspicuous in stars of the next group belonging to Division *c*, have here also an intensity exceeding that seen in stars of Division *a*.

Group VI. B8

I. Typical star, β Persei.

II. Distinguishing features of the group.

1. Each line of the pair 4128.5 and 4131.4 is as strong as line 4144.0, or even stronger.

2. The transitional line 4481.4 has an intensity equal to, but not far exceeding, that of the Orion line 4471.8.

3. The Orion lines 3819.2, 4026.4, 4387.8, and 4471.8 are always present, the second and fourth of these being well marked. Line 4009.5 may or may not be found.

III. Further description.

1. The Orion lines, as may be seen from Table IV., are greatly reduced both in number and intensity as compared with those of the early groups. The maximum number found is nineteen, including those which may be solar. All are faint, except 3819.2, 4026.4, 4471.8, and the transitional lines 4128.5, 4131.4, and 4481.4, which have moderate intensity.

2. The number of solar lines varies from about twenty-five to forty-five. It is smallest in those stars which in the intensity of their Orion lines approach the preceding group.

The solar lines present are as a rule those strongest in α Canis Majoris, the typical star of the next group. The entire list is given in Table V.

3. The hydrogen lines are nearly or quite as strong as those of α Canis Majoris, and, as in that star, a slight absorption is visible, spreading for some distance beyond their borders. In stars of Division *a*, Hο is included among the hydrogen lines visible.

In Division *c*, the system extends to Hσ, possibly to Hυ. The decline in intensity at the close of the system is regular.

4. The K line has a greater intensity than line 4026.4, but is not as strong as in α Canis Majoris. The other calcium line is present, though not always separable from Hε.

This group is important as showing the transition from the Orion type to the first type of Secchi. The stars contained in the group show various degrees of resemblance to those of Secchi's first type, being more like the latter in proportion as they lose the characteristics of the Orion type.

If we compare successively γ Orionis of Group IV., β Tauri and β Persei of Group VI., and α Canis Majoris of Group VII., we shall see the gradual disappearance of the Orion lines, and the accompanying development of solar lines.

Group VI. — Division *b*. B8

I. Typical star, α Leonis.

II. Differences as compared with Division *a*.

1. All the lines are very wide. Those of hydrogen are more or less hazy, and the remaining lines of the spectrum are very faint, owing to haziness.

2. Except those of hydrogen nearly all the lines of Division *a* are lost. The only lines commonly shown in addition to the hydrogen and K lines are 3819.2, 4026.4, 4144.0, 4387.8, 4471.8, 4925.7, and the lines 4128.5, 4131.4, and 4481.4, whose increase marks the transition to the first type. Stars of this class have the minimum number of lines found in any stars included in the series. These lines are given in Table V.

Group VI. — Division *c*. B8

I. Typical star, β Orionis.

II. Differences as compared with Division *a*.

1. All lines, including those of hydrogen, are extremely narrow. The intensity of the latter is only about four tenths that seen in α Canis Majoris, and there is no absorption spreading beyond the borders. Hydrogen lines include Hσ, and possibly Hτ and Hυ. This gives seventeen at least, the maximum number found in any star in the course of this investigation.

2. The K line is as strong as in stars of Group VII. belonging to Division *a*, and the other calcium line, which has a somewhat smaller intensity, is distinctly seen separate from Hε.

3. The Orion lines are, as a rule, stronger than in Division *a*. The lines 3854.2, 3856.2, and 3863.2 are conspicuously strong in the ultra-violet. The list of those present is given in Table IV.

4. The metallic lines are fewer than in Division *a*. They consist of the strongest lines found in Group VII., Division *c*. Their wave lengths and intensities are given in Table VII.

Group VII.

I. Typical stars, α Canis Majoris and α Lyræ.

II. Distinguishing features of the group.

1. Orion lines, except the two which may be solar and the transitional pair 4128.5 and 4131.4, are absent in typical stars. A trace of line 4471.8, however, is found in α Lyræ.

2. Solar lines are numerous but faint, the one at 4481.4 being the only one clearly shown in photographs taken with one prism.

3. The intensity of the line K does not much exceed one tenth that of the line Hδ.

III. Further description.

1. The lines of hydrogen are at their maximum intensity, and strongly predominant over all other lines. They are accompanied by a slight absorption spreading beyond their borders, yet leaving the borders well defined. The series includes Hπ, and probably Hρ.

2. In α Canis Majoris more than one hundred and thirty solar lines have been found, over a hundred of which lie between Hβ and Hη. In α Lyræ the number is smaller, and this doubtless varies in different stars of the group.

The lines found in α Canis Majoris with their estimated intensities, are given in Table V.

3. Both lines of calcium are present, and the H line is easily separable from Hε in photographs taken with three or four prisms.

A number of stars have been included in this group which approach the preceding in having line 4026.4 clearly present, and yet agree with α Canis Majoris in the intensity of their solar lines.

Group VII. — Division *b*.

I. Typical stars, ζ Aquilæ and ο Herculis.

II. Differences as compared with Division *a*.

1. All lines are wide: K and the solar lines are hazy.

2. The fainter lines of Division *a* are lost.

The Orion line 4026.4 is very frequently present, and is often well marked.

Group VII. — Division *c*.

I. Typical star, η Leonis.

II. Differences as compared with Division *a*.

1. The hydrogen lines are narrow, and have only seven or eight tenths the intensity of those of Sirius.

2. The metallic lines present are the strong lines of α Cygni of Group VIII., Division *c*, and their relative intensity resembles that shown in α Cygni, and differs from that shown in α Canis Majoris. These lines in general are stronger than those of stars of this group which belong to Division *a*.

3. The Orion lines are more persistent than in Division *a*. Thus lines 4026.4 and 4471.8 are well marked in the typical stars, while 4009.5, 4267.4, and 4387.8 are seen in stars which approach the preceding group. The two lines which may be common to the solar and Orion systems, and which appeared in Division *a*, are also well marked.

4. The intensity of the K line is probably a little greater than in Division *a*.

These stars form an interesting connecting link between the Orion stars having narrow lines, and those stars of the first and second type belonging to Division *c*, which differ so widely from stars of Division *a*. As compared with β Orionis of Group VI., Division *c*, and α Cygni of Group VIII., Division *c*, the typical star of this group, η Leonis, is intermediate in regard to metallic, Orion, and calcium lines, while in regard to its hydrogen spectrum it exceeds both, thus marking the maximum hydrogen intensity for the entire series of stars belonging to Division *c*.

This connection is the more fully established, because the remaining stars included in this group, notably H. P. 551, do not closely resemble the typical star, but in respect to hydrogen, Orion, and metallic lines are intermediate between it and β Orionis of Group VI., Division *c*.

The Orion lines of the typical star η Leonis, and those of the intermediate star H. P. 551, are given in separate columns in Table IV., and the metallic lines of each, with estimated intensities, may be found in Table VII.

Group VIII.

I. Typical star, α Geminorum.

II. Distinguishing features of the group.

1. The intensity of the K line is approximately two tenths that of Hδ.

2. The solar lines are stronger than in α Canis Majoris, and somewhat more numerous. In addition to the line 4481.4, seen in the preceding group, line 4549.7, and the band containing lines 4172.3, 4173.6, 4177.8, and 4179.5, and several other bands, can be seen in the plates taken with one prism.

III. Further description.

1. The lines of hydrogen are nearly, if not quite, equal to those of α Canis Majoris, and like the latter are accompanied by slight absorption spreading beyond their borders. The system extends at least to Ho.

2. One hundred and thirty solar lines were found between Hβ and Hη. These include, with several slight exceptions, all the lines in α Canis Majoris found in the regions covered by the photographs of both stars, together with a few additional lines.

The relative intensity of the lines in this group differs but little from that shown in the preceding group, such differences as occur showing an approach to the following groups.

The increase in general intensity, as well as in the number of lines, may be seen from Table V.

Group VIII. — Division *b*.

I. Typical star, γ Ursæ Majoris.

II. Differences as compared with Division *a*.

1. All lines are wide and hazy, and the fainter lines of Division *a* are lost.

The width of the lines varies greatly in different stars, and the number of fine lines disappearing varies with the width of the lines in general.

2. The K line, owing to this widening, often appears to have an intensity greater than that in Division *a*. It is often estimated as having four tenths or more the intensity of Hδ.

For this reason stars of Division *b* belonging to this group are difficult to separate from those of Group IX. They may generally, however, be known by the smaller number of lines.

The differences seen in this division as compared with Division *a* are exactly paralleled by the changes undergone by the close binaries ζ Ursæ Majoris and β Aurigæ. These stars, which when their spectra appear single are typical stars of Group VIII., Division *a*, become just before doubling typical stars of Group VIII., Division *b*. In the latter phase, they show not only the wide and hazy appearance of all the lines, together with loss of the fainter ones, but also, frequently, the apparent increase in the intensity of the K line. A good photograph of ζ Ursæ Majoris, taken in this phase, gave the intensity of the K line as seven tenths that of Hδ, and only fifty-eight solar lines in place of one hundred and ten shown when the spectrum was single.

Group VIII. — Division *c*.

I. Typical star, α Cygni.

II. Differences as compared with Division *a*.

1. The lines of hydrogen are narrow and unaccompanied by absorption spreading beyond their borders. Their intensity is estimated at five tenths that of the hydrogen lines of α Canis Majoris, or about half that shown in Division *a*.

2. The relative intensity of the metallic lines is unlike that shown in Division *a*, and resembles that found in Division *c* of other groups. Also, the wave lengths of the lines are not in all cases identical in the two divisions.

One hundred and thirty lines were found between Hβ and Hη, and seventeen beyond Hβ. Those between Hβ and Hη appear with their estimated intensities in Table VII. It will be seen that strong lines are here more abundant than in Division *a*.

3. The calcium lines have about the same actual intensity as in Division *a*; their ratio to the hydrogen lines is, however, of course greater.

α Cygni is the only star as yet found belonging to Division *c* in Group VIII.

Stars intermediate between Groups VIII. and IX., Division *ac*.

I. Typical star, τ Argus.

II. Differences as compared with Division *a*.

The lines of hydrogen have about eight tenths the intensity of those of α Canis Majoris. This is intermediate between the intensities of these lines in Divisions *a* and *c* at this point in the series.

The metallic lines present appear to be identical with those of α Cygni of Group VIII., Division *c*. Fifty of these lines were found in the rather faint photographs of τ Argus taken with two prisms, and they include all the principal metallic lines found in similar photographs of α Cygni. The relative intensity also of these lines appears to be exactly the same as in α Cygni. The actual intensity may be a little greater, but this is uncertain, owing to the faintness of the image.

The K line has between three and four tenths the intensity of Hδ.

τ Argus is the only star found at this point in the series having a spectrum intermediate between Divisions *a* and *c*.

Group IX.

I. Typical star, α Piscis Austrini.

II. Distinguishing features of the group.

1. The K line has from four to eight tenths the intensity of Hδ.

2. The aggregate intensity of the solar lines is greater than in the preceding group, and lines are numerous and well marked in the plates taken with one prism.

III. Further description.

1. The lines of hydrogen are still very strong. Their intensity is estimated at ninety-five hundredths of that seen in α Canis Majoris.

2. The solar lines present are mainly those of the preceding group, with the addition of a few belonging to the groups following. Since, however, the lines of the few stars in this group bright enough to be photographed with four prisms were all more or less wide, the maximum number of lines found was not quite as great as in the preceding group. α Piscis Austrini, which belongs to Division *ab*, was chosen as the typical star of the group, because it most nearly resembled stars of Division *a* in regard to the width of its lines. The general intensity of the solar lines is greater than in the preceding group, and a few slight changes in relative intensity show advance toward the second type. The lines found in α Piscis Austrini of this group are given in Table II. They could not be introduced into the general table of solar lines, because the slight widening rendered it difficult to compare them with the lines of stars belonging to Division *a*. This group is an arbitrary one, and contains stars showing various phases intermediate between the preceding and the following group.

TABLE II.

WAVE LENGTHS OF LINES IN SPECTRUM OF α PISCIS AUSTRINI.

3850.0	3923.0	4024.8	4122.8	4187.6	4260.5	4370.0	4455.0	4554.2
3856.5	3933.8	4030.8	4128.1	4191.8	4271.7	4374.7	4469.5	4556.0
3863.9	3945.2	4041.5	4131.4	4195.6	4275.0	4383.7	4481.4	4558.9
3865.7	3949.0	4045.9	4143.9	4198.5	4282.9	4385.2	4490.0	4564.0
3872.7	3953.0	4048.9	4149.5	4202.2	4289.9	4391.2	4491.6	4572.2
3878.5	3956.6	4054.0	4150.5	4215.7	4297.1	4395.3	4501.5	4584.0
3889.1	3961.6	4057.6	4154.1	4227.0	4299.2	4400.2	4508.5	4588.4
3900.7	3970.2	4063.7	4154.9	4233.6	4302.6	4401.6	4515.4	4619.2
3903.1	3997.6	4067.0	4156.7	4239.0	4308.0	4405.0	4520.3	4629.9
3905.6	4003.0	4071.9	4167.5	4242.5	4315.2	4415.3	4522.9	4635.3
3913.6	4005.3	4077.9	4172.3	4247.3	4321.0	4417.9	4528.8	4647.6
3914.5	4012.6	4035.4	4173.6	4248.7	4326.0	4435.2	4534.2	4657.0
3916.4	4017.4	4101.8	4177.8	4251.0	4340.7	4444.0	4541.6	4668.0
3920.4	4018.4	4118.9	4179.5	4254.5	4352.0	4450.6	4549.7	4703.1

Group IX. — Division *b*. A2

I Typical star, δ Ursæ Majoris.

II. Differences as compared with Division *a*.

All lines are wide; all except those of hydrogen are hazy, and the fainter lines of Division *a* are lost.

Group X. A5

I. Typical star, β Trianguli.

II. Distinguishing features of the group.

1. The intensity of the calcium and hydrogen lines is approximately equal.

The group has been made to include all stars in which the K line has from nine to eleven tenths the intensity of Hδ.

2. The intensity of the compound line H and Hε is greater than that of K.

III. Further description.

1. The intensity of the lines of hydrogen is beginning to diminish. It is estimated at nine tenths that shown in α Canis Majoris.

2. The number of solar lines present is not definitely known, because none of the stars of this group are bright enough to be photographed with four prisms. Photographs of these stars taken with one and two prisms show all the lines seen in stars of the preceding groups under similar dispersion, and some additional ones of the groups following.

The general intensity of the solar lines is a little greater than in the preceding group. A few slight changes in relative intensity show advance toward the second type. In number and intensity the lines may be assumed as intermediate between those of Groups VIII. and XII., which are given in Table V.

Group X. — Division *b*. A5

I. Typical star, α Aquilæ.

II. Differences as compared with Division *a*.

All lines are very wide, and the solar lines are hazy. The number of lines is considerably less than in Division *a*. The typical star, however, contains nearly all the lines found in α Piscis Austrini of Group IX., Division *ab*.

In the case of the majority of the stars contained in this group, it has not been found possible to decide whether they belong to Division *a* or *b*, as they have not been photographed with sufficient dispersion to determine the width of their lines.

Group XI. 70

I. Typical star, δ Aquilæ.

II. Distinguishing features of the group.

1. The intensity of the calcium lines exceeds that of the hydrogen lines. The K line has from fifteen to twenty-five tenths the intensity of Hδ.

2. The intensities of K and the compound line H and Hε are approximately equal. In most stars of the group, K slightly exceeds the other line.

3. In the plates taken with one prism the band at 4307 (Fraunhofer's G) does not appear, except that the compound line 4299.2–4302.6 included in it is visible as in the preceding group.

III. Further description.

1. The lines of hydrogen have about seven tenths of the intensity of those in α Canis Majoris.

2. The solar lines in this group are nearly identical with those in Group XII., as regards number and intensity, except that the lines between wave lengths 4299.2 and 4315.2 in stars of the second type, and forming the G band of Fraunhofer, and also line 4326.0 are much weaker in this group. The general intensity of solar lines is slightly greater than that in the preceding group.

The majority of stars included in this group, owing to insufficient dispersion, cannot be assigned with certainty to Divisions *a* or *b*, and among the few which were photographed with four prisms none were of Division *a*. This group, like the preceding, is a somewhat arbitrary one, and shows a number of intermediate phases.

Group XI. — Division *ab*.

I. Typical stars, γ Boötis and γ Virginis. 70

II. Differences as compared with Division *a*.

The lines are but little wider than those of stars belonging to Division *a*. The spectra seem nearly to agree with stars of Group XII., Division *ab* in the number and intensity of the lines present, except in regard to the band at 4307, and the lines of hydrogen and calcium. The only stars of the group that have been photographed with four prisms belong to Division *ab*.

Group XI. — Division *ac*. 70

I. Typical star, 22 Andromedæ.

II. Differences as compared with Division *a*.

The intensity of the metallic lines is intermediate between the intensities of the lines of Divisions *a* and *c*.

In the plates taken with a single prism these differences show themselves only in a somewhat increased intensity in certain lines as compared with those of Division *a*.

They are most easily recognized by the greater intensity of line 4417.9, which appears to coalesce with 4415.3.

Only two stars of this intermediate division were found which properly fall into this group. They were too faint to be photographed with four prisms.

Stars intermediate between Groups XI. and XII. — Division *a* or *b*.

A number of stars are found intermediate between Groups XI. and XII.

In these the K line has about three and five tenths times the intensity of the line Hδ, and slightly exceeds that of the compound line H and Hε. The hydrogen lines have about four tenths the intensity of those of α Canis Majoris. The intensity of the solar lines is intermediate between the two groups, and a trace of the band at 4307 is commonly seen in photographs taken with one prism.

Stars intermediate between Groups XI. and XII. — Division *ac*. 70

I. Typical star, α Leporis.

Among those stars which are intermediate between Groups XI. and XII., several are found whose metallic lines are of a character intermediate between those of Divisions *a* and *c*.

In α Leporis, the only one of these stars bright enough to be photographed with four prisms, all the lines of Group XII., Division *c* appear, their intensity being intermediate between that shown in ε Aurigæ of Group XII., Division *c*, and α Canis Minoris of Group XII., Division *a*.

In photographs taken with one prism, as previously stated in regard to stars of Division *ac* properly falling in Group XI., the most noticeable deviation from Division *a* is in the greater intensity of the line 4417.9, which coalesces with 4415.3.

The intensities of the lines of hydrogen and calcium are about the same as in stars of Division *a* or *b*, intermediate between Groups XI. and XII.

Group XII. 75

I. Typical star, α Canis Minoris.

II. Distinguishing features of the group.

1. The intensity of the K line is decidedly greater than that of the compound line H and Hϵ, the intensity of the latter being only seven or eight tenths that of the former.

2. The band at 4307 is faintly seen in plates taken with one prism. It is not nearly as strong as in the Sun and in stars of the solar type. The plates taken with four prisms show the appearance of this band to be due to the increased intensity of the lines 4299.2, 4300.8, 4302.6, 4305.8, 4308.0, 4309.5, and 4315.2, lying adjacent to one another so as to form a nearly, but not quite, continuous band. Line 4326.0 is also seen in the plates taken with one prism, but is not strong.

III. Further description.

1. The intensity of the lines of hydrogen is estimated at twenty-five hundredths of that shown in α Canis Majoris. All the lines of this system found in the early first type stars appear still to be present.

2. Three hundred and ten solar lines were found between Hη and Hβ. These, with their estimated intensities, are given in Table V. The number, it will be noticed, is nearly three times that found in Group VII., while the aggregate intensities of solar lines between Hϵ and Hβ in the two groups have the ratio of 100 to 430.

3. The bands of calcium are very wide, but do not equal those of the Sun and of stars of the later second type. Their intensity is estimated at about eight tenths that of the H and K bands in the Sun, and less than seven tenths those of α Boötis. The same estimate, however, gives their intensity as ten times that of the K line of α Geminorum of Group VIII. It will be apparent from the above description that spectra of this class are intermediate between the first and second types.

Group XII. — Division *ab*.

The star β Cassiopeiæ has lines in a slight degree wide and hazy. This is the last group in the series in which the peculiarities of Division *ab* have been observed. As few of the stars of this group were photographed with four prisms, it may contain others with slightly widened lines.

Group XII. — Division *c*.

I. Typical star, ϵ Aurigæ.

II. Differences as compared with Division *a*.

1. The intensity of the lines of hydrogen is probably less than in Division *a*. It appears to be two tenths that of the hydrogen lines of α Canis Majoris.

2. The metallic lines differ widely in relative intensity from those of Division *a*,

and strong lines are more abundant. In a few cases the wave lengths are different. The one hundred and fifty lines found between $H\zeta$ and $H\beta$ are given with their estimated intensities in Table VII. It will there be seen that their resemblance to the lines of δ Canis Majoris is very marked. It is also further apparent that these lines are fewer in number, but in many cases stronger, than those found in Division *a*.

3. Lines 4299.2, 4302.6, 4314.3, and 4315.2 are seen in the plates taken with one prism; but the intermediate lines being invisible or extremely faint with this dispersion, no continuous G band appears.

4. The calcium bands appear to be narrower than in Division *a*. Their comparative width in the two divisions is uncertain, as it varies with different dispersions. In the plate taken with four prisms the width appears to be not more than five tenths as great in this division as in Division *a*. The spectrum on this plate is faint, yet this would probably not tend to decrease the width of the bands. From plates taken with fewer prisms the width should be seven or eight tenths, while in the plate taken with one prism it appears about the same as in Division *a*.

In all other groups the calcium lines are stronger in Division *c* than in Division *a*.

Group XII. — Division *ac*.

The star ν Persei is intermediate between Divisions *a* and *c* in regard to metallic lines. For a more detailed description, see "Stars intermediate between Groups XII. and XIII., Division *ac*," which stars it resembles, but with which it has not been classed because the intensities of its hydrogen and calcium lines place it in Group XII.

Stars intermediate between Groups XII. and XIII. — Division *ac*.

I. Typical star, α Persei.

II. Differences as compared with Division *a*.

The metallic lines are intermediate in intensity between those of Divisions *a* and *c*. In the typical star all the lines of Group XIII., Division *c*, are present with two or three possible exceptions, but with intensity approaching that of the typical stars of Group XIII., Division *a*.

In photographs taken with one prism the differences between the spectra of the two divisions are not in general clearly marked, owing to the crowding of the lines. Spectra of Division *ac* can, however, be then distinguished by the greater intensity of line 4417.9, and by the fact that, in place of the wide band at 4307 containing all or nearly all of the lines found in the Sun between 4299.2 and 4315.2, a line composed of 4300.2 and 4302.6 is all that is usually shown. This line further appears hazy toward the blue, owing to the adjacent lines 4288.1, 4289.8, 4294.3, and 4297.1, some or all of which come out more distinctly than in stars belonging to Division *a*, and photographed with the same number of prisms. Again, the line 4326.0 is commonly invisible in the photographs of stars belonging to Division *ac*, taken with the same dispersion.

The lines of calcium have an intensity at least as great as in stars of Group XIII., belonging to Division *a*, and those of hydrogen have an intensity intermediate between the intensities shown in stars of the two groups belonging to Division *a*.

Group XIII.

I. Typical star, χ Orionis.

II. Distinguishing features of the group.

1. The spectrum agrees nearly with that of the Sun.

2. The lines of hydrogen, however, are decidedly stronger than in the Sun. Their intensity is estimated at two tenths of that in α Canis Majoris, and is intermediate between that given in the preceding group and that found in the Sun and other stars of Group XIV.

III. Further description.

The band 4307 and the calcium bands appear as in the Sun, and the number and intensity of the solar lines does not differ appreciably from that seen in the Sun and those stars of Group XIV. photographed with the same number of prisms. No stars of this group have been taken with more than two prisms, so that a more exact comparison cannot be made. This group may be called an arbitrary one, since the spectra classed in it present a gradation from the type of the preceding group to that of the Sun.

In stars approaching the preceding group, the band 4307 is faint, and the solar lines less strong, while the lines of hydrogen have nearly the same intensity as in Group XII.

Group XIII. — Divisions *c* and *ac*.

I. Typical stars, for Division *c*, δ Canis Majoris; for Division *ac*, α Ursæ ~~Majoris~~.

II. Differences as compared with Division *a*.

1. The intensities of the solar lines in Division *c* are widely different from those of the lines of Division *a*, and the wave lengths in some cases are probably different.

The two hundred and fifteen lines found between K and Hβ are given, with their estimated intensities, in Table VII.

2. Spectra of Divisions *c* and *ac*, when photographed with one prism, may be recognized by the prevalence of strong lines, and by the defective G band. This band, so conspicuous in stars belonging to Division *a* and containing all lines of the Sun from 4299.2 to 4315.2, is here represented, as in Divisions *c* and *ac* of Group XII., chiefly by a line composed of 4300.2 and 4302.6. The line 4315.2, however, is commonly shown in good plates as a faint separate line. As in stars of Division *ac* of the preceding group, the defective G band appears hazy toward the blue on account of the greater intensity of some of the adjacent lines. Line 4326.0, if visible, is very faint.

3. The width of the calcium bands, as shown in the typical star of Division *c*, exceeds that found in any other class of stars in the series. The estimates vary with the dispersion of the spectra, but the average value taken from the different dispersions, both for the typical star and for the group, gave the intensities of the lines K and H as fourteen and fifteen tenths respectively of their intensities in the solar spectrum. This exceeds the intensity of these bands in α Boötis and α Tauri of Groups XV. and XVI., Division *a*, which have the maximum intensity of these bands in stars of that division.

The K band is probably not so wide in all the stars here included, but is in all cases at least equal to that of α Boötis.

4. In the intensity of their hydrogen lines the stars here described approach the following group. In the plates taken with one prism, Hγ and Hβ appear much stronger than the other hydrogen lines owing to the coalescence of Hγ with the strong line 4337.6, and of Hβ with 4855.7 and a band covering the solar lines at 4864.2 and 4866.5. In this group it was found impossible to separate Divisions *c* and *ac*. The group includes ρ Cassiopeiæ, δ Canis Majoris, γ Cygni, *d* Draconis, and α Ursæ Minoris. When taken in this order, these stars show a gradual transition of type from the extreme form of Division *c* to a form differing comparatively little from Division *a*. This fact was mentioned on page 5. In ρ Cassiopeiæ the peculiar strong lines of δ Canis Majoris are still stronger. They become less intense in each successive star, except that the third and fourth in order are probably alike. Again, in photographs of δ Canis Majoris taken with four prisms, a considerable number of the solar lines of stars belonging to Division *a* were not found, but in α Ursæ Minoris the number of solar lines absent was exceedingly few. This star also, under this dispersion, did not differ greatly from stars belonging to Division *a* in the general intensity of most of its lines.

Group XIV. *G0*

I. Typical stars, α Aurigæ, η Boötis, and the Sun.

II. Features determining the group.

1. The lines of hydrogen have not more than about fifteen hundredths their maximum intensity as seen in α Canis Majoris.

2. The G band is the most conspicuous feature of these spectra, except the bands of calcium. It contains the lines 4299.2, 4300.8, 4302.6, 4305.8, 4308.0, 4309.5, 4311.7, 4313.0, 4314.3, 4315.2, and others not separately visible, but appearing as a continuous haze, connecting the stronger lines into an almost unbroken band. It of course appears most unbroken in the plates taken with few prisms.

3. The combined intensity of the hydrogen line Hγ and line 4337.6, which, when photographed with few prisms, coalesces with Hγ, exceeds that of line 4326.0 even when the latter is combined with 4323.7. The intensity of the former compound line usually appears about twice that of the latter, but the ratio varies under different dispersions. When the lines are resolved, the line Hγ alone is seen to be stronger than line 4326.0.

III. Further description.

1. In the typical star α Aurigæ three hundred and twenty-eight solar lines were found between Hη and Hβ, and one hundred and forty seven appeared in the region between Hβ and D in plates stained with erythrosin. The total number found in the entire photographic spectrum was four hundred and eighty-eight. Since a large number of these are complex bands, the actual number of course is much greater, and in general it may be said that, with a few slight exceptions, all the clearly defined lines found in the photographs of the Sun taken with similar dispersion are present in this star, and have the same width and intensity.

The same is true for η Boötis in the regions covered by the photographs of that star. The few cases where variation was observed in the intensity of special lines are enumerated in the Remarks on Individual Stars, page 97.

The lines found in this group between Hη and Hβ, with their estimated intensities, are given in Table V. It will there appear that, with several exceptions, all the lines of Group XII. are included among those of this group. As the lines of α Aurigæ, however, are not as well defined as those of α Canis Minoris, many lines resolved in the latter star are united into bands in the former.

2. The calcium bands have nearly, but not quite, reached their maximum intensity. It is difficult to estimate their intensity in terms of any other lines, but the K band may perhaps be called equal to two or three times the line Hδ of α Canis Majoris,

when width is considered as one of the factors in intensity. Such estimates, however, vary so greatly with the dispersion employed as to be of little use.

3. A slight contrast is now visible in the intensity of the portions of the spectrum separated by the band 4307, that of shorter wave length being somewhat brighter in the negative, and therefore fainter in the star. This is not nearly so marked, however, as in the following group. The bands of increased brilliancy, 4315 to 4368, 4470 to 4525, and 4614 to 4648, are faintly seen in plates taken with one prism.

Group XIV. — Division *ac*. 90

I. Typical star, η Aquilæ.

II. Differences as compared with Division *a*.

These spectra differ from Division *a* in nearly the same manner as α Ursæ Minoris differs from Group XIII., Division *a*. The difference, however, is less in degree, and the spectra are often barely distinguishable from those of Division *a*.

When photographed with one prism, and none of them have been photographed with more, they may be distinguished from spectra of Division *a* by the somewhat greater intensity of many of their solar lines, by the more or less imperfect G band, and by the apparently great intensity of the Hγ and Hβ lines, owing to coalescence with adjacent lines under the lower dispersion. In the G band, as in stars of this division in preceding groups, the only line of great intensity which commonly appears is 4300.2 to 4302.6, and this is hazy toward its edges owing to adjacent lines. Line 4326.0 is commonly faint or invisible, but sometimes clearly seen.

Hγ and Hβ have at least double the intensity of Hδ, owing, as in the preceding group, to the coalescence of Hγ with 4337.6, and of Hβ with 4855.7 and the band extending probably over the solar lines 4864.2 and 4866.5.

The remaining lines of hydrogen are the same as in Division *a*, or slightly approach the diminished intensity shown in the next group.

The width of the calcium bands varies. It however generally equals or exceeds that of stars belonging to Division *a* in Groups XV. and XVI., which is the maximum intensity found in stars of that division. This is the last group of the series in which stars representing Divisions *c* or *ac* have been found. If the three peculiar stars, ϵ Leonis, ξ Argus of this group, and ζ Capricorni, intermediate between Groups XIV. and XV., are in some degree allied to this division, the relation is not well established, and they lack some of the most constant features of stars belonging to Division *c*.

Stars intermediate between Groups XIV. and XV. G5

I. Typical Star, κ Geminorum.

A number of stars intermediate between Groups XIV. and XV. were at first classed as a separate group.

II. Distinguishing features.

1. The intensity of the Hγ line in coalition with line 4337.6 is approximately equal to that of line 4326.0. This applies to the spectra as shown under the dispersion of a single prism, as none have been obtained under greater dispersion. Were the lines Hγ and 4337.6 resolved, the estimated intensity of the compound line would probably be increased.

2. The intensity of the hydrogen and calcium lines is intermediate between Groups XIV. and XV., that of the hydrogen lines being estimated at eleven hundredths of that of the lines of α Canis Majoris.

3. The degree of general absorption in the violet is less than in Group XV., but greater than in Group XIV.

4. Lines 4077.9 and 4215.7 commonly appear stronger than in the typical stars of either group. Line 4077.9 is not separated from 4076.8, and the increased intensity may therefore be due to the latter line. It is however probably due to change in 4077.9, since this line has in other stars shown a tendency to variation. The lines in general are very clear and distinct, although this may be due to the photographs.

5. In other respects these stars resemble those of Group XV.

Group XV. K0

I. Typical stars, α Boötis and α Cassiopeiæ.

II. Distinguishing features of the group.

1. The intensity of the line 4326.0 exceeds the combined intensity of the line Hγ and 4337.6. This does not appear true, according to the estimated intensities of these lines as given in Table VII. The reason is that, when the components of a double line are separately estimated, the sum of the estimates will exceed the values estimated for the two as a single line. In photographs taken with one or with two prisms, the intensity of 4326.0 appears to be double that of Hγ and 4337.6; and this is true whether Hγ and 4337.6 are resolved or not. In photographs taken with four prisms this contrast is diminished, but the intensity of 4326.0 is still nearly double that of the line Hγ alone.

2. The line 4227.0 has not more than from one and a half to two times the intensity of the compound line 4383.7 to 4385.2. The former line is of course, under all dispersions, far less conspicuous than the band 4307.

3. The band 4307 still appears continuous, and resembles that of the Sun. There is a slight increase in intensity in some of the lines composing it.

III. Further description.

1. The lines of hydrogen have less than one tenth their maximum intensity as seen in α Canis Majoris.

2. In this group three hundred and thirty-seven solar lines were found between K and Hβ, and one hundred and sixty-one between Hβ and D. Thus, not including the many ultra-violet lines which appeared in plates of lower dispersion, nearly five hundred lines were found. The sum of the estimated intensities of lines between Hβ and H was 712, against 568 in Group XIV., Division *a*, of which the Sun is a typical star. Nearly all the lines of the preceding group are included, and their general intensity is increased. The relative intensity of the lines of this group, however, differs a little from that of the preceding; so that, while the triple line b, the lines 4063.7, 4143.9, and others, show a very marked increase, other lines have less intensity than in Group XIV.

3. The K line in this group has the maximum intensity found in Division *a*. It is estimated as about twelve tenths that of its intensity in the Sun. The line H has about eight tenths this intensity, which appears to be a little less than in the following group.

4. The contrast in the brightness of the portions of the spectrum separated by the band 4307 is greater than in the preceding group, but not nearly so marked as in the group following. The portion of greater wave length is rendered more intense by the three apparently bright bands, 4315 to 4368, 4470 to 4525, and 4614 to 4648, approximately, and by a diffused brightness extending from the G band to the line Hβ.

The portion of shorter wave length is rendered faint by general absorption, which is most visible between wave lengths 4144 and 4216, and between 4055 and 4078. This faintness in the violet is interrupted by a distinct bright region between wave lengths 4078 and 4096.

A sudden diminution in brightness occurring at wave length 3889 renders all rays of shorter wave length faint.

5. The narrow bright bands 5436.8 to 5445.2 and 5156.0 to 5167.6, which in stars of the third type form the borders of absorption bands, are clearly seen. These are faintly visible in the Sun. The stars of this group appear to fall into two

divisions, exhibiting a slight difference in the degree of general absorption in the violet region. Of these divisions α Boötis and α Cassiopeiæ are respectively typical. In the first, the general absorption is slight; in the second, it is more conspicuous, both in the regions of the violet above mentioned and beyond wave length 3889, where the photographic spectrum generally appears to be suddenly cut off. In the latter class of stars, also, the spectrum between lines 4215.7 and 4227.0 generally appears brighter. Frequently also the lines 4227.0 (except in α Cassiopeiæ), 4215.7, and the compound line 4076.8 to 4077.9 seem stronger, but this difference may be due to accidental photographic conditions. The degree of absorption indicated also varies in photographs of different density, so that while there seems to be sufficient ground for believing that the distinction is a real one, there is more or less liability to error in assigning individual stars to one or the other division.

Aside from these slight variations and from such as approach the preceding or the following group, the stars of this group have spectra which under the present dispersion are indistinguishable. This identity of the spectra is the more remarkable when we consider the number of stars included in this group, and the number of lines shown in their spectra. One hundred and eleven stars, out of the six hundred and eighty-one which were examined, fall in this group. Of these about twenty have been well photographed with two prisms, and show more than two hundred and thirty lines of exactly the same intensity as those shown in the similar plates of α Boötis. Several of these stars have been successfully photographed with four prisms, and give more than three hundred lines, none of which are distinguishable from those of the typical stars. The remaining stars are photographed with one prism, but as all the compound lines which crowd these spectra have the same intensity as those in the similar photographs of the typical stars, it is altogether probable that no disagreement would be found in photographs taken with more prisms.

Stars intermediate between Groups XV. and XVI.

Typical stars, β Cancri and α Hydræ.

The general absorption in the violet is greater than in Group XV., and the contrast between the portions of the spectrum separated by the band 4307 is very great. The rays having wave lengths shorter than 3970 are faint and difficult to photograph.

The line 4227.0 is stronger than in stars of Group XV.

Group XVI. K5

I. Typical star, α Tauri.

II. Distinguishing features of the group.

1. The line 4227.0 has three or four times the intensity of 4383.7 to 4385.2. It is now the most conspicuous band in the spectrum excepting those of calcium. From its greatly increased width in this group, it would appear to be complex, and to include lines weak or absent in stars of the solar type.

2. The G band 4307 is no longer continuous, but, owing to the disappearance of 4311.7 and numerous fine lines which formed a connecting haze, it is broken into two distinct portions. Of the lines now composing it, 4299.2, 4300.8, 4302.6, 4305.8, 4308.0, 4309.5, 4313.0, and 4314.3 to 4315.2, all but the fifth and seventh have greater intensity than in α Boötis and the Sun.

3. The absorption bands seen in the green portion of spectra of the third type are absent, and the diffused brightness in the blue extends from the band 4307 to Hβ, and beyond. The bright bands 5156.0 to 5167.6, and 5436.8 to 5445.2, which border two of the absorption bands, however, are strongly marked.

III. Further description.

1. The lines of hydrogen are but little weaker than in the preceding group. They have seven or eight hundredths their maximum intensity as seen in α Canis Majoris.

2. The solar lines include all those of the preceding group, and nearly all of the following group. The intensity of these lines in the region of wave length shorter than 4860 is, in general, so nearly the same as in α Boötis that separate estimates have not been made. The principal differences observed, however, are enumerated on page 41. α Orionis of Group XVIII. has been used for comparison, since estimates of the intensities of its lines are given in Table V. Most of the lines between 4860 and 5900 also resemble in intensity those of α Boötis. The triple line b, however, the compound line 5204.8 to 5206.2, line 5208.7, and some other lines in this region, are stronger than in α Boötis. The general intensity of the lines of α Tauri in both regions is somewhat greater than in α Boötis.

3. Of the calcium lines, K is probably the same as in the preceding group, while the intensity of H may be somewhat greater.

4. The contrast in the brightness of the portions of the spectrum separated by the band 4307 is at a maximum in this group. In the portion of greater wave length, the bands 4315 to 4368, 4470 to 4525, and 4614 to 4648 are very strong, and numerous narrower bright bands appear. As these latter vary under different dispersions, and are perhaps merely due to the bright background, in absence of lines,

they have not been further studied. They are, for the most part, faintly visible in the Sun. The diffused brightness above mentioned renders this portion of the spectrum still more intense.

In the violet the absorption is more marked and more extensive than in the preceding group. It covers almost uniformly the portion of the spectrum having wave length shorter than the band 4307, except where interrupted by the bright region 4078 to 4096. The portion of the spectrum having wave length shorter than 3970 is faint and difficult to photograph.

There is no evidence of variation among the stars of this group, except such as constitutes an advance toward the group following. Five out of the twenty-three stars contained in the group have been photographed with either two or four prisms, so that they would show from two to three hundred lines, and all these show entire agreement. In four, the spectrum between Hβ and D has been photographed with the same result.

The star α Tauri, chosen as typical because the brightest star of the group, in reality approaches the group following, as a slight diminution in brightness occurs at 4762 and another at 4954, thus showing the incipient absorption bands of the third type.

Differences observed in the Solar Lines of α Tauri as compared with α Boötis.

Among the lines of α Tauri which have greater intensity than in α Boötis, and approach the intensity shown in α Orionis, the following have been noted: 4027.2, 4030.8, 4034.6, 4072.7, 4077.9, 4081.2, 4082.4, 4083.8, 4090.2, 4096.2, 4110.0, 4115.3, 4116.8, 4121.8, 4140.3, 4159.2, 4165.6, 4169.8, 4175.1, 4187.6, 4191.8, 4206.9, 4251.0, 4271.7, 4275.0, 4289.9, 4291.2 to 4292.2, 4305.8, 4309.5, 4326.0, 4337.6, 4405.0, and 4408.5.

The following appear to be stronger in α Tauri than in either α Boötis or α Orionis: 4044.0, 4047.4, 4112.0, 4152.2, and 4227.0.

Line 4044.7, not certainly present in the other stars, appears in α Tauri to be certainly included in the band whose centre is at 4045.9.

Line 4196.8 is weaker than in α Boötis, and perhaps weaker than in α Orionis. Line 4154.9 is probably weaker than in either star.

GROUP XVII.

I. Typical star, β Andromedæ.

II. Distinguishing features of the group.

1. The absorption bands having their edges of shorter wave length at 4762, 4954, and 5168, respectively, are clearly shown. They are not, however, as well marked as in the next group. The diffused brightness extending, in stars of the preceding group, from the band 4307 to Hβ is still seen overlapping the first mentioned absorption band; so that the latter is divided into halves of unequal intensity. These phenomena are best observed in plates taken with one prism.

2. The bright band 4556 to 4586, not entirely absent from the preceding group, is here clearly seen. It is as yet, however, weaker than any of the bands 4315 to 4368, 4470 to 4525, or 4614 to 4648.

III. Further description.

1. The lines of hydrogen and those of calcium have probably the same intensity as in the preceding group, the former being seven or eight hundredths as strong as the hydrogen lines of α Canis Majoris, the latter in the case of K and H respectively about twelve tenths and fourteen tenths as strong as the corresponding bands of the Sun.

2. The solar lines are those of α Orionis of the following group, and their intensity is intermediate between the intensities shown in that star and in α Tauri of the preceding group.

3. The contrast in brightness in the portions of the spectrum separated by the band whose centre is at 4307, the intensity of the apparent bright bands in the blue and elsewhere, the intensity of the compound line at 4227.0, and other features of these spectra, are nearly the same as in the preceding group.

No variation has been observed in stars of this group except such as consists in approximation toward the group following or the one preceding.

Group XVIII.

I. Typical stars, α Orionis and η Geminorum.

II. Distinguishing features of the group.

1. The four absorption bands having their edges of shorter wave length at 4762, 4954, 5168, and 5445, respectively, are all distinct, and the first three are strong. The diffused brightness extending from the G band now terminates at the edge of the first absorption band.

2. The bright band 4556 to 4586 is stronger than the band 4470 to 4525, but not so strong as the band 4614 to 4648.

III. Further description.

1. The hydrogen lines may vary to some degree in different stars of the group.

Their intensity is probably six or seven hundredths that of the hydrogen lines of α Canis Majoris. In α Orionis they are considerably stronger than in the remaining stars.

2. Three hundred and seven lines have been found between Hϵ and Hβ, and one hundred and fifty-six between Hβ and D. This makes in all four hundred and sixty-three lines, most of which are complex bands containing innumerable lines. With but few exceptions, all the lines of Group XV. are included, and probably also those of the intervening groups. The general intensity of the lines between Hϵ and Hβ is greater in this group than in Group XV. The sum of the estimated intensities between Hϵ and Hβ is 860 against 712 in that group. The intensity of the lines between Hβ and D does not appear to be greater, according to the estimates given in Table VI.; but these are probably too low, owing to faintness caused by the absorption bands. At all events, the triple line b, and other neighboring lines, are very strong.

3. The calcium bands are probably narrower than in the three preceding groups. They are only seen with difficulty in the photographs, owing to the faintness of the continuous spectrum.

4. The line 4227.0, as in Group XVI. and all the groups of the third type, is the most conspicuous band excepting those of calcium. It appears to be nearly as strong as in the two preceding groups, but varies in different stars.

5. The band 4307, as in Group XVI. and all the groups of the third type, appears divided into two parts, owing to the disappearance of central lines. The lines which remain, except 4308.0 and 4313.0, are stronger than in the preceding groups, yet are no longer conspicuous owing to the greater intensity of neighboring lines.

6. The contrast in the brightness of the portions of the spectrum separated by the band 4307 is marked. It is, however, not so strong as in the two preceding groups, owing to a diminution in the brightness of the bands 4315 to 4368 and 4470 to 4525. The diffused brightness is still marked between the band 4307 and the first absorption band at 4762. The absorption in the violet, except where interrupted by the brighter region 4078 to 4096 and a similar fainter one, is now uniform over the region between the band 4307 and Hϵ. Beyond this point the photographic spectrum is only seen with difficulty, owing to its faintness.

7. Of the four absorption bands mentioned at the beginning of the description of Group XVIII., the first three fade gradually in the direction of greater wave length, and appear each to extend nearly to the bright border of the succeeding band. The fourth is broken by a bright region extending from 5515 to 5587. They are all bordered by distinct bright bands, having wave lengths 4750 to

4762, 4949 to 4954, 5156 to 5168, and 5437 to 5445, respectively. Of these borders, the last two are very strong and well defined, the first two weaker and somewhat indefinite.

Stars of this group appear to vary only in the intensity of the hydrogen lines and of the line 4227.0.

α Orionis is not typical in either of these respects, having the lines of hydrogen about twice as strong as the average of the stars of the group, and the line 4227.0 hardly more than one third as strong. The degree of variation from the mean is much less in the case of the remaining stars.

Group XIX.

I. Typical star, ρ Persei.

II. Distinguishing features of the group.

1. The bright band having wave length 4556 to 4586 is stronger than the band 4614 to 4648. This last appears narrower than in the preceding group. These two are now the only conspicuous bright bands in the blue, the other two having almost entirely faded away.

2. The contrast in the light intensities of the portions of the spectrum separated by the band 4307 is slight, but still clearly evident. A diffused brightness still appears between the band 4307 and the edge of the absorption band 4762.

3. The four absorption bands having their edges of shorter wave length at 4762, 4954, 5168, and 5445, respectively, are very clearly marked, and stronger than in the preceding group. The bright borders mentioned as occurring in spectra of Group XVIII. are also stronger.

Traces of a new absorption band are thought to be visible, 4586 being probably the edge of shorter wave length.

III. Further description.

In this and the following group, lines are giving place to bands and flutings. The solar lines show a diminution in number and intensity, which is slight in this group, but unmistakable in the next. This is true in all parts of the spectrum, but more especially in the region covered by the absorption bands. That the lines really give place to the bands, and are not merely rendered invisible by them, is shown by the absence of lines in places where the absorption bands fade away. This is best seen in the case of the two bands having their edges of shorter wave length at 4762 and 4954, respectively.

Except in regard to this slight diminution, the solar lines are nearly the same as in the preceding group.

The lines of hydrogen and calcium and the line 4227.0 are probably of about the same intensity as in the preceding group. The now divided band at 4307 is still less conspicuous.

Stars intermediate between Groups XIX. and XX.

Several stars, like α Herculis, appear to lie between Groups XIX. and XX. In these stars, the contrast between the brightness of the portions of the spectrum divided by the band at 4307 is slight or inappreciable. The flutings, also, are more marked, the lines are weaker, the band 4614 to 4648 is narrower, and the bands 4315 to 4368 and 4470 to 4525 are absent.

The stars g Herculis and BD. +44° 3877 show an even distribution of light from the edge of the absorption band 4762 to the line Hε. They should, therefore, really be classed in a separate group, and have not been included in Group XX. only because all stars of that group studied in this investigation have the hydrogen lines reversed. Besides this the dark lines in their spectra are not certainly known to be identical with those of the above stars.

The star BD. +44° 3877 shows distinctly the absorption band at 4586.

Group XX.

I. Typical star, o Ceti.

II. Distinguishing features of the group.

1. The distribution of light is sensibly uniform from 4762 to Hε, and the photographic spectrum extends into the ultra-violet.

2. The entire portion of the spectrum having wave length greater than 4420 assumes a more or less fluted character. The primary absorption bands appear to break up into secondary ones, which also as a rule fade in the direction of greater wave length, and have the same tendency to recur at regular distances.

3. The lines of hydrogen are bright. Hγ, Hδ, Hζ, Hη, Hθ, Hι, and frequently Hκ, Hλ, Hμ, and Hν are seen. The bright Hβ may or may not be present; the line Hε is never seen bright, owing possibly to the superposed calcium band. The intensity is greatest in Hδ and declines in either direction, except that Hν is next to Hι in brightness. The reversal of the hydrogen lines is complete; no accompanying dark lines are shown. Compare the bright-lined stars of the Orion type, in which Hβ is brightest and the reversal is always incomplete.

III. Further description.

1. Absorption lines, if present in the portion of the spectrum having greater wave length, are for the most part indistinguishable among the bands and flutings. In the region of shorter wave length, lines are found agreeing in general with those of α Herculis, but less numerous and of less intensity.

2. The calcium lines and the line 4227.0 are about the same as in the preceding group; the divided band 4307 is even more insignificant than in that group.

3. The four absorption bands having their edges of shorter wave length at 4762, 4954, 5168, and 5445, respectively, are all very clear and strongly defined, and the bright borders described on page 43 under Group XVIII. are stronger than in the preceding groups. There is probably a new band having its edge of shorter wave length at 4586, and bordered by the bright band at 4556 to 4586. It is possible that the appearance of this new band may be merely due to a collection of flutings, although it appears quite distinctly in some stars.

4. Of the bright bands seen in the blue region of the spectra in preceding groups 4556 to 4586 and 4614 to 4648 alone remain. The first is narrow and inconspicuous.

Several new bands of slightly increased brilliancy are present, the one which is commonly strongest and most clearly defined having wave length 4408 to 4423 approximately. These are faintly visible in α Herculis.

5. A slight increase in brightness is sometimes seen at about the region 4100. This may vary with the changes in the magnitude of these stars.

Peculiar Stars of Group XX.

The stars χ Cygni and T Cephei, which are long-period variables having bright hydrogen lines, show a variation from the foregoing description of stars of this group. In these stars the maximum brightness is in the region of the bright bands in the blue 4556 to 4586 and 4614 to 4648. This is chiefly owing to the greater brilliancy of the bands themselves, but the absorption in the violet is probably greater than in o Ceti.

These stars should perhaps form another group. In distribution of light they might be thought to approach the preceding group, but their dark lines differ more from those of that group than do the lines of o Ceti, and they are therefore clearly not intermediate.

χ Cygni has the bright $H\beta$ well marked.

Group XXI. — Fourth Type Stars.

I. Typical stars, 19 Piscium, and BD. +38° 1539.

II. Distinguishing features of the group.

A very wide band of complete absorption is seen in the photographic spectrum, its edge of greater wave length being probably at or near 4862. This band is abrupt and bright bordered on the edge of greater wave length, and fades somewhat gradually on the other side.

III. Further description.

1. In photographs stained with erythrosin a similar absorption band is shown about midway between the first band and the region of the line D. In one photograph this band also is shown to be abrupt on the edge of greater wave length; the remaining plates are too faint to show whether this is true or not. The band however appears in all cases to fade gradually toward the violet.

2. A strong line is seen, probably in the neighborhood of D. Seven or eight other lines are visible at this end of the spectrum, and a few others elsewhere. These lines have not yet been identified with those of other classes of stars, owing to the total dissimilarity of the spectra.

Group XXII. — Fifth Type Stars.

I. Typical star, H. P. 1311, in Canis Major.

II. Distinguishing features of the group.

Wide bright bands are shown on a faint continuous spectrum, most of these bands apparently agreeing with lines of hydrogen and prominent Orion lines. The strongest one, however, 4688, is a band which is probably present also in the spectra of gaseous nebulæ.

III. Further description.

Twelve bright bands were seen in H. P. 1311. In the three remaining stars of the fifth type which have been photographed with the same dispersion, the strongest bands only were visible, owing perhaps to the faintness of the stars.

The agreement of the principal bright bands of these stars with lines of hydrogen and Orion lines was first found at this Observatory in a study of the plates taken with the 8-inch telescope, and was brought to notice in an article entitled "A Fifth Type of Stellar Spectra," in the Astronomische Nachrichten, Vol. 127, p. 1. The photographs taken with the 11-inch telescope confirm the agreement, both by superposition on similar photographs of stars of the Orion type, and by means of micrometric measures.

Table III. gives, in the first column, the names of the hydrogen lines; in the second column, the wave length of these lines and of such of the Orion lines as have been identified with those seen in the spectrum of H. P. 1311; in the third, the wave length of the bands of H. P. 1311 as taken from a curve giving the relation between the micrometric measures of the bands of H. P. 1311, and the true wave lengths; in the fourth, the wave lengths of the same bright bands as obtained by Campbell and given in Frost's translation of Scheiner's Astronomical Spectroscopy, p. 274; in the fifth, the roughly estimated intensity of the bands; and in the last column, their approximate limiting wave lengths.

TABLE III.

BRIGHT BANDS OF H. P. 1311.

Des.	Standard.	Curve.	Campbell.	Intensity.	Limits.
Hζ	3889	3889	....	1	3878–3895
..	3926	3926	....	1	3923–3940
Hε	3970	3970	....	1	3965–3986
..	4026	4026	....	1	4015–4035
..	....	4059	....	4	4046–4072
Hδ	4102	4102	....	5	4088–4121
..	4200	4200	....	3	4190–4213
Hγ	4341	4340	4342	3	4325–4357
..	4543	4544	4544	2	4530–4563
..	....	4614	4614	2	4596–4630
..	4685	4688	4688	10	4671–4707
Hβ	4862	4862	4862	1	4849–4874

COMPOSITE SPECTRA.

Examples, ζ Aurigæ and δ Sagittæ.

Spectra of this class unite the characteristics of groups more or less widely separated in the series.

In most cases a well defined spectrum of the second or third type is combined with the strong hydrogen spectrum characteristic of the first type. Other combinations, however, occur in which the spectra are not so widely different.

In ζ Aurigæ a spectrum like that of α Boötis appears in combination with one of the Orion type; in δ Sagittæ, a spectrum of the third type, showing clearly the characteristic absorption bands in the region between 4762 and 5900, is combined with the strong hydrogen spectrum belonging to the first type.

In the single case of *o* Andromedæ, a spectrum of the Orion type was found united with one of the first type belonging to Division *c*.

The hypothesis already proposed at this Observatory, that stars having these anomalous spectra may be double, appears to explain all the principal facts observed.

Thus, when strong hydrogen lines occur in the spectrum of a star of the second or third type, the K line is invariably narrow or obscure. When the hydrogen lines are very strong, as though belonging to a star of the first type, like α Canis Majoris, the K line appears as a clouded band, having sometimes a fine central line. When the hydrogen lines have the moderate intensity seen in stars intermediate between the first and second types, the K line appears more or less narrow, with haze beyond the edges. Moreover, when the hydrogen lines are very strong, most of the solar lines characteristic of the second type disappear from the ultra-violet, while from Hδ to Hβ they are strongly marked. The predominance of the second type in the blue, and of the first type in the violet, is exactly what would be anticipated, especially if the star of the first type were the fainter, as is usually the case in known doubles.

This explanation is borne out by the well known tendency of binaries to exhibit contrasting types, and still further by the fact that one third of the anomalous stars thus independently grouped proved to be known doubles.

A means may thus be furnished of detecting close binaries when the types of the components differ.

It is interesting to observe that in all these stars but one, *o* Andromedæ, the spectrum of the earlier type was the fainter.

It was generally easy to determine in these composite spectra, the group to which the primary spectrum belonged. That of the secondary spectrum was generally uncertain, owing to the fact that the hydrogen lines are narrowed by superposition on the bright continuous spectrum of the other star, while the K line is widened by superposition on the wider K band.

A list of stars of composite spectra is given in Table X. The groups of the primary spectra and the types of the secondary spectra are there indicated.

Stars of Orion Type having Bright Lines.

Examples, γ Cassiopeiæ and 11 Monocerotis.

These spectra generally resemble those of the normal Orion groups, but have lines of hydrogen and prominent Orion lines partly or wholly bright. In the case of a few of the stars, as γ Cassiopeiæ and ϕ Persei, the resemblance to any particular group of Orion type stars is not close.

In the hydrogen spectrum of these stars, the bright lines are as a rule either centrally superposed upon, or adjacent to, the dark lines; that is, half the line is reversed. When they are centrally superposed, as in the case of γ Cassiopeiæ, there is commonly a double reversal; the bright bands lying upon wider dark ones, and being themselves centrally crossed by fine dark lines. In all such cases the brightness attains its maximum in the line Hβ, and decreases with each successive hydrogen line of shorter wave length.

The phenomena are very complex, and each case is discussed in the Remarks on Individual Stars. A list of the stars of this class is given in Table XI., the Orion group which they most closely resemble being indicated.

CHAPTER III.

The Orion Lines.

Table IV. contains the results of the investigations made with regard to the Orion lines in the spectra of stars belonging to the first seven groups of the series described in Chapter I. Besides the Orion lines properly so called, the lines of hydrogen and calcium occurring in that portion of the spectrum to which the investigation related are included in Table IV., in the first column of which their designations are given. The second column contains the wave lengths of all the lines. The unit is the ten-millionth of a millimeter. Approximate wave lengths are indicated by the omission of the tenths of a unit. The third column contains six places for residuals, which correspond to six different methods of determining the wave lengths given in the previous column. A residual printed in Italics is to be regarded as negative, and corresponds to a measurement which gave a shorter wave length than that adopted in the second column. Both the positive and the negative residuals are given in terms of the last place in the adopted wave lengths; that is, in hundred-millionths of a millimeter. Instead of a residual, the letter A frequently occurs. When it stands in the first of the six places, it denotes that the adopted wave length was obtained from previously published measurements made by trustworthy authorities. Any numerical residuals which may occur in subsequent places then indicate the variations of the measurements made here from this accepted value, not from their own mean. The letter A, in any except the first place, signifies that the method of measurement corresponding to the place where the letter stands was the only method available for determining the wave length given in the second column. In such cases, therefore, the remaining places contain neither letters nor figures.

The residuals given in the second place result from measurements made with the scale divided to hundredths, and estimated to thousandths, of an inch. About thirty photographs of the spectra of seven stars, β Canis Majoris, β Orionis, γ Orionis, δ Orionis, ϵ Orionis, ζ Orionis, and κ Orionis, were measured in this manner, and the residuals given in the second place relate to the mean of all these measurements. In seven cases, however, those of the lines whose wave lengths are given as 3728.1, 3779.5, 3784.6, 3790.9, 3805.1, 3876.4, and 3881.7, the results were obtained by interpolation between the wave lengths previously found for adjacent lines.

The residuals given in the third place result from the study of photographs of the spectra of β Persei and β Orionis. In these photographs, the relative positions of lines were repeatedly estimated with respect to other lines of known wave length, on each side of the lines the wave lengths of which were to be determined. This method enables some faint lines to be measured, which would escape observation under the microscope. The two stars above mentioned were chosen to serve as a basis for the estimates, because their spectra contain many known lines of the solar spectrum, although they do not appear in Table IV. Of the two stars, the solar lines are more prominent in the spectrum of β Persei, and the Orion lines in that of β Orionis, as appears above in the general description of Group VI., page 21.

The residuals given in the fourth and fifth places respectively express the results of measurements made with the dividing engine mentioned on page 2, and reduced, as there described, on photographs of the spectra of β Persei and β Orionis. The plates used for these measurements were, for β Persei, C 1050, taken February 6, 1888, with an exposure of 86^m, and twice measured; C 1060 and C 1061, both taken on February 9, 1888, with exposures of 87^m and 108^m respectively; for β Orionis, C 399, taken March 8, 1887, with an exposure of 72^m, and measured three times; C 415, taken March 25, 1887, with an exposure of 79^m, and measured three times; and C 1492, taken October 29, 1888, with an exposure of 119^m, and twice measured.

The residuals given in the sixth place result from three additional measurements of plate C 1492, representing the spectrum of β Orionis, as just stated. This plate had been exposed for 119 minutes, and the brighter portions of the spectrum were over exposed, so that only the more marked lines were visible, while in the ultra-violet portion even the fainter lines were well shown. Residuals in this sixth place accordingly appear only for lines of wave length shorter than 4036.0.

The fourth column of Table IV. gives in its five successive numbers the result of estimates of the relative intensity of the lines seen in typical spectra of Division *a* of Groups II., III., IV., V., and VI., respectively. As Group I. contains only stars of Division *b*, it is not represented in this column. Almost all the estimates were made upon an arbitrary scale, the number 1 representing the faintest lines, the interrogation point a doubtful trace of a line, and the figure 0 the absence of the line in the photographs examined. The omission of any symbol signifies that the image was too faint to enable any conclusion to be reached with regard to the presence or absence of a line. In the case of the very strong lines, as comparison of these with the faint lines is liable to great uncertainty, the numbers have been so chosen as to preserve the true relation of the strong lines to one another in the successive groups. As shown below, the dispersion employed in taking the photographs was not always the same, and allowance was made in the estimates for this circumstance.

In all the groups the estimates for lines having wave lengths less than 3889 were derived from spectra photographed by means of one or two prisms only, since in them the lines were most distinct in the ultra-violet region. But in that region, beyond the line $H\theta$, the variation in focus makes the estimates for the hydrogen lines rather doubtful. For greater wave lengths, plates photographed with four prisms were preferred, and in the case of Group II., ϵ and κ Orionis were the stars from the spectra of which the estimates were derived, the mean of the two estimates being employed when they differed. In the other groups, β Canis Majoris was the star taken to represent Group III., γ Orionis was that representing Group IV., η Tauri and ζ Draconis those representing Group V., and β Persei that representing Group VI. Except the two stars representing Group V., these were all photographed with four prisms.

The fifth column of Table IV. indicates by means of dots the presence of the successive lines in Division *b*, Groups I. to VI. inclusive. No estimates of the relative intensity of these lines were made. The absence of any one of the six dots in the column indicates the absence of a given line in the corresponding group. For Group I., the stars chiefly studied were ι and λ Orionis, S Monocerotis, and ξ Persei; for Group II., δ and ζ Orionis; for Group III., α Virginis; for Group IV., η Ursæ Majoris and λ Tauri; for Group V., τ Orionis; and for Group VI., α Leonis. The photographs used for Groups I. and V. had been taken with one or two prisms, the remainder with four.

The sixth column of Table IV. relates to spectra belonging to Division *c*, in five successive groups: III., V., VI., the group intermediate between VI. and VII., and finally Group VII. The presence or absence of lines is shown by dots, as in the fifth column. No stars belonging to Division *c* were found in other Orion groups than those just named. For Group III. the star employed was χ^2 Orionis; for Group V., chiefly η Canis Majoris; for Group VI., β Orionis; for Group VI.–VII., chiefly H. P. 551 and 4 Lacertæ; and for Group VII., η Leonis. Of these χ^2 Orionis was photographed with one prism, and the remainder with two, except η Canis Majoris and β Orionis, which were photographed with four prisms.

TABLE IV.

WAVE LENGTH, INTENSITY, AND DISTRIBUTION OF ORION LINES.

Des.	λ	Residuals.	Div. *a*.	Div. *b*.	Div. *c*.	Des.	λ	Residuals.	Div. *a*.	Div. *b*.	Div. *c*.
	3584.	. . . . . .	6 6				3975.2	A	1 1 ? 0 0		
	3634.	. . . . . .	6 6 0				3982.8	A	1 1 ? 0 0	.	.
Hσ	3683.5	A			.		3994.9	*2* . . . 2	1 2 2 0 0	.	. . .
Hρ	3686.7	A			.		4009.5	. 0 . . . 0	2 6 7 3 1	. . . . .	. . . .
Hπ	3691.5	A			.		4026.4	. *4* 5 1 *1* *1*	10 12 12 6 5	. . . . . .	. . . . .
Ho	3697.4	A	0 0 0 15 15		. . .		4036.0	. A	0 0 1 0 0		.
Hξ	3704.0	A	13 20 25 20 20	. . . . . .	. . . . .		4042.2	. A	1 1 ? 0 0		
Hν	3711.8	A	10 10 20 30 30	. . . . . .	. . . . .		4069.4	. A	1 2 1 0 0	. . .	. .
Hμ	3721.9	A	12 15 30 50 55	. . . . . .	. . . . .		4072.0	. A	1 1 1 0 0	.	.
	3728.1	. A	3 0 0 0 0				4075.9	. A	1 2 1 0 0	. . .	. . .
Hλ	3734.2	A	13 25 35 60 65	. . . . . .	. . . . .		4084.9	. A	1 1 1 0 0	.	
Hκ	3750.2	A	15 25 35 65 75	. . . . . .	. . . . .		4089.2	. A	10 2 1 0 0	. . .	.
	3760.1	. . . . . A	1 2 0 0 0	. .	.		4093.7	. A	0 1 0 0 0		
Hι	3770.8	A	15 25 35 65 75	. . . . . .	. . . . .		4096.9	. A	3 1 0 0 0	. . .	
	3779.5	. A	1 1 0 0 0			Hδ	4101.8	A 0	15 25 35 65 75	. . . . . .	. . . . .
	3784.6	. A	1 1 1 0 0	.	. .		4111.2	. A	0 1 1 0 0	.	
	3790.9	. A	1 1 0 0 0	.			4116.2	. A	6 1 0 0 0	. .	.
Hθ	3798.1	A 5	15 25 35 65 75	. . . . . .	. . . . .		4120.5	. A	3 7 4 2 2	. . . . .	. . . . .
	3805.1	. A	1 2 3 0 0	.	. . .		4128.5	. 3 1 1 *4* .	0 ? 1 3 3	. . .	. . . .
	3812.4	. . . . . A	1 0 0 0 0		.		4131.4	. 1 *2* 6 *4* .	0 0 1 3	. . .	. . . .
	3819.2	. . . . . A	10 13 13 6 3	. . . . . .	. . . . .		4134.0	. A	1 1 ? 0 0	.	.
Hη	3835.5	A *5*	15 25 35 65 75	. . . . . .	. . . . .		4144.0	. 0 *1* . . .	3 7 8 4 2	. . . . . .	. . . . .
	3850.	. . . . . .	1 1	.			4152.	. . . . . .	0 0 1 0 0		
	3854.2	. . 5 . . *6*	0 0 0 1 1		.		4154.7	. A	1 1 1 0 0	. . . .	. . .
	3856.2	. . 3 . . *3*	0 1 1 3 3	. . . .	. . . . .		4169.2	. A	0 1 2 0 0	. .	. .
	3863.2	. . 7 . . *8*	0 0 0 2 2		. . . .		4186.2	. A	1 0 0 0 0	. .	
	3864.	. . . . . .	0 1 ? 0 0				4200.3	. A	1 0 0 0 0	. .	
	3867.6	. . . . . A	1 1 2 1 1	. . . .	. . .		4224.8	. A	0 0 1 0 0		
	3872.4	. . 3 . . *2*	0 1 2 1 1	. .	. .		4237.4	. A	0 1 1 0 0		?.
	3876.4	. A	0 1 1 0 0				4242.6	. A	? 1 1 0 0		?.
	3881.7	. A	1 1 0 0 0				4254.1	. A	2 2 1 0 0	. .	?
Hζ	3889.1	A 0 . . . 1	15 25 25 65 75	. . . . . .	. . . . .		4267.4	. *1* 2 *1* . .	1 2 3 2 1	. . .	?. . .
	3912.2	. A	1 1 1 0 0	.			4276.7	. A	1 1 1 0 0	. .	
	3920.6	. *5* . . . 5	1 1 2 0 0		.		4285.1	. A	1 1 1 0 0	.	
	3925.9	. A	0 1 2 1 0	. . . .	. . .		4304.4	. A	1 1 1 0 0	.	.
	3927.1	. A	1 1 4 2 0	. . . .	. . .		4318.0	. A	1 1 1 0 0	.	.
K	3933.8	A 0 . . . 0	2 1 3 4 6	. . . . . .	. . . . .		4320.7	. A	1 1 1 0 0	.	. .
	3947.8	. A	1 1 1 0 0	.			4327.3	. A	1 1 0 0 0		
	3954.8	. A	1 1 1 0 0	.			4334.5	. A	0 1 0 0 0		
	3962.	. . . . . .	1 0 0 0 0			Hγ	4340.7	A 3	15 25 35 65 75	. . . . . .	. . . . .
	3964.6	. *3* . . . 4	2 3 4 0 0	.	. . .		4346.	. . . . . .	1 0 0 0 0		
H	3968.6	. . . . . .	0 0 0 0		?. . . .		4350.1	. A	2 1 1 0 0	. .	.
Hε	3970.2	A *3* . . . 0	15 25 35 65 80	. . . . . .	. . . . .		4361.0	. A	0 1 0 0 0		

Des.	λ	Residuals.	Div. *a*.	Div. *b*.	Div. *c*.	Des.	λ	Residuals.	Div. *a*.	Div. *b*.	Div. *c*.
	4367.3	. A	1 1 1 0 0	. . .			4591.6	. A	1 1 ? 0 0	.	
	4373.2	. A	0 1 1 0 0				4598.2	. A	1 1 0 0 0	.	
	4380.1	. A	1 0 0 0 0	. .			4603.7	. A	0 0 1 0 0		
	4387.8	. 0 *8* 0 9 .	3 7 8 4 1	. . . . . .	. . . .		4611.2	. A	? 1 0 0 0		
	4395.7	. A	0 1 ? 0 0	.			4619.8	. A	0 1 1 0 0	.	
	4415.1	. A	1 1 1 0 0	.			4630.6	. A	1 1 1 0 0	.	.
	4417.5	. A	1 1 ? 0 0	.	. .		4641.1	. A	2 2 1 0 0	.	.
	4437.9	. A	0 1 2 0 0	.	. . .		4649.2	. A	12 7 2 0 0	. . .	. .
	4447.7	. A	0 0 1 0 0		. .		4661.7	. A	2 2 1 0 0	.	
	4471.8	A 0 1 6 5 .	10 11 12 5 4	. . . . . .	. . . . .		4675.3	. A	1 1 1 0 0	. .	.
	4481.4	A 4	1 1 2 3 4	. . . . .	. . . .		4685.4	. A	2 0 0 0 0	. . .	
	4490.6	. A	1 0 ? 0 0				4697.9	. A	1 1 0 0 0	.	
	4514.5	. A	0 ? 1 0 0	.			4705.0	. A	1 1 0 0 0		
	4531.4	. A	0 1 1 0 0	.	.		4712.8	. A	2 2 2 1 1	. . . . .	. . .
	4542.7	. A	1 0 0 0 0	. .		Hβ	4861.5	A *1*	15 25 35 65 75	. . . . . .	. . . . .
	4553.4	. 0 0 . . .	2 3 2 1 0	. .	. .		4925.7	. A	4 6 6 3 1	. . . . . .	. . . .
	4568.6	. A	2 2 2 0 0	. .	. . .		5023.	. . . .	1 1 1 1	. .	. . . .
	4576.5	. A	1 1 1 0 0	.	. . .						

REMARKS.

3805.1. In Group II. this line is probably combined with one having greater wave length.

3856.2. In stars of Group II. an indistinct line having greater wave length appears. This may be due to the presence of a second line.

3920.6 and 3925.9. In stars of Division *a*, both these lines are present. Owing to their faintness in stars of Division *b* it was not possible to determine which of the two was present, or whether both were included. In Group I. the line appearing in this region may have a wave length greater than either of the lines named above.

3968.6. Apparently combined with Hε in Group VI., Division *a*. In Group III., Division *c*, its presence was doubtful, owing to insufficient dispersion; but as Hε seemed to have relatively great intensity, and as K was also intense, it is probable that the calcium line H is present in the spectrum.

4009.5. This line is present in some stars of Group VI., Division *a*; for example, in *β* Tauri. It is not found in *β* Persei.

4318.0 and 4320.7. Owing to the low dispersion it is uncertain which of these lines is present in χ^2 Orionis. Probably both are included.

4415.1 and 4417.5. Both these lines appear in stars of Division *a*. It is uncertain which of these lines is present in Division *c*, or whether both are included.

The general comments to be made on the results of Table IV. may be divided into those relating respectively to the three divisions.

Division a. In Groups II. and III., as in Group I., Division *b*, the line Hξ, which in these groups terminates the system of hydrogen lines, has greater intensity than the lines Hμ and Hν, the last named being the faintest. In Group IV., Hξ is stronger than Hν, but fainter than Hμ, and in all following groups of Orion and first type stars the intensity regularly diminishes with decreasing wave length. The line Ho first appears in Group V. The number and intensity of the Orion lines diminish as the series approaches the first type, as appears by inspection of Table IV. Beyond

Group VI. the only Orion lines which commonly persist in stars of Division *a* are 4128.5 and 4131.4. These become fainter and disappear in the first type groups.

The lines 4481.4 and 4144.0 fall within solar bands. The former increases in intensity toward the first type, and reaches its maximum in Group VIII., becoming fainter in the later groups. There is no proof that it may not be one of the components of the solar band. In the case of the line 4144.0, however, there is reason to doubt its real identity with the solar line, owing to its great intensity in Group IV. and its steady diminution to the first type. It will appear from Table V. that the double solar line having its centre at 4143.9, from which the Orion line is indistinguishable, becomes faintest in Group VII. and increases rapidly as far as Group XV. Both components, but especially 4144.0, are strong in the Sun.

While, therefore, the line 4144.0 appearing in spectra of the Orion type may agree with one of these components, it appears to be more safely classed as an Orion line.

Division b. In this division there is a maximum number of Orion lines in Group III. This may be partly due to the fact that in α Virginis, the star of Group III. of which the best photographs have been obtained, the widening of the lines is not great. Hence few faint lines are lost.

It is interesting to note that Group VI., Division *b*, contains the smallest number of lines found in any group of the series.

No solar lines are present in any of these groups of Division *b*. This statement does not apply to the two lines 4144.0 and 4481.4 present in Orion stars generally, and having a real or apparent agreement with solar lines.

In α Virginis of Group III. six lines were found between 4860 and 5900 on a plate stained with erythrosin. Their wave lengths have not been determined, and it is not known whether they are present in any other stars of the Orion type.

Division c. The intensities in the earlier groups do not differ greatly from those in stars of Division *a*, the few marked cases being mentioned in Chapter II., "Detailed Description of the Classification." The lines, however, are sharper, and in general more conspicuous. The most important difference is, that the lines retain their intensity longer than those of Division *a*, many of them persisting and being fairly conspicuous in Group VII.

The maximum number of lines, according to Table IV., should be in Group VI. This, however, probably does not represent the true proportion, since the plates of β Orionis were of exceptionally fine quality, while those of χ^2 Orionis, being somewhat faint and taken with a single prism, show a much smaller number of lines.

A number of metallic lines are present in the stars of Division *c* from Group VI. onward. These are given in Table VII.

CHAPTER IV.

SOLAR LINES BETWEEN 3686 AND 4862.

TABLE V. shows the distribution and roughly estimated intensity of the lines in stars of Division *a* from Group VI. to Group XVIII. These lines include almost all the lines seen in photographs of the solar spectrum taken with the same number of prisms, besides a few others. All the lines are found on Rowland's map of the solar spectrum, some of the faint lines there shown coming out more strongly in stars of Group XV. and the groups following. The lines of hydrogen and calcium are included in the table.

The first column contains the designation of such lines as are known by letters. In the second column are the wave lengths taken from the second edition of Rowland's map of the solar spectrum; the wave lengths of the lines of hydrogen and calcium, however, are taken from a memorandum kindly furnished by Professor Rowland in advance of publication. The third column shows the intensities of the lines as found in β Persei, the typical star of Group VI. The fourth column shows the intensities of the lines as found in α Canis Majoris, the typical star of Group VII. The fifth, sixth, seventh, eighth, and ninth columns, respectively, show the intensities for α Geminorum of Group VIII., α Canis Minoris of Group XII., α Aurigæ of Group XIV., α Boötis of Group XV., and α Orionis of Group XVIII. It is to be regretted that none of the Groups IX., X., or XI. could be represented, since they contain no stars of Division *a* bright enough to be well photographed with four prisms. α Tauri of Group XVI. was omitted, owing to the close resemblance in intensity of nearly all its lines to those of α Boötis.

The intensities given in this table are estimated on an arbitrary scale. The number 1 represents the faintest lines; while in the use of the higher numbers the attempt has been made to express as nearly as possible the changing intensity of each line in the successive typical stars, as well as its relation to the other lines of the same star. An interrogation point indicates that an uncertain trace of a line is present. A zero indicates that a line is absent, or too faint to be visible on a good plate. A dot indicates that the presence or absence of a line is undetermined. This has been used in the region of the ultra-violet, where the faintness of the light renders it difficult to obtain a distinct image under the highest dispersion.

In cases where the lines whose wave lengths are given in the table appeared as a single band, the combined intensity is given, and is placed between the two lines in the table. The combined intensity of a band containing three of these lines is placed opposite the middle line, the absence of the zero opposite the preceding and following lines indicating that the given intensity is that of the three combined. Estimates of combined intensity are generally a little less than the sum of the intensities of the same lines when estimated separately.

An estimate of the intensity of the lines in Rowland's map of the solar spectrum is given in the tenth column. The scale is such that the densest lines were estimated as 5, and the faintest lines as 1. The letter d denotes that the estimated intensity is that of two lines, and g that of a group. Since in these photographs the dispersion diminishes as the wave length increases, it follows that, when the wave length is great, two lines may appear as a single line, although widely separated in the normal spectrum.

The remaining columns of Table V. contain residuals derived as follows. A number of plates, which are named at the tops of the respective columns, were measured with a dividing engine, having two screws at right angles to each other, the pitch of each screw being $\frac{1}{24}$ of an inch. These screws moved a metal plate, on which the photograph was placed, beneath a fixed microscope. The arbitrary readings obtained in this manner for the position of any given line were first reduced by subtracting such a quantity from each that the readings for all the plates agreed at the line Hγ. They were then reduced approximately to wave lengths by means of an empirical table. This reduction enabled each line to be identified with the corresponding line in the solar spectrum as given by Rowland. Residuals were then found by subtracting the values given by Rowland from the corresponding measured values. These residuals were next plotted as points on a chart in which their values were the ordinates, while the abscissas represented wave lengths. A smooth curve was then drawn through these points, and systematic corrections were found from the curve and applied to the measured values in order to reduce them to Rowland's scale. The individual residuals remaining after these corrections, and found, as before, by subtracting the value given by Rowland from the measured value, are those given in Table V., as above stated, negative values being indicated by Italics. The systematic errors having been removed, as just explained, these residuals show the actual deviations, if any, of the lines, combined with the accidental errors of measurement.

All of these lines were also identified independently by direct comparison with a photograph of the solar spectrum taken with the same dispersion, and thus compared with Rowland's map. This identification was checked in detail with the results of the measurements, and all cases of discordance carefully investigated.

TABLE V.

SOLAR LINES.

Desig.	Wave Length.	VI.	VII.	VIII.	XII.	XIV.	XV.	XVIII.	S. S.	470 484	1486 1507	387 493	1086	453 1717	505 634	393 429	401 475	1493 1504
Hρ	3686.7	15	15	.	6	.	.	.	.	....	....	....	..	....	....	....	....	....
Hπ	3691.5	20	20	.	6	.	.	.	.	....	....	....	..	....	....	....	....	....
Ho	3697.4	25	25	.	6	.	.	.	.	....	....	....	..	....	....	....	....	....
Hξ	3704.0	30	30	.	12	.	.	.	.	....	....	....	..	....	....	....	....	....
Hν	3711.8	35	35	.	12	.	.	.	.	....	....	....	..	....	....	....	....	....
Hμ	3721.9	45	45	.	16	.	.	.	.	....	....	....	..	....	....	....	....	....
	3727.5	.	2	.	.	.	.	.	4	....	....	....	..	....	....	....	....	....
Hλ	3734.2	50	50	.	16	.	.	.	.	....	....	....	..	....	....	....	....	....
	3737.1	.	3	.	.	.	.	.	5	....	....	....	..	....	....	....	....	....
	3741.7	.	2	.	.	.	.	.	3	....	....	....	..	....	....	....	....	....
	3743.5	.	2	.	.	.	.	.	4	....	....	....	..	....	....	....	....	....
	3745.8	.	3	.	.	.	.	.	5	....	....	....	..	....	....	....	....	....
Hκ	3750.2	55	55	.	16	.	.	.	.	....	....	....	..	....	....	....	....	....
	3758.2	.	3	.	.	.	.	.	5	....	....	....	..	....	....	....	....	....
	3761.5	.	2	.	.	.	.	.	3	....	....	....	..	....	....	....	....	....
	3764.0	.	2	.	.	.	.	.	4	....	....	....	..	....	....	....	....	....
Hι	3770.8	65	65	60	16	.	.	.	.	....	....	....	..	....	....	....	....	....
	3782.0	.	2	.	.	.	.	.	2 g	....	....	....	..	....	....	....	....	....
	3786.3	.	1	.	.	3	.	.	4 g	....	....	....	..	....	....	....	....	....
	3788.0	.	1	.	.	?	.	.	3	....	....	....	..	....	....	....	....	....
	3790.0	.	1	.	.	2	.	.	3 g	....	....	....	..	....	....	....	....	....
	3795.0	.	1	.	.	2	.	.	4	....	....	....	..	....	....	....	....	....
Hθ	3798.1	65	65	60	16	?	.	.	.	....	....	....	..	....	....	....	....	....
	3798.7	.	0	.	.	3	.	.	4	....	....	....	..	....	....	....	....	....
	3799.8	.	0	.	.		.	.	4	....	....	....	..	....	....	....	....	....
	3802.0	.	?	.	.	2	.	.	3 g	....	....	....	..	....	....	....	....	....
	3807.3	.	1	.	.	3	.	.	3 g	....	....	....	..	....	....	....	....	....
	3813.1	.	2	.	1	3	.	.	3	....	....	....	..	....	....	....	....	....
	3814.9	.	2	.	.	0	.	.	3 d	....	....	....	..	....	....	....	....	....
	3816.0	.	2	.	1	3	.	.	5	....	....	....	..	....	....	....	....	....
	3820.5	3	2	.	3	5	.	.	5	....	....	....	..	....	....	....	....	....
	3822.0	.	1	.	.	0	.	.	3	....	....	....	..	....	....	....	....	....
	3824.6	.	2	.	.	2	.	.	4	....	....	....	..	....	....	....	....	....
	3826.0	.	2	.	.		.	.	5	....	....	....	..	....	....	....	....	....
	3828.0	.	2	.	.	2	.	.	4	....	....	....	..	....	....	....	....	....
	3829.6	.	2	.	.		.	.	4	....	....	....	..	....	....	....	....	....
	3832.5	.	2	.		2	.	.	4	....	....	....	..	....	....	....	....	....
	3834.4	.	0	.		2	.	.	4	....	....	....	..	....	....	....	....	....
Hη	3835.5	65	65	60	25	4	.	.	3 g	....	....	....	..	....	....	....	....	....
	3838.4	.	3	.		.	.	.	4	....	....	....	..	....	....	....	....	....
	3840.8	.	3	.		4	.	.	4 g	....	....	....	..	....	....	....	....	....
	3843.6	.	0	.	1	1	.	.	3 g	....	....	....	..	....	....	....	....	....
	3845.4	.	0	.	1	1	.	.	3 g	....	....	....	..	....	....	. . *0.4*	....	....
	3846.9	.	0	.	1	1	.	.	3	....	....	....	..	....	....	....	....	....
	3850.0	?	3	3	3	6	.	.	4	....	....	....	..	....	....	. . *1.1*	....	....

Desig.	Wave Length.	VI.	VII.	VIII.	XII.	XIV.	XV.	XVIII.	S. S.	470 484	1486 1507	387 493	1086	453 1717	505 634	393 429	401 475	1493 1504
	3852.7	.	0	0	0	2	.	.	3 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . 0.2	. . . .	. . . .
	3854.6	1	2	1	0	2	.	.	3 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . 0.3	. . . .	. . . .
	3856.5	3	4	4	4	5	.	.	4	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . 1.0	. . . .	. . . .
	3858.4	0	0	0	0	3	.	.	3	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . 0.4	. . . .	. . . .
	3860.0	0	1	1	3	5	.	.	5	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . 0.2	. . . .	. . . .
	3861.6	0	0	0	0	4	.	.	4 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . 1.0	. . . .	. . . .
	3863.9	1	2	2	1	1	.	.	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . 0.7	. . . .	. . . .
	3865.7	0	1	1	1	2	.	.	4	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . . .
	3867.2	0	0	0	?	1	.	.	2 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . . .
	3868.4	0	0	0	0		.	.	3 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . 0.1	. . . .	. . . .
	3872.7	0	2	3	3	10	.	.	4	*0.5* 0.0	. . . .	. . . .	. .	. . . .	. . . .	*1.1* 0.9	. . . .	. . . .
	3876.0	0	0	0	2	1	.	.	2 g	. . . .	. . . .	. . . .	. .	. . . .	*1.2* . .	*0.9 0.5*	. . . .	. . . .
	3878.5	0	3	4	10	8	.	.	5	*0.1* 1.0	. . . .	. . . .	. .	. . . .	*0.7* . .	0.9 1.3	. . . .	. . . .
	3880.3	0	0	0	2	1	.	.	2 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . 0.6	. . . .	. . . .
	3883.2	0	0	0	2	8	.	.	4	. . . .	. . . .	. . . .	. .	. . . .	0.0 . .	*1.1 0.6*	. . . .	. . . .
	3886.4	0	0	0	0	8	.	.	4	. . . .	. . . .	. . . .	. .	. . . .	*1.0* . .	*1.1 0.6*	. . . .	. . . .
	3887.1	0	0	0	1		.	.	3	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . . .
Hζ	3889.1	65	65	60	16	8	.	.	. .	0.3 0.2	. . *0.3*	. . . .	. .	. . . .	. . . .	*0.3 0.2*	. . . .	. . . .
	3890.5	0	0	0	0	1	.	.	1 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	0.4 0.8	. . . .	. . . .
	3892.0	0	0	0	0	1	.	.	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	1.0 . .	. . . .	. . . .
	3893.3	0	0	0	1	2	.	.	3	. . . .	. . . .	. . . .	. .	. . . .	. . . .	0.8 0.4	. . . .	. . . .
	3895.5	0	0	0	3	6	.	.	4 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	*0.3* 0.2	. . . .	. . . .
	3898.1	0	0	0	2	2	.	.	3	. . . .	. . . .	. . . .	. .	. . . .	. . . .	*0.7 0.3*	. . . .	. . . .
	3899.9	0	0	0	1	2	.	.	3	. . . .	. . . .	. . . .	. .	. . . .	*0.7* . .	*0.2 0.5*	. . . .	. . . .
	3900.7	0	3	2	1	2	.	.	2	*0.2 0.6*	. . *0.2*	. . . .	. .	. . . .	. . . .	*0.1 0.3*	. . . .	. . . .
	3903.1	0	2	3	3	5	.	.	3	. . 0.4	. . 0.0	0.5 . .	. .	. . . .	*0.2* . .	0.0 0.1	. . . .	. . . .
	3905.6	2	3	3	3	4	.	.	4	. . . .	. . *0.1*	0.3 *0.3*	. .	. . . .	. . . .	0.2 0.1	. . . .	. . . .
	3906.6	0	0	?	?	2	.	.	2	*0.3 0 3*	. . . .	0.2 0.0	. .	. . . .	0.1 . .	. . . .	. . . .	. . . .
	3907.8	0	0	0	0	1	.	.	2 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	*1.0* . .	. . . .	. . . .
	3908.9	0	0	0	0	1	.	.	1	. . . .	. . . .	. . . .	. .	. . . .	. . . .	*1.1 0.2*	. . . .	. . . .
	3910.0	0	0	0	?	1	.	.	3	. . . .	. . . .	. . . .	. .	. . . .	. . . .	0.4 *0.1*	. . . .	. . . .
	3910.8	0	0	0	0	1	.	.	2 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	0.8 0.0	. . . .	. . . .
	3912.0	0	0	0	0	1	.	.	1 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . 0.0	. . . .	. . . .
	3913.6	1	2	2	2	1	.	.	3 d	0.0 0.1	0.2 0.0	. . . .	. .	. . . .	0.3 . .	. . . .	. . . .	. . . .
	3914.5	0	1	2	2	2	.	.	3 d	. . . .	. . . .	*0.2* . .	. .	. . . .	. . . .	*0.5 0.4*	. . . .	. . . .
	3916.4	0	1	2	3	3	.	.	2 d	. . . .	. . . .	. . . .	. .	. . . .	0.0 . .	. . . .	. . . .	. . . .
	3917.2	0	0	?			.	.	2	*0.1 0.2*	. . . .	*0.1* . .	. .	. . . .	. . . .	. . . .	. . . .	. . . .
	3918.6	0	?	1	3	3	.	.	3 d	0.5 0.4	. . . .	0.5 *0.4*	. .	. . . .	*0.1* . .	*0.2* 0.3	. . . .	. . . .
	3920.4	0	1	2	3	5	.	.	3	0.4 0.7	. . . .	1.3 *0.1*	. .	. . . .	0.5 . .	. . . .	. . . .	. . . .
	3921.0	0	0	0	0		.	.	3 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	0.0 *0.2*	. . . .	. . . .
	3923.0	0	1	2	3	3	.	.	4	0.4 0.4	. . . .	0.5 . .	. .	. . . .	0.1 . .	0.3 0.4	. . . .	. . . .
	3926.0	0	?	1	3	3	.	.	3 d	0.1 0.5	. . . .	0.6 . .	. .	. . . .	*0.1* . .	0.2 0.2	. . . .	. . . .
	3928.0	0	1	2	2	2	.	.	4	0.5 0.5	. . . .	0.3 . .	. .	. . . .	. . . .	0.6 0.1	. . . .	. . . .
	3930.3	0	1	1					2	0.8 0.8	0.4 0.1	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . . .
K	3933.8	5	8	13	135	160	200	170	5	0.3 0.4	0.2 0.0	0.4 0.0	1.3	. . . .	0.2 . .	0.0 0.0	. . . .	. . . .
	3936.0	0	1	?					2	0.0 . .	0.3 0.1	0.7 . .	. .	. . . .	. . . .	. . . .	. . . .	. . . .
	3938.5	0	2	2	2	2	.	.	3	0.1 0.3	0.1 0.0	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . . .
	3941.4	0	0	0	1	2	.	.	3 g	. . . .	. . . .	0.3 . .	. .	. . . .	0.1 . .	0.2 *0.1*	. . . .	. . . .
	3944.1	0	0	?	2	3	3	.	4	. . . .	. . . .	*0.6 0.3*	. .	. . . .	. . . .	0.7 0.3	*1.4* 0.2	. . . .

Desig.	Wave Length.	VI.	VII.	VIII.	XII.	XIV.	XV.	XVIII.	S. S.	470	484	1486	1507	387	493	1086	453	1717	505	634	393	429	401	475	1493	1504
	3945.2	0	2	2	2	3	3	.	2 d	*0.4*	*0.3*	0.2	0.0	*1.1*	..	..	..	..	*0.1*	..	..	0.3	*0.6*	..	..	..
	3947.7	0	0	0	0	2	2	.	2 g	..	..	..	..	..	..	..	..	..	..	..	..	..	0.2	..	..	..
	3949.0	0	1	1	2	2	2	.	3 d	*0.1*	..	..	..	*0.8*	0.0	..	..	..	0.0	..	0.0	0.3	*0.1*	*0.4*	..	..
	3950.0	0	0	0	1	1	1	.	2	..	..	..	..	*0.5*	0.2	..	..	..	0.8	..	..	0.4	0.2	..	..	..
	3951.3	0	0	0	?	0	0	.	2	..	..	..	..	*0.5*	0.1	..	..	..	..	..	..	..	..	..	..	..
	3953.0	0	1	1	2	7	7	.	4 g	*0.4*	..	*0.6*	*0.9*	0.5	0.1	..	..	..	*0.3*	..	0.4	0.3	0.4	0.2	..	..
	3956.6	0	1	2	3	4	4	.	3 g	0.5	..	..	..	0.5	0.2	..	..	..	0.1	..	0.1	0.4	0.2	0.1	..	..
	3958.4	0	0	0	2	2	3	.	2	..	..	..	..	0.3	0.5	..	..	..	0.2	..	0.0	0.4	0.2	0.2	..	..
	3961.6	0	2	2	2	6	6	.	4	*0.4*	..	*0.1*	*0.3*	0.5	0.3	..	..	..	0.2	..	0.7	0.4	0.0	0.6	..	..
	3963.4	0	0	0	1	?		.	2	..	..	..	..	0.1	0.1	..	..	..	0.4	..	..	0.7	*0.5*	..	..	..
	3964.5	0	0	0	0	?		.	2 d	..	..	0.3	*0.1*	..	..	..	..	..	..	..	..	..	..	..	..	..
H	3968.6	70	6	70	100	120	170	140	5	..	..	0.1	0.3	0.8	1.0	..	..	..	0.6	..	0.2	*0.2*	*0.4*	0.2	..	..
Hε	3970.2		65							*0.2*	*0.5*	0.4	0.4	..	..	3.2	0.1	1.5	..	..	..	..	..	..	..	..
	3973.8	0	0	0	?	1		.	2	..	..	0.5	..	..	..	..	..	..	..	..	..	..	0.2	..	..	..
	3974.7	0	0	0	1	2		.	3 d	..	..	..	..	0.1	0.0	..	..	..	..	..	0.0	*0.2*	0.4	..	..	..
	3976.8	0	0	0	1	2	2	1	2	..	..	..	..	0.4	0.3	..	..	..	0.0	..	*0.2*	0.2	*0.1*	0.1	..	..
	3978.7	0	0	0	?	1	1	0	1 g	..	..	..	..	0.0	*0.2*	..	..	..	..	..	*0.3*	*0.2*	*0.1*	*0.1*	..	..
	3979.7	0	0	0	1	1	1	1	1 d	..	..	0.2	0.1	0.5	0.3	..	..	..	..	..	*0.1*	*0.2*	0.2	0.0	*0.7*	..
	3982.0	0	?	1	1	3	2	4	2 d	..	..	0.1	0.3	0.7	0.0	..	..	..	0.3	0.4	0.0	*0.1*	0.3	*0.1*	0.1	..
	3982.7	0	0	0	0	0	1	0	1 d	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*0.2*	..	..
	3984.1	0	0	0	1	2	1	?	2 d	..	..	..	..	..	0.0	..	..	..	..	..	0.0	0.1	0.1	0.2	..	..
	3985.5	0	0	0	1	?	1	0	2	..	..	..	..	*1.0*	*0.2*	..	..	..	..	..	..	..	0.0	0.0	..	..
	3987.0	0	0	?	2	3	3	1	3 d	*0.2*	..	..	..	0.4	*0.1*	..	..	..	0.5	..	*0.3*	0.5	0.3	0.3	..	..
	3990.0	0	0	0	2	3	4	4	3	..	..	..	..	*0.7*	0.0	..	..	..	0.4	1.2	*0.7*	0.4	0.1	0.3	*0.1*	..
	3991.6	0	0	0	1	1	0	2	2 d	..	..	..	..	*1.0*	*0.5*	..	..	0.6	0.4	..	..	0.4	..	..	..	..
	3993.0	0	0	0	0	?	2	?	1	..	..	..	..	*0.8*	*0.5*	..	..	..	..	..	..	..	*0.8*	*0.9*	..	..
	3994.2	0	0	0	1	1	1	2	2 d	..	..	..	..	0.4	0.1	..	..	..	0.1	..	*0.3*	*0.3*	*0.4*	*0.1*	..	..
	3994.8	0	0	0	0	0	?	?	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.0	..	..
	3995.5	0	0	0	1	1	1	1	3	..	..	..	..	0.8	0.2	..	..	0.3	0.4	..	..	..	..	0.0	..	..
	3997.6	0	1	1	2	2	1	?	3	0.2	*0.8*	..	*0.3*	0.2	0.1	..	..	..	0.1	0.0	..	..	..	*1.3*	..	..
	3998.1	0	0	0	0		1		3 d	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*1.0*	..	..
	3998.8	0	0	0	2	2	2	4	2	..	..	..	..	0.5	0.0	*0.1*	..	0.2	0.3	..	0.0	..	0.8	0.2	*0.3*	..
	4000.5	0	0	0	1	1	1	?	3 d	..	..	..	..	0.4	0.3	..	..	..	0.3	..	0.2	0.0	*0.1*	0.0	*0.2*	..
	4001.3	0	0	0	0	0	1	?	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	4001.8	0	0	0	1	1		1	2	..	..	..	..	0.4	0.4	..	..	..	..	..	0.3	*0.1*	*0.5*	*0.2*	..	..
	4003.0	0	1	1	1	?	1	0	1	0.1	*0.2*	*0.4*	*0.6*	0.4	0.2	*0.6*	*0.9*	*0.3*	..	..	0.3	*0.4*	*0.4*	*0.3*	..	..
	4003.9	0	0	0	0	0	1	0	2	..	..	..	..	..	..	..	..	..	..	..	..	..	*0.2*	*0.1*	0.0	..
	4005.3	0	2	3	3	6	7	5	5	0.1	0.3	0.5	0.2	0.2	0.1	*0.2*	2.4	0.5	0.3	*0.2*	0.3	0.0	*0.1*	0.2	..	..
	4006.9	0	0	0	3	1	1	0	3 d	..	..	..	..	0.2	*0.2*	..	..	..	..	..	..	0.0	..	0.9	..	..
	4009.0	0	0	0	0	0	1	0	3	..	..	..	..	..	..	..	..	..	..	..	..	..	*0.3*	0.0	..	..
	4009.9	0	0	0	?	1	1	3	3	..	..	..	..	0.3	*0.2*	..	..	..	..	..	*0.2*	*0.2*	*0.3*	*0.1*	..	..
	4010.9	0	0	0		1	1		2 g	..	..	..	..	..	..	..	..	..	..	..	..	*0.2*	0.3	..	..	..
	4011.6	0	0	0	0	0	0	3	2 d	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	4012.6	0	1	1	1	2	2		3	*0.1*	*0.1*	*0.1*	*0.1*	0.1	*0.1*	*0.7*	..	*0.3*	*0.1*	*0.9*	*0.5*	0.0	*0.1*	*0.1*	..	..
	4013.9	0	0	0	1	2	1	2	3 d	..	..	..	..	..	*0.3*	..	..	..	..	..	..	..	..	*0.4*	*0.2*	..
	4014.7	0	0	0	0	?	1		3	..	..	..	..	..	*0.1*	0.0	..	*0.1*	0.1	0.1	*0.3*	*0.2*	*0.4*	*0.5*	..	..
	4015.2	0	0	1	0	0	0	0	0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	4015.8	0	0	?	1	1	1	0	2	..	..	*0.4*	*0.5*	0.1	*0.4*	..	..	..	..	..	..	..	*0.2*	*0.4*	0.8	..

Desig.	Wave Length.	VI.	VII.	VIII.	XII.	XIV.	XV.	XVIII.	S. S.	470 484	1486 1507	387 493	1086	453 1717	505 634	393 429	401 475	1493 1504
	4017.4	0	0	0	2	1	1	0	3	....	....	.. *0.1*	..	....	....	0.2 ..	*0.6 0.1*	....
	4018.4	0	0	0	2	2	2	3	3 d	....	....	*0.3* 0.0	..	1.1 *0.4*	*0.6 0.5*	0.0 *0.5*	*0.4 0.4*	*0.7 0.2*
	4019.2	0	0	0	0	0	1	1	1	....	....	....	..	....	....	....	0.1 *0.1*	*1.3* ..
	4020.4	0	0	0	0	2	2	3	3 g	....	....	....	..	....	....	0.1 0.1	0.1 0.0	....
	4022.0	0	0	0	1	2	2	3	3	....	....	0.3 *0.2*	..	.. *0.5*	*0.1 0.8*	0.2 0.1	*0.2 0.1*	*1.1 0.5*
	4023.5	0	0	0	1	0	1	2	2	....	....	0.0 *0.1*	..	....	0.1 ..	....	.. *0.1*	....
	4024.8	0	1	1	2	3	3	3	3 d	*0.3 0.5*	*0.4* 0.0	0.4 0.1	0.0	1.6 0.5	0.2 *0.6*	0.1 0.0	0.3 0.1	*0.5* 0.3
	4027.2	0	0	0	0	0	1	2	2	....	....	....	..	....	....	.. *0.4*	*0.5 0.2*	*0.2* 0.1
	4028.5	0	1	1	1	1	1	1	3	*0.3 0.5*	0.0 0.1	0.1 *0.2*	*0.4*	*0.4* 0.0	*0.2 0.9*	....	*0.4* 0.0	*0.1* 0.8
	4030.8	0	1	1	2	3	5	8	4 d	*0.5* ..	....	.. 0.0	*0.6*	0.8 *0.5*	0.0 *0.4*	0.0 *0.1*	*0.2 0.1*	0.1 *0.2*
	4033.2	0	1	1	2	2	3	4	4	....	0.2 *0.1*	*0.1* 0.0	*0.7*	....	*1.4* 0.5	*0.4* 0.0	*0.3 0.3*	*0.1* ..
	4034.6	0	0	0	1	1	2	5	4	....	....	*0.1* 0.0	*0.2*	....	0.2 ..	*0.7* 0.0	0.0 *0.2*	*0.4 0.1*
	4035.8	0	0	?	1	1	2	2	4	....	.. *0.1*	0.2 0.0	*0.3*	0.1 ..	0.2 0.7	*0.6* 0.1	0.0 *0.2*	*0.2* 0.0
	4037.3	0	0	0	1	?	0	0	1	....	....	*0.2 0.2*	0.4	....	....	.. 0.3	....	....
	4039.0	0	0	0	1	1	1	?	2 g	....	....	0.1 *0.1*	..	....	....	....	*0.4 0.4*	.. *1.0*
	4040.8	0	0	0	0	?	?	0	2	....	....	....	*0.8*	*0.9 0.3*	.. *0.4*	....	....	....
	4041.5	0	0	1	2	2	2	5	3	*0.4 0.4*	.. *0.2*	0.0 *0.1*	..	....	*0.4* ..	*0.2 0.3*	*0.6 0.5*	*0.2 0.3*
	4044.0	0	0	0	?	1	1	1	3	....	....	.. 0.4	..	.. *1.0*	*0.1* .	.. *0.1*	*1.0 1.3*	*0.3* ..
	4045.9	1	2	3	5	10	13	7	5	*0.2* 0.2	*0.1 0.3*	0.2 0.1	*0.4*	0.0 *0.2*	0.1 *1.1*	0.1 0.0	0.0 *0.1*	0.0 *0.2*
	4047.4	0	0	0	1	0	0	1	2	....	....	.. *0.3*	..	....	....	....	....	*0.1* ..
	4048.9	0	1	1	1	2	?	1	3	0.3 0.0	*0.2 0.1*	0.3 0.1	*0.8*	*0.4 0.6*	0.1 *0.3*	0.4 0.1	....	*0.4* 0.4
	4049.7	0	0	0	0	0	1	?	2 g	....	....	....	..	....	....	....	0.4 *0.5*	....
	4050.8	0	0	0	1	1	1	1	2	....	....	0.2 *0.4*	0.3	....	*0.2* ..	.. 0.2	0.2 0.1	0.1 0.7
	4052.6	0	0	0	1	2	2	?	3 g	....	*0.8 0.6*	*0.1 0.2*	..	.. 0.4	*0.4* ..	*0.1* 0.0	0.0 *0.2*	*0.4* ..
	4054.0	?	1	1	1	0	0	0	2 g	0.1 ..	*0.2 0.1*	0.1 *0.1*	*0.5*	....	....	....	....	....
	4055.0	0	0	0	1	2	3	6	3 d	....	....	0.5 0.0	..	....	....	0.0 0.1	*0.3 0.3*	*0.1 0.1*
	4057.6	?	?	1	2	2	2	3	4 d	0.6 1.2	*0.1* ..	0.3 *0.1*	0.4	*0.3* ..	0.0 ..	0.7 *0.3*	0.0 *1.6*	*0.6* ..
	4059.0	0	0	0	1	1	2	2	3 d	....	....	0.5 *0.2*	..	2.0 0.2	....	.. 1.0	0.1 *1.0*	2.4 *0.4*
	4063.7	1	2	3	3	7	10	10	5	*0.3 0.1*	0.1 *0.1*	0.1 *0.1*	*0.5*	*0.1* 0.1	*0.2 1.6*	0.2 *0.1*	0.1 0.1	0.4 *0.1*
	4065.4	0	0	0	1	0	0	0	2	....	....	0.2 *0.4*	..	....	....	....	....	....
	4067.0	1	2	2	2	6	3	4	3 g	*1.1* 0.3	*0.1* 0.0	.. 0.3	0.1	0.5 0.6	0.2 *0.7*	0.3 0.1	0.0 *0.1*	0.5 0.4
	4068.2	0	0	0	1	0			3	....	....	*0.8 0.1*	..	....	....	....	....	....
	4069.4	0	0	0	0	1	1	1	1	....	....	....	..	....	....	.. *0.1*	*0.3 0.5*	*0.1* ..
	4071.9	1	2	3	3	7	8	8	4	.. *0.3*	0.0 *0.3*	0.2 0.0	*0.2*	0.1 0.3	*0.1 0.9*	*0.2 0.1*	0.0 0.0	0.1 0.0
	4072.7	0	0	0	0	0	0	2	2	....	....	....	..	....	....	....	0.0 0.7	1.1 ..
	4075.0	0	0	0	1	1	1	2	3 g	....	....	0.1 0.0	..	.. 0.4	0.8 ..	.. 0.1	*0.4 0.2*	*0.1* 0.3
	4076.8	0	0	0	1	1	3	3	4 g	....	....	*0.1 0.3*	..	....	....	....	0.0 *0.3*	....
	4077.9	1	2	3	3	7	4	5	4	1.1 *0.2*	.. *0.2*	0.1 *0.1*	*0.5*	*0.5 0.8*	*0.1 1.6*	*0.2 0.1*	*0.1 0.4*	0.0 0.2
	4079.5	0	0	0	1	1	2	2	3 d	....	....	0.3 0.2	..	....	....	.. 0.3	0.4 *0.2*	....
	4081.2	0	0	0	0	0	?	2	2 d	....	....	....	..	....	....	....	....	0.3 0.0
	4082.4	0	0	0	0	1	2	5	2 d	....	....	....	..	....	....	....	.. *0.3*	....
	4083.8	0	0	0	1	2	2		3	....	....	*0.2 0.3*	0.4	*0.5 0.2*	*0.4 2.0*	*0.5 0.5*	*0.6 0.3*	*0.6 0.4*
	4085.4	0	0	?	2	2	2	2	3	....	....	*0.2 0.1*	..	....	*0.3 0.2*	0.5 0.1	0.0 *0.2*	.. 0.4
	4086.8	0	0	0	1	2	2	3	2 g	....	....	0.2 0.0	0.5	1.0 0.2	0.3 ..	.. 0.2	0.1 *0.2*	*0.3* 0.4
	4089.0	0	0	0	?	?	1	1	2 d	....	....	0.2 *0.3*	..	....	....	.. 0.1	*0.3 0.6*	0.0 *0.1*
	4090.2	0	0	0	0	1	2	3	2	....	....	....	..	*0.5* 0.8	0.3 *1.0*	0.0 0.5	0.5 0.3	0.7 0.5
	4092.7	0	0	0	2	3	3	3	4 g	....	....	0.1 *0.2*	..	0.1 0.0	0.2 *1.4*	*0.3* 0.0	0.1 0.0	0.2 0.2
	4095.0	0	0	0	0	1	0	0	2	....	....	*0.1* ..	..	....	....	.. *0.4*	....	....
	4096.2	0	0	0	1		2	4	3	....	....	.. *0.4*	..	0.3 0.2	0.5 *1.3*		0.2 *0.2*	0.2 0.0

Desig.	Wave Length.	VI.	VII.	VIII.	XII.	XIV.	XV.	XVIII.	S. S.	470 484	1486 1507	387 493	.086	453 1717	505 634	393 429	401 475	1493 1504
	4097.3	0	0	0	1	2	2	?	3	. . . .	. . . .	0.9 0.2	. .	. . . .	. . . .	1.0 0.9	. . 0.3	. . . .
	4098.5	0	0	0	1	1	1	1	3 d	. . . .	. . . .	0.6 0.0	. .	0.0 0.5	0.2 1.5	0.0 0.2	0.3 0.2	0.3 0.0
	4100.2	0	0	0	0	0	0	2	3 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	0.5 . .
	4100.9	0	0	0	0	0	2	2	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	0.2 . .	. . . .
Hδ	4101.8	65	65	60	16	10	6	4	5	0.3 0.1	0.0 0.0	0.4 0.4	0.4	0.0 0.7	0.3 1.4	0.2 0.2	0.2 0.3	0.2 0.6
	4103.1	0	0	0	0	0	1	?	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	0.4 0.2	0.2 . .
	4104.3	0	0	0	0	2	0	0	2	. . . .	. . . .	. . . .	. .	. . . .	0.1 . .	0.2 0.7	. . . .	. . . .
	4105.3	0	0	0	0	0	3	3	2 d	. . . .	. . . .	. . . .	. .	. . . .	. . 0.5	. . . .	0.2 0.4	0.1 0.5
	4106.6	0	0	0	?	1	2	1	2 d	. . . .	. . . .	0.1 0.1	. .	0.1 1.1	. . . .	. . 0.5	0.0 0.3	0.1 1.0
	4107.7	0	0	0	?	1	1	1	2	. . . .	. . . .	0.2 0.0	. .	. . . .	. . . .	0.0 0.2	0.1 0.2	. . . .
	4108.9	0	0	0	0	0	1		2	. . . .	. . . .	. . . .	. .	. . . .	. . 0.2	. . . .	0.4 0.5	0.5 . .
	4110.0	0	0	0	?	2	1	4	3	. . . .	. . . .	0.1 0.0	. .	0.3 0.3	0.3 . .	0.4 0.6	0.3 0.2	0.1 0.1
	4110.8	0	0	0			1		2	. . . .	0.6 0.5	. . . .	0.3		. . . .	. . . .	. . 0.1	. . . .
	4112.0	0	0	0	?	2	2	1	2	. . . .	. . . .	0.2 0.0	. .	. . . .	0.5 . .	. . . .	. . 0.2	. . . .
	4113.1	0	0	0	1		2	4	2	. . . .	. . . .	0.3 0.1	0.3	. . 0.2	0.5 0.3	0.2 0.2	0.6 0.4	0.6 0.7
	4114.6	0	0	0	0	?	0	1	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	0.8 0.3
	4115.3	0	0	0	1	1	1	2	2 d	. . . .	. . . .	0.2 0.6	. .	0.9 0.3	. . . .	0.4 0.2	0.0 0.1	0.0 . .
	4116.8	0	0	0	1	1	2	2	2	. . . .	. . . .	. . 0.3	. .	. . . .	. . . .	0.2 0.8	0.1 0.1	0.0 0.1
	4118.9	1	1	1	2	3	3	3	4 d	0.3 0.3	. . . .	0.4 0.3	0.3	0.3 0.5	0.1 1.6	0.5 0.3	0.2 0.2	0.2 0.0
	4120.4	0	0	0	1	1	?	0	2	. . . .	. . . .	. . 0.2	. .	. . . .	. . . .	. . . .	. . . .	. . . .
	4121.8	0	0	0	1	1	2	3	3 d	. . . .	. . . .	0.6 0.1	. .	. . . .	. . . .	0.2 0.6	0.3 0.2	0.1 0.2
	4122.8	1	1	1	1		0	0	2 d	0.4 0.0	0.1 0.2	. . 0.1	0.1	0.3 0.7	0.7 1.2	. . . .	. . . .	. . . .
	4123.9	0	0	0	1	2	3	3	2	. . . .	. . . .	0.1 0.0	. .	. . . .	. . . .	0.3 0.1	0.0 0.0	0.0 0.2
	4126.1	0	0	0	1	1	2	1	3 g	. . . .	. . . .	0.1 0.0	. .	. . . .	. . . .	0.1 0.1	0.1 0.4	0.2 0.2
	4128.1	0	0	2	2	2	3	3	3 g	1.6 0.4	0.3 0.4	0.1 0.1	0.1	0.4 1.0	0.7 0.7	0.0 0.0	. . 0.0	0.2 0.1
	4128.5	2	3	?	0	0	0	0	0	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . . .
	4129.8	0	0	0	1	1	2	3	2 g	. . . .	. . . .	. . 0.2	0.5	. . . .	. . . .	0.4 0.5	0.2 0.5	0.3 0.7
	4131.4	3	2	1	1	0	0	0	1	0.3 0.5	0.3 0.3	. . 0.5	. .	. . . .	. . . .	. . . .	. . . .	. . . .
	4132.2	0	?	1	2	4	4	3	4	0.3 0.2	. . . .	0.5 0.2	0.5	0.6 0.9	0.3 0.2	0.5 0.6	0.4 0.4	0.4 0.4
	4134.8	0	0	1	1	3	4	4	4 d	0.7 0.2	. . . .	0.1 0.2	. .	0.0 0.2	0.2 1.6	0.1 0.2	0.1 0.0	0.1 0.0
	4137.4	0	0	1	1	2	2	2	3 g	0.4 0.5	. . . .	0.6 0.4	0.1	0.9 0.8	0.3 . .	0.7 0.7	0.3 0.2	0.3 0.2
	4140.3	0	0	0	1	1	2	3	2	. . . .	. . . .	0.5 0.0	. .	. . . .	. . . .	0.1 0.4	0.0 0.5	0.0 0.2
	4142.5	0	0	0	1	1	13	0	2 g	. . . .	. . . .	0.1 0.3	. .	. . . .	. . . .	. . . .	. . . .	. . . .
	4143.9	2	1	2	3	5		8	4 d	0.0 0.1	0.2 0.7	0.2 0.0	0.3	0.4 0.2	0.1 2.0	0.1 0.6	0.3 0.2	0.2 0.3
	4146.1	0	0	0	0	1	1	1	2 d	. . . .	. . . .	. . . .	. .	. . . .	0.3 0.4	. . . .	0.2 0.1	0.3 . .
	4147.9	0	0	0	1	1	1	2	2	. . . .	. . . .	0.2 0.2	. .	. . . .	0.2 . .	0.3 0.1	0.1 0.2	0.0 0.5
	4149.5	0	?	1	1	3	4	5	3 d	0.3 0.2	. . . .	. . 0.0	0.0	0.5 0.2	. . . .	0.2 0.2	0.1 0.2	0.3 0.1
	4150.5	0	0	0	1				2	. . . .	. . . .	0.3 0.5	. .	. . . .	. . . .			
	4152.2	0	0	0	1	2	3	3	3	. . . .	. . . .	0.4 0.0	. .	. . . .	0.2 0.6	0.6 0.6	0.4 0.4	0.5 0.2
	4154.1	0	1	1	1	3	0	0	3	0.2 0.3	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . . .
	4154.9	0			1		3	3	3 d		. . . .	0.2 0.3	0.3	0.4 0.2	0.2 0.0	0.2 0.0	0.1 0.2	0.3 0.3
	4156.7	0	0	0	2	3	3	3	3 g	. . . .	. . . .	0.5 0.2	0.0	0.2 0.2	0.1 0.5	0.4 0.6	0.2 0.5	0.0 0.1
	4158.0	0	0	0	?	?	1	?	2	. . . .	. . . .	. . 0.2	. .	. . . .	. . . .	. . . .	0.1 0.2	0.2 . .
	4159.2	0	0	0	1	1	0	2	3 d	. . . .	. . . .	0.3 0.1	. .	. . . .	0.2 0.6	. . 0.2	0.1 . .	0.7 0.2
	4160.2	0	0	0	0	0	1	0	1 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	0.1 0.2	. . . .
	4161.7	0	0	1	2	2	2	2	2	0.9 0.1	. . . .	0.1 0.2	0.6	0.1 0.1	0.2 0.3	0.1 0.0	0.1 0.3	0.3 0.3
	4163.9	0	1	1	1	1	?	0	2	0.1 0.6	0.1 0.2	0.4 0.1	0.1	0.1 0.0	0.3 0.3	0.5 0.5	. . . .	. . . .
	4165.6	0	0	0	1	1	2	3	2	. . . .	. . . .	0.1 0.1	. .	. . . .	0.5 0.2	0.3 0.1	0.3 0.4	0.9 0.5
	4167.5	0	?	1	2	2	2	2	3	0.2 0.4	. . . .	0.4 0.1	0.0	0.8 1.4	0.3 1.4	0.3 0.1	0.2 0.2	0.5 0.4

Desig.	Wave Length.	VI.	VII.	VIII.	XII.	XIV.	XV.	XVIII.	S. S.	470 484	1486 1507	387 493	1086	453 1717	505 634	393 429	401 475	1493 1504
	4169.8	0	0	0	?	?	1	2	1 d	. . . .	. . . .	*0.3* . .	. .	. . . .	. . . .	. . 0.5	0.1 *0.3*	*0.1* *0.1*
	4171.2	0	0	0	1	0	0	0	3 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . *0.2*	. . . .
	4172.3	1	1	2	2		5		2 d	*3.7* . .	. . . .	. . *0.1*	. .	. . . .	. . . .	. . . .	0.2 0.2	. . . .
	4172.9	0	0	?	?	5		12	3	. . . .	*0.7* . .	. . . .	. .	. . . .	*0.5* *1.3*	0.0 0.0		*0.3* *0.3*
	4173.6	1	1	2	3		?		2	0.0 *0.2*	0.2 0.3	*0.6* 0.1	*0.6*	*0.5* *0.2*	0.3 0.0	0.6 . .	. . 0.4	0.4 0.3
	4175.1	0	0	0	0	?	1	3	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	0.4 1.0	0.6 0.2	0.2 0.4
	4177.8	0	1	3	2	2	3	2	3	0.3 0.7	0.2 . .	0.1 *0.1*	0.1	0.1 0.2	0.1 . .	0.6 0.4	0.4 0.3	*1.0* 0.0
	4179.5	1	2		2	1	1	1	2		*0.4* *0.2*	0.0 *0.2*			*0.3* 1.0	. . 0.2	. . 0.1	0.1 . .
	4182.0	0	1	1	2	2	2	2	2	0.1 0.1	. . . .	0.3 0.2	. .	0.0 0.6	0.3 0.6	0.2 0.7	*0.1* 0.8	0.3 0.1
	4184.2	0	1	1	2	2	?	0	2	0.0 0.1	. . . .	. . 0.2	. .	. . . .	. . . .	0.0 0.3	0.0 . .	. . . .
	4185.0	0	0	0	0	0	1	2	2	. . . .	. . . .	. . . .	*0.5*	*0.7* *0.2*	*0.2* 0.5	. . . .	. . . .	*0.3* *0.6*
	4187.6	0	2	2	2	4	4	5	4 g	0.5 *0.9*	. . 0.6	0.2 0.3	*0.1*	*0.3* 0.0	0.0 . .	0.1 0.2	0.0 0.2	*0.1* 0.1
	4189.0	0	0	0	1	0	0	0	2	. . . .	. . . .	*0.1* 0.0	. .	. . . .	. . 0.6	. . . .	. . . .	. . . .
	4191.8	0	1	1	2	3	3	.6	3 d	0.8 0.3	. . . .	0.1 *0.1*	*0.7*	*0.3* *0.2*	*0.2* . .	0.0 0.2	*0.2* 0.0	*0.4* *0.3*
	4194.0	0	0	0	0	?	1	0	1 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . 0.5	*0.3* *0.2*	. . . .
	4195.6	0	1	1	2	3	1	1	3 d	0.2 0.3	. . . .	0.0 *0.2*	. .	0.0 *0.4*	*0.1* 0.5	0.1 0.5	*0.1* *0.3*	0.1 *0.1*
	4196.8	0	0	0			2	1	2 d	. . . .	. . . .						0.1 0.1	0.6 0.1
	4198.5	0	1	3	3	3	2	1	4 g	0.0 0.5	. . . .	0.2 0.2	0.6	0.5 0.1	0.3 . .	0.2 0.3	0.1 0.0	. . . .
	4200.9	0	0	0	0	0	1	2	3 g	. . . .	. . . .	. . . .	. .	. . . .	. . *0.5*	. . . .	*0.4* *0.4*	*0.7* *1.0*
	4202.2	0	1	2	2	3	3	1	4	*0.1* 0.2	. . 0.1	0.0 0.1	*0.1*	*0.1* *0.2*	0.2 1.0	0.1 0.2	0.1 0.1	0.2 0.0
	4204.2	0	0	0	1	0	0	1	2	. . . .	. . . .	. . *0.4*	. .	. . . .	. . . .	. . . .	. . . .	*0.2* . .
	4205.3	0	0	1	1	2	2	2	2	0.0 *0.5*	. . . .	0.1 *0.2*	*0.4*	0.0 *0.5*	*0.2* *0.1*	*0.1* 0.1	*0.2* *0.1*	0.0 *0.1*
	4206.9	0	0	0	1	1	1	3	2	. . . .	. . . .	0.4 0.1	. .	. . 0.1	0.3 1.4	0.3 0.2	*0.2* 0.0	0.2 0.1
	4208.8	0	0	0	1	0	1	1	2	. . . .	. . . .	. . *0.1*	. .	. . *0.3*	0.2 . .	. . 0.2	*0.4* *0.3*	. . 0.1
	4210.5	0	0	1	1	2	2	1	3	0.4 . .	. . . .	*0.2* *0.1*	. .	*0.4* . .	*0.1* . .	. . . .	*0.4* *0.3*	*0.1* *0.4*
	4212.1	0	0	0	1	0	1	1	2	. . . .	. . . .	*0.4* 0.0	. .	. . . .	*0.1* . .	. . . .	*0.9* *0.3*	*0.2* *0.3*
	4213.9	0	0	0	1	1	1	1	2	. . . .	. . . .	*0.1* *0.2*	. .	. . . .	. . . .	0.2 *0.3*	*0.3* *0.2*	0.1 *0.1*
	4215.7	0	1	2	3	5	7	9	3	*0.2* *0.3*	1.3 *0.1*	0.1 *0.3*	0.0	0.1 0.1	0.0 *0.4*	0.3 0.4	0.4 0.4	0.4 0.3
	4217.6	0	0	0	2	1	1	1	3 d	. . . .	. . . .	0.2 *0.2*	. .	0.2 . .	0.2 0.3	0.1 . .	0.3 *0.1*	0.4 0.3
	4219.6	0	0	0	2	2	1	0	3	. . . .	. . . .	0.2 *0.5*	. .	0.3 0.3	0.5 0.8	*0.1* 0.0	0.0 *0.1*	*0.5* *0.4*
	4220.5	0	0	0				1	2	. . . .	0.7 . .			. . . .	. . . .		0.2	0.1 0.1
	4222.4	0	0	0	1	1			3	. . . .	. . . .	0.3 *0.1*	. .	0.1 0.1	0.4 . .	0.5 0.2	. . . .	*0.3* *0.1*
	4223.7	0	0	0	0	?	2	3	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	*1.2* *0.5*	. . . .
	4224.7	0	0	0	0	1			3 g	. . . .	. . 0.5	. . . .	. .	*0.3* 0.7	0.5 0.5	0.1 . .	0.0 . .	. . . .
	4227.0	1	1	2	7	10	20	40	5 d	0.0 0.6	. . . .	0.1 0.2	*0.2*	0.0 *0.3*	0.0 0.8	0.1 0.1	0.1 0.1	*1.3* *0.4*
	4229.9	0	0	0	0	1	2	3	3	. . . .	. . . .	. . . .	. .	. . . .	0.1 1.3	0.3 0.0	0.0 0.3	0.2 0.7
	4233.6	2	2	3	3	3	3	6	4 g	*0.3* *0.3*	*0.4* *0.5*	0.0 *0.1*	*0.3*	*0.5* *0.4*	*0.2* . .	0.0 *0.1*	0.1 0.0	0.0 *0.3*
	4236.0	0	0	1	1	2	2	2	4	*0.1* 0.3	. . . .	0.3 *0.1*	*0.1*	0.1 0.0	0.2 . .	*0.2* 0.2	0.4 . .	*0.5* *0.6*
	4237.3	0	0	0	0	0	1	1	3	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	0.6 *0.1*	. . . .
	4239.0	0	0	0	0	0	0		3	0.3 0.2	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . . .
	4240.0	0	0	0	2	2	2	3	3 d	. . . .	. . . .	0.2 0.0	0.1	*1.0* *0.8*	*1.5* *1.1*	0.1 *0.1*	0.4 0.5	*0.8* *0.5*
	4242.5	0	1	1	1	2	1	1	3 g	0.3 0.1	*0.3* *0.1*	0.1 0.1	*0.2*	0.1 *0.1*	0.1 *1.2*	*0.1* 0.1	. . . .	. . . .
	4243.6	0	0	0	1		2	1	3	. . . .	. . . .		. .	. . . .	. . . .		*0.5* *0.3*	*0.3* 0.3
	4245.5	0	0	0	1	0	1	1	3	0.1 . .	. . . .	*0.3* *0.2*	. .	. . . .	. . . .	. . . .	*0.1* 0.2	0.2 . .
	4247.3	0	1	1	2	1	1	4	3	0.4 0.0	*0.5* *0.2*	0.2 *0.1*	*0.7*	*0.6* *0.3*	0.1 . .	0.3 0.4	0.1 0.0	*0.2* *0.3*
	4248.7	0	0	1	1	1	1	1	3 g	. . . .	. . . .	. . . .	. .	. . . .	. . *0.1*	. . . .	*0.2* *0.1*	*0.2* *0.3*
	4251.0	0	1	2	3	3	4	4	4	*0.7* *0.3*	. . *0.6*	*0.3* *0.6*	*0.6*	*0.7* *0.5*	*0.4* 0.2	*0.3* *0.4*	*0.2* *0.3*	0.2 *0.2*
	4253.0	0	0	0	0	0	1	1	1 g	. . . .	*0.3* 0.1	. . . .	*1.1*	. . . .	*0.5* *0.7*	. . . .	. . *0.5*	. . . .
	4254.5	0	?	1	1	2	3	5	4	*0.1* 0.2	. . . .	. . 0.0	*0.4*	*0.1* *0.3*	0.0 *0.5*	*0.1* 0.0	*0.1* 0.1	0.2 0.0

Desig.	Wave Length.	VI.	VII.	VIII.	XII.	XIV.	XV.	XVIII.	S. S.	470 484	1486 1507	387 493	1086	453 1717	505 634	393 429	401 475	1493 1504
	4255.7	0	0	0	1	2	2	1	3	. . . .	. . . .	*0.7* 0.3	. .	. . . .	. . . .	0.1 0.2	0.4 0.4	0.5 . .
	4258.7	0	1	1	1	2	2	3	3 g	*0.7 0.5*	*0.7 0.3*	*0.3* 0.0	*0.7*	*1.4 0.3*	*0.1 0.4*	*0.1* 0.0	0.1 0.0	0.0 *0.3*
	4260.5	0	1	1	2	3	3	2	4 g	*0.1* 0.2	. . . .	0.1 *0.1*	*0.1*	*0.2* 0.3	0.1 *0.2*	0.1 0.3	*0.1* 0.0	0.5 0.0
	4261.8	0	0	0	1	1	2	0	3 g	. . . .	0.3 0.2	. . 0.1	0.3	. . 0.8	0.5 1.2	. . . .	*0.1* 0.3	. . . .
	4264.4	0	0	0	0	1	1	0	2 g	. . . .	. . . .	. . . .	. .	*0.9* . .	. . . .	0.2 0.5	0.2 0.2	. . . .
	4268.0	0	0	0	?	1	2	2	3	. . . .	. . . .	0.0 . .	. .	. . . .	*1.0 0.7*	*1.3* 0.0	*0.2* 0.2	0.6 0.5
	4270.0	0	0	0	0	1	1	0	2	. . . .	*0.4* 0.9	. . . .	*1.0*	. . *0.6*	*0.9 0.2*	*0.4 0.3*	*0.1* 0.0	. . . .
	4271.7	1	1	2	3	5	8	8	5 d	*0.4 0.1*	. . . .	0.2 0.1	*0.3*	*0.6 0.4*	0.3 *0.6*	0.1 0.1	0.1 0.3	0.3 0.2
	4273.8	0	0	0	1	0	0	0	3 g	. . . .	*0.7 0.7*	. . *0.6*	*1.0*	. . *0.4*	*0.2 0.6*	. . . .	. . . .	. . . .
	4275.0	0	?	1	2	3	5	6	4	0.4 0.5	0.6 1.2	0.2 0.1	0.5	0.0 0.3	0.3 1.6	0.0 0.2	0.1 0.1	0.1 *0.1*
	4277.3	0	0	0	0	1	1	1	1 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	0.0 0.4	0.0 0.2	*0.4 0.4*
	4278.4	0	0	0	0	0	?	1	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . 0.4	0.3 0.1
	4280.5	0	0	0	1	2	3	2	2 g	. . . .	. . . .	*0.2 0.1*	. .	. . *0.2*	0.2 0.3	*0.1* 0.1	0.0 0.0	0.5 *0.2*
	4282.9	0	0	1	2	2	2	3	3 g	0.1 *0.5*	. . . .	*0.1 0.1*	. .	*0.1 0.1*	0.0 *0.3*	*0.2 0.1*	*0.2* 0.0	*0.3 0.4*
	4284.8	0	0	0	0	0	1	0	2 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	*0.2 0.2*	. . . .
	4286.2	0	0	0	?	2	2	1	2 g	. . . .	. . . .	*0.8* 0.7	. .	. . . .	. . . .	. . *0.3*	*0.3* . .	*0.2 0.3*
	4288.1	0	0	?	1	?	1	1	2 d	*0.3 0.2*	*0.4* . .	*0.3* 0.0	*0.3*	. . *0.5*	*0.1* . .	0.1 . .	*0.7 0.1*	*0.1 0.6*
	4289.9	1	1	2	3	4	5	6	3	0.2 0.3	0.4 0.5	0.5 . .	0.3	0.0 0.3	0.3 . .	. . 0.3	*0.2 0.1*	*0.1 0.1*
	4291.2	0	0	0	1	2	3	7	3 d	. . . .	. . . .	. . *1.1*	. .	. . . .	. . . .	*0.7* . .	*0.2* 0.2	*0.4* 0.1
	4292.2	0	0	0	0	0			2	. . . .	. . . .	. . . .	. .	. . . .	. . 0.6	. . . .		
	4294.3	0	1	1	1	2	2	3	3	*0.5 0.5*	*0.1* 0.0	0.2 0.0	0.1	*0.1* 0.1	0.2 0.7	0.1 0.4	0.1 0.0	. . . .
	4296.0	0	0	0	0	0	0	1	1 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	0.1 0.4
	4297.1	0	0	1	1	2	1	0	2 g	*0.5 0.5*	*0.4 0.6*	*0.2 0.3*	*0.6*	*0.7 0.5*	*0.1* . .	0.1 0.0	*0.1* 0.0	. . . .
	4299.2	1	1	2	2	6	4	8	3 g	0.1 *0.2*	0.4 0.3	*0.4* 0.1	*0.1*	*0.3 0.2*	*0.5* . .	0.1 0.0	0.1 0.2	0.1 0.1
	4300.8	0	0	0	2		4		3 g						. . . .		*0.1*	
	4302.6	1	1	2	3	3	3	4	4	*0.3 0.4*	0.9 0.8	0.0 *0.1*	*0.2*	*0.1* 0.2	0.1 1.5	0.1 0.3	0.3 0.2	0.0 0.1
	4305.8	0	0	0	2	2	2	4	3 g	. . . .	. . . .	*0.3 0.1*	*0.2*	*0.3 0.5*	*0.3* 0.5	0.0 *0.1*	0.0 0.1	*0.4* 0.2
	4308.0	1	1	1	2	5	5	4	5	1.0 0.1	*0.1* 0.0	*0.2* 0.1	0.3	0.3 *0.8*	0.0 0.1	0.4 0.3	0.1 0.1	. . *0.3*
	4309.5	0	?	?	2		2	4	3 g	0.1 . .	. . . .	*0.2 0.1*	0.7	. . *0.2*	0.1 . .	. . . .	*0.3* 0.0	1.1 0.4
	4311.7	0	0	0	0	1	1	0	2 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . *0.7*	*0.5*	. . . .
	4313.0	0	0	1	1	2	2	1	2 d	0.0 . .	. . . .	*0.3 0.3*	0.0	. . . .	0.1 0.2	*0.3 0.3*	*0.4* 0.0	*0.2 0.1*
	4314.3	0	0	0	?	3	5	7	2 d	. . . .	. . . .	. . . .	. .	*0.2* . .	*0.1* . .	0.0 0.3	0.0 0.2	0.1 0.0
	4315.2	1	2	2	3				4	*0.2* 0.3	*0.7 0.4*	*0.2 0.3*	*0.5*	. . *0.5*				
	4317.0	0	0	0	0	0	1	1	1	. . . .	. . . .	. . . .	*0.2*	. . *0.2*	0.0 *0.1*	. . . .	0.2 0.2	0.7 0.2
	4318.9	0	0	0	1	1	1	2	3	. . . .	. . . .	0.2 *0.2*	. .	. . . .	. . . .	0.2 *0.4*	*0.1* 0.3	0.2 0.1
	4321.0	0	?	1	2	2	2	2	3 d	*0.2* 0.2	0.1 0.0	0.0 0.1	0.1	0.0 0.5	0.5 0.4	0.5 0.2	0.2 0.3	0.2 0.1
	4323.7	0	0	0	?	1	2	1	3 g	. . . .	. . . .	*0.6 0.3*	. .	. . . .	. . . .	. . 0.4	0.0 0.0	*1.3 0.5*
	4326.0	1	2	3	4	6	10	11	5	0.1 0.0	*0.3 0.4*	*0.1* 0.1	*0.5*	*0.6 0.1*	*0.4 1.0*	0.0 *0.1*	0.0 0.0	0.3 0.5
	4330.9	0	0	0	2	2	2	3	2	. . . .	*0.1* . .	0.2 *0.2*	0.1	*0.3* 0.0	0.2 *1.2*	0.1 0.0	*0.4* 0.2	0.1 *0.2*
	4333.0	0	0	0	0	1	1	1	1	. . . .	. . . .	. . . .	. .	0.7 1.4	. . 0.0	. . . .	*0.3* 0.1	*0.1 0.1*
	4334.0	0	0	0	0	0	1	1	1 g	. . . .	. . . .	. . . .	. .	. . . .	0.1 . .	0.2 0.1	0.3 0.6	0.7 0.4
	4335.2	0	0	0	0	0	0		1 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . . .
	4337.6	0	0	?	2	5	5	7	·3 g	. . . .	. . . .	0.6 *0.3*	0.3	*0.2* 1.1	0.5 *0.9*	0.6 0.5	0.5 0.5	. . . .
	4339.8	0	0	0	0	0	0	0	3 d	. . . .	. . . .	. . . .	. .	. . . .	. . *0.5*	. . . .	. . . .	. . . .
Hγ	4340.7	65	65	60	16	10	6	4	5	0.1 0.2	*0.2* 0.0	0.1 0.3	0.0	*0.5* 0.6	0.2 0.1	0.0 0.2	0.0 0.3	. . . .
	4343.4	0	0	0	0	0	2	0	2	. . . .	. . . .	. . . .	0.0	. . . .	. . *0.3*	. . . .	. . . .	. . . .
	4344.7	0	0	0	2	2		3	2	. . . .	. . . .	*0.3* 0.5		*0.3 0.5*	*0.6* . .	*0.4 0.1*	*0.2 0.3*	0.1 0.1
	4346.8	0	0	0	0	2	2	0	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	0.0 0.6	. . . .	. . . .
	4348.0	0	0	0	?			4	2 d	. . . .	. . . .	0.2 0.2	. .	. . . .	. . . .		*0.1 0.2*	*0.1 0.3*

Desig.	Wave Length.	VI.	VII.	VIII.	XII.	XIV.	XV.	XVIII.	S. S.	470 484	1486 1507	387 493	1086	453 1717	505 634	393 429	401 475	1493 1504
	4352.0	2	2	3	5	5	5	5	4	0.3 0.0	0.0 0.1	0.1 0.2	0.2	*0.4* 0.1	*0.2 1.6*	0.2 0.3	0.1 0.4	0.0 0.3
	4353.0	0	0	0	0	?	1	2	3	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	*0.2* . .
	4355.3	0	0	0	1	1	1	1	2	. . . .	. . . .	0.4 0.3	. .	*0.3 0.2*	*0.7 1.2*	0.3 0.3	*0.5* . .	*0.5* 0.1
	4356.8	0	0	0	0	0	0	1	1	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	*0.6 0.6*	*0.8* . .
	4358.8	0	0	0	?	3	1	2	3 d	. . . .	. . . .	. . . .	. .	. . . .	0.4 0.0	. . . .	. . . .	. . . .
	4359.9	0	0	0	2		2	3	3	. . . .	. . . .	*0.1 0.1*	0.3	*0.9 0.3*	. . . .	0.1 *0.2*	*0.1* 0.1	0.0 0.0
	4361.0	0	0	0	0	0	0	1	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	0.2 . .
	4362.7	0	0	0	?	2	2	1	1 d	. . . .	. . . .	0.0 *0.3*	. .	. . . .	. . . .	0.1 0.1	0.3 0.1	*0.7* . .
	4364.3	0	0	0				1	2 d	. . . .	. . . .	. . 0.2	. .	. . . .	. . . .			*0.8 0.5*
	4366.8	0	0	0	0	0	?	1	2 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	*0.3* . .	*0.6 0.5*
	4367.9	0	0	0	2	2	3	3	3	. . . .	1.0 0.6	0.0 0.2	*0.1*	*0.3* 0.0	0.2 *0.6*	0.2 0.2	0.1 0.2	0.8 0.6
	4370.0	?	1	1	1	1	1	1	3	*0.8 0.7*	. . . .	0.0 0.1	0.1	. . . .	0.3 . .	. . *0.8*	0.4 0.3	. . . .
	4371.5	0	0	0	1	1	1	1	2	. . . .	. . . .	*0.2* 0.1	0.2	*1.4* 0.4	0.2 *0.7*	*0.3 0.4*	0.1 0.2	0.2 0.2
	4374.7	1	1	2	3	4	4	?	3 g	0.1 *0.1*	*0.7 0.7*	*0.2 0.2*	0.0	*0.2* 0.1	*0.3 0.4*	*0.1 0.1*	0.0 *0.1*	. . . .
	4376.1	0	0	0				6	3								. .	*0.2 0.4*
	4379.4	0	0	0	1	0	1	1	3	. . . .	. . . .	0.9 0.6	*1.0*	0.9 1.0	0.2 0.0	. . . .	. . 0.2	0.8 0.5
	4380.9	0	0	0	0	1	1	0	2	. . . .	. . . .	. . . .	0.1	. . . .	. . . .	*0.4* 0.1	*0.1* 0.2	. . . .
	4383.7	1	2	4	3	11	10	13	5	0.2 0.9	. . . .	0.9 0.3	0.1	0.9 . .	0.5 0.1	. . 0.0	0.4 0.9	0.1 . .
	4385.2				3		5		3 g	0.4 . .	0.4 0.2	1.3 0.1	0.2	. . 0.2		*0.4 0.1*	*0.1* . .	*0.4 0.5*
	4387.8	0	0	0	1	1	1	?	2 g	. . . .	. . . .	0.9 0.9	. .	. . . .	. . . .	0.2 *0.2*	*0.2* 0.2	. . . .
	4389.8	0	0	0	0	0	1	4	2 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . 0.5	0.0 0.0
	4391.2	1	1	1	1	2			3	0.1 *0.6*	*0.6* 0.1	0.0 0.3	0.2	*0.1* 0.3	. . *0.5*	0.4 0.0	. . . .	
	4392.0	0	0	0	0		1	1	2 g	. . . .	. . . .	. . . .	. .	. . . .	*0.3* . .	. . . .	0.3 *0.5*	. . . .
	4394.3	0	0	0	0	0	1	0	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . 0.3	*0.9* . .
	4395.3	1	2	3	3	3	3	4	3 d	*0.3* 0.2	0.2 0.1	0.4 0.3	*0.1*	0.0 0.3	0.5 *0.1*	0.4 0.4	0.4 0.6	0.3 0.3
	4398.2	0	0	0	?	0	1	1	2	. . . .	. . . .	*0.1* 0.0	. .	. . . .	0.5 *0.7*	. . . .	. . 0.2	*0.1* 0.0
	4400.2	0	1	1	2	0	0	0	3 d	. . . .	*0.1* 0.0	0.4 0.1	0.3	0.5 0.2	. . 0.1	. . . .	. . . .	. . . .
	4401.6	0	0		3	3	3	4	3	1.3 *1.3*	. . . .		. .	. . . .	*0.6* . .	*0.3 0.6*	*0.5 0.3*	0.0 *0.6*
	4405.0	0	1	1	2	4	6	7	5	0.1 0.0	*0.3* 0.2	0.0 *0.1*	0.1	0.0 0.3	0.3 *0.6*	0.1 0.0	*0.1* 0.3	0.6 0.4
	4408.5	0	0	0	2	2	4	7	3	. . . .	. . . .	0.1 0.0	. .	. . 0.4	0.9 0.0	0.4 0.3	0.3 0.5	0.4 0.0
	4412.1	0	0	0	1	1	1	1	2	. . . .	. . . .	*0.1 0.7*	*1.5*	*0.5 0.1*	0.3 *1.1*	0.0 0.0	0.1 0.5	0.8 0.1
	4415.3	1	1	1	2	3	4	4	4	. . . .	. . . .	0.0 0.2	. .	0.3 0.3	0.3 *0.3*	0.1 0.2	0.2 0.5	0.3 0.3
	4417.9	0	1	2	2	2	1	2	2	0.2 *0.4*	*0.5 0.5*	0.5 0.1	*0.2*	0.3 *0.4*	0.5 *0.1*	0.2 0.5	*0.3 0.3*	0.5 0.3
	4420.5	0	0	0	0	0	?	1	1	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . 0.0	*0.3* . .
	4422.8	0	0	1	2	3	3	3	2	1.4 . .	. . . .	0.2 0.1	*0.1*	*0.2 0.1*	*0.2* 0.2	0.4 0.2	0.0 0.1	*1.0 0.5*
	4424.2	0	0	0	0	0	?	1	1	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . 0.5	*1.1* 0.0
	4425.6	0	0	0	1	1	2	2	2	. . . .	. . . .	0.4 *0.1*	. .	. . . .	. . . .	*0.3* 0.1	0.4 0.6	0.4 0.1
	4427.4	0	0	0	2	1	2	4	3 d	. . . .	. . . .	0.2 0.2	. .	0.5 0.0	0.4 0.4	0.0 0.4	0.3 0.5	0.3 0.4
	4430.8	0	0	0	2	2	4	3	2	. . . .	. . . .	0.1 *0.2*	. .	*0.1* 0.1	*0.3 0.2*	*0.2* 0.2	*0.4* 0.1	0.2 *0.3*
	4433.5	0	0	?	0	0	1	?	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	0.7 0.4	0.3 0.3
	4435.2	0	0	0	2	3	5	8	3 d	. . . .	. . . .	0.3 0.5	. .	0.2 0.4	0.4 0.3	0.5 0.4	0.3 0.8	0.8 0.6
	4438.5	0	0	0	0	0	1	1	1	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	*0.1 0.2*	0.2 0.1
	4441.0	0	0	0	0	0	1	0	1 g	. . . .	. . . .	*1.4* . .	. .	. . . .	. . . .	. . . .	*0.3* . .	. . . .
	4442.5	0	0	0	?	1	2	3	3	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	0.3 . .	0.2 0.3
	4444.0	1	1	2	2	2	2	3	3	0.0 0.1	0.8 0.1	*0.3 0.2*	0.3	*0.5 0.3*	0.0 *0.2*	*0.6 0.2*	0.5 *0.6*	*0.4* 0.1
	4445.7	0	0	0	0	0	0	1	1	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	0.5 0.2
	4447.9	0	0	0	1	1	2	2	3	. . . .	. . . .	0.1 0.0	. .	. . . .	. . . .	*0.5 0.3*	*0.1* 0.0	*0.3 0.2*
	4450.6	0	0	1	2	2	2	2	2 d	0.4 0.8	0.7 0.9	0.7 0.4	0.4	0.5 0.7	0.1 0.3	0.0 0.2	0.1 0.1	0.6 *0.1*
	4453.5	0	0	0	0	0	1	1	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	*0.2 0.2*	*0.3 0.2*

Desig.	Wave Length.	VI.	VII.	VIII.	XII.	XIV.	XV.	XVIII.	S. S.	470 484	1486 1507	387 493	1086	453 1717	505 634	393 429	401 475	1493 1504
	4455.0	0	0	1	3	3	2	3	4 g	2.1 0.7	. . . .	0.6 1.1	*0.1*	0.2 0.6	*0.1* 0.8	0.3 0.3	0.3 0.5	0.7 0.6
	4457.6	0	0	0	0	0	0	?	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	*0.3* . .
	4459.3	0	0	0	2	2	2	2	3	. . . .	. . . .	*0.1* 0.4	. .	. . . .	. . . .	0.2 0.1	0.3 0.7	0.8 0.5
	4462.0	0	0	0	2	3	4	5	3 d	. . . .	. . . .	0.3 0.0	0.0	0.0 *0.7*	0.2 *0.1*	0.0 0.3	0.3 0.7	0.3 0.3
	4464.8	0	0	0	1	1	1	1	3 d	. . . .	. . . .	. . 0.0	0.1	*0.1 0.1*	0.2 *0.5*	0.0 0.5	0.3 0.7	. . . .
	4466.8	0	0	0	1	1	1	3	3	. . . .	. . . .	*0.2 0.2*	. .	. . . .	. . . .	0.2 *0.1*	0.1 0.4	0.1 0.0
	4469.5	?	1	1	2	2	2	2	2	*0.1 0.5*	*0.5 0.3*	0.0 0.3	*0.7*	*0.5 0.6*	*0.3* 0.0	0.3 0.5	*0.1* 0.4	*0.4 0.5*
	4471.0	0	0	0	2	1	1	0	2	. . . .	. . . .	*0.3* . .	. .	0.1 . .	0.3 *0.1*	. . . .	0.5 0.8	. . . .
	4473.0	0	0	0	1	0	1	3	2 d	. . . .	. . . .	0.1 0.1	. .	0.0 0.8	0.6 0.1	*0.6* . .	0.0 0.4	*0.6 1.0*
	4475.0	0	0	0	0	0	1	2	1	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . 0.6	. . . .
	4476.2	0	0	0	1	1	2		3	. . . .	. . . .	*0.2* 0.2	. .	0.2 0.2	0.4 1.0	0.2 0.3	*0.4* 0.4	0.1 *0.3*
	4480.0	0	0	0	0	?	3	1	2 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	0.7 0.5	0.3 . .
	4481.4	4	4	5	5	4	0	0	2 d	0.7 0.4	0.3 0.4	. . . .	0.3	0.3 . .	0.3 . .	. . . .	. . . .	. . . .
	4482.5	0	0	0			3	5	4	. . . .	. . . .	*0.6 0.4*	. .	. . 0.1		*0.4 0.8*	0.0 0.4	0.0 *0.1*
	4484.4	0	0	0	0	?	1	1	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	0.0 0.7	0.2 *0.1*
	4485.9	0	0	0	?	0	?		2	. . . .	. . . .	0.1 0.2	. .	. . . .	. . . .	. . . .	. . . .	. . *0.1*
	4488.4	0	0	0	0	0	0	?	2 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . *0.9*
	4490.0	0	1	1	2	4	4	5	2 d	. . *0.7*	*0.6 0.5*	*0.1 0.8*	*0.6*	*0.6 0.5*	*0.5* 0.4	0.1 0.2	0.1 0.4	0.4 0.4
	4491.6	0	0	1	2	0	0	0	2	*0.7* 0.2	0.5 0.2	. . 0.3	0.2	0.3 *0.2*	0.0 . .	. . . .	. . . .	. . . .
	4494.8	0	0	0	1	2	3	2	3	. . . .	. . . .	0.1 0.0	0.0	*0.4* 0.0	0.1 0.6	0.1 1.0	0.3 0.2	0.0 0.1
	4497.0	0	0	0	1	1	3	4	2	. . . .	. . . .	*0.7 0.2*	. .	0.2 0.2	0.2 0.6	0.1 . .	*0.3* 0.2	*0.1 0.1*
	4499.1	0	0	0	1	0	1	1	2 d	. . . .	. . . .	*0.6* 0.0	. .	. . . .	. . . .	. . . .	0.2 *0.2*	. . 0.4
	4501.5	0	1	2	3	3	3	3	3	*0.1* 0.0	0.1 0.0	*0.2 0.3*	*0.2*	*0.6* 0.0	*0.3* 0.4	*0.3* 0.1	*0.1* 0.5	0.5 0.3
	4507.0	0	0	0	0	0	1	2	0	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	*1.3* . .	*0.2* 0.8
	4508.5	1	1	2	2	2	?	0	3	*0.1 1.2*	0.3 0.4	*0.1* 0.0	0.3	0.2 0.3	0.3 0.9	0.6 *0.4*	1.8 *0.3*	. . . .
	4513.0	0	0	0	0	1	1	2	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . *0.2*	*0.7* 1.2	. . 0.7
	4515.4	0	1	2	2	2	1	0	2	0.9 0.3	0.4 0.5	*0.1 0.2*	0.2	0.2 0.2	0.3 1.1	0.0 0.1	. . . .	*0.9* . .
	4518.0	0	0	0	1	1	2	3	2 g	. . . .	. . . .	0.9 0.6	. .	. . . .	. . . .	0.3 0.3	0.4 1.0	0.4 . .
	4520.3	0	1	1	1	1	1	1	2 d	0.4 0.6	0.6 0.8	. . 0.5	0.4	*0.4* 0.3	0.4 0.4	0.4 0.0	*0.1* 0.6	*0.4* . .
	4522.9	1	1	1	2	2	2	2	3 d	0.8 0.1	2.4 . .	0.1 0.1	0.0	0.4 *0.2*	0.7 0.5	*0.1* 0.0	0.1 0.6	1.4 0.4
	4525.3	0	0	0	1	0	?	0	3	. . . .	. . . .	*0.3 0.3*	. .	. . *0.2*	. . . .	*1.1 1.1*	. . 0.3	. . . .
	4527.0	0	0	0	1	1	1	3	3 g	. . . .	. . . .	*0.3 0.1*	. .	. . . .	. . . .	. . *0.4*	0.2 0.4	. . 0.5
	4528.8	0	0	0	1	1	2	3	4	. . . .	. . . .	*0.1* 0.3	0.5	0.7 0.4	0.3 *0.9*	. . *0.1*	0.1 0.5	*0.2 0.2*
	4531.2	0	1	0	1	1	2	3	3 g	. . . .	. . . .	*0.5* 0.1	. .	. . 0.3	0.3 *0.9*	0.5 *0.1*	0.2 0.2	0.2 *0.2*
	4534.2	1	1	2	2	?	1	?	3 d	0.2 0.5	0.0 0.4	0.8 0.1	*0.1*	0.7 0.7	0.3 . .	. . . .	. . *0.3*	. . . .
	4535.0	0	0	0	0	0	0	7	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	0.1 0.2
	4536.0	0	0	0	2	3	4		3 g	. . . .	. . . .	. . 0.2	. .	. . . .	. . *0.6*	*0.5 0.6*	*0.2* 0.3	
	4541.6	0	1	1	1	2	2	3	2	*0.4* 0.1	0.3 0.5	*0.8* 0.1	0.6	*0.8* 0.5	*0.3* 1.1	*0.2 0.4*	*0.4 0.7*	*0.4* 0.0
	4544.9	0	0	0	1	?	2	3	3	. . . .	. . . .	0.4 0.1	0.4	0.4 0.3	0.7 . .	0.2 0.8	0.6 0.1	1.3 0.6
	4547.2	0	0	0	0	2	0	0	2 d	. . . .	. . . .	. . *0.2*	. .	. . . .	. . *0.8*	. . . .	. . 0.5	. . . .
	4549.7	2	2	3	4	3	3	4	4 d	0.1 0.3	*0.1* 0.4	0.1 0.0	0.1	0.4 0.4	0.1 2.0	0.1 0.1	*0.1* 0.2	0.4 *0.1*
	4552.7	0	0	0	0	0	1	1	4	. . . .	. . . .	. . *0.8*	. .	. . . .	. . . .	*0.3* . .	0.0 0.1	. . *0.5*
	4554.2	0	?	1	1	1	1	3	4	*0.3* . .	. . . .	0.6 0.1	. .	. . . .	. . . .	. . *0.3*	0.2 0.6	0.0 0.1
	4556.0	1	1	2	2	2	2	2	3 g	. . *0.5*	*0.1* 0.1	. . 0.1	*0.3*	*0.5 0.7*	*0.3* 0.8	*0.3 0.4*	0.4 *0.1*	*0.3 0.3*
	4558.9	0	1	1	1	1	1	1	2	0.1 0.3	*0.2* 0.1	0.4 *0.6*	0.3	0.9 0.8	0.4 . .	*0.6* 0.8	. . *0.5*	. . . .
	4561.0	0	0	0	1	1	1	2	1 d	. . . .	. . . .	. . *0.3*	. .	. . . .	. . 0.8	*0.3* . .	*0.1 0.4*	*0.6 0.3*
	4564.0	1	1	2	2	4	1	3	3	0.3 0.2	0.4 0.4	0.5 *0.2*	*0.2*	0.4 0.8	*0.2* . .	. . . .	0.2 *0.1*	*0.3 0.2*
	4565.8	0	0	?	1		3	2	3 d	. . . .	. . . .	2.5 0.7	. .	. . . .	. . 0.8	*0.1 1.0*	*0.7* 0.3	0.0 *0.3*
	4569.0	0	0	0	0	1	1	0	2	. . . .	. . . .	. . . .	. .	. . . .	. . .	*0.1* . .	*0.5* 0.2	. . . .

Desig.	Wave Length.	VI.	VII.	VIII.	XII.	XIV.	XV.	XVIII.	S. S.	470 484	1486 1507	387 493	1086	453 1717	505 634	393 429	401 475	1493 1504
	4572.2	1	1	2	3	3	4	4	3	0.1 0.2	0.4 0.2	*0.3* 0.0	0.1	0.3 0.2	0.1 . .	*0.2 0.3*	*0.2* 0.0	0.1 *0.2*
	4574.7	0	0	0	0	1	1	1	2 d	. . . .	. . . .	. . . .	. .	. . . .	. . *0.3*	*0.1* . .	1.2 0.2	0.7 1.0
	4576.5	0	0	1	1	1	?	1	2	0.5 0.2	0.1 0.1	0.3 0.2	*0.1*	0.2 . .	*0.2* 1.4	0.7 *0.3*	. . 0.3	0.7 0.8
	4578.7	0	0	0	0	0	0	1	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . . .
	4580.2	0	0	0	?	2	2	3	2	. . . .	. . . .	*0.6* . .	. .	. . . .	. . . .	*0.2* 0.2	0.4 0.7	0.4 0.2
	4581.7	0	0	0	1		1	0	4	. . . .	. . . .	. . *0.4*	. .	. . . .	. . . .	0.5 1.3	. . . .	. . . .
	4584.0	1	1	2	2	2	1	2	2	*0.1 0.1*	*0.1* 0.2	*0.5 0.1*	*0.2*	*0.1* 0.0	*0.1* . .	*0.1* . .	*0.2* 0.1	0.9 0.0
	4586.1	0	0	0	1	1	2	2	3	. . . .	. . . .	. . 0.3	. .	. . . .	. . *0.1*	*0.1 0.6*	0.5 0.4	0.7 0.0
	4588.4	0	1	1	1	0	0	0	2	*0.6* 0.7	. . . .	1.0 *0.1*	. .	. . . .	. . . .	. . *0.8*	. . . .	. . . .
	4590.1	0	0	0	1	0	0	0	2	. . . .	. . . .	. . 0.1	. .	. . . .	. . . .	. . . .	. . . .	. . . .
	4592.8	0	0	?	2	2	1	2	4 d	*0.7* 0.2	. . . .	*0.5* 0.0	. .	*0.6* 1.1	0.2 . .	*0.2 0.7*	*0.5 0.6*	*0.7 0.9*
	4595.9	0	0	0	1	1	1	3	2 g	. . . .	. . . .	*0.4* 0.0	. .	. . . .	. . 0.3	*0.2* 0.6	*0.7* 0.0	*1.2 1.2*
	4598.2	0	0	0	1	1	1	1	2 g	. . . .	. . . .	*0.7* 0.2	. .	. . . .	. . . .	*0.2* . .	*0.4* 0.1	*0.1* 0.1
	4600.6	0	0	0	1	2	2	2	3 g	. . . .	. . . .	0.1 0.5	. .	. . . .	. . . .	0.2 0.7	0.2 0.1	*0.2* 0.2
	4603.1	0	0	0	0	?	1	1	3	. . . .	. . . .	. . . .	. .	. . . .	. . . .	0.0 . .	*0.8* 0.1	*1.1 0.1*
	4605.5	0	0	0	1	1	1	0	2	. . . .	. . . .	. . 0.2	. .	. . . .	. . . .	0.3 0.5	. . *0.4*	. . . .
	4606.4	0	0	0	0	0	?	3	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	*0.3* 0.0
	4607.9	0	0	0	1	1	1		2	. . . .	. . . .	*0.4 0.5*	. .	. . . .	. . . .	0.3 . .	0.0 *0.3*	
	4611.4	0	0	0	1	1	1	1	4	. . . .	. . . .	*0.2 0.2*	. .	. . . .	. . . .	*0.2* 0.0	*0.3 0.4*	0.5 0.2
	4613.5	0	0	0	1	1	1	2	3 d	. . . .	. . . .	0.0 0.1	. .	. . . .	0.4 *1.0*	0.2 0.0	0.2 . .	0.5 *0.1*
	4616.9	0	0	0	1	1	1	2	3 g	*0.3* . .	. . . .	*0.1 0.7*	. .	0.3 *0.3*	0.0 0.3	*0.6 0.2*	0.0 *0.3*	*1.0* 0.0
	4619.2	0	1	1	1	2	2	2	3 g	. . . .	0.9 0.4	*0.1* 0.8	0.5	1.1 1.0	1.0 1.4	0.4 0.0	0.5 0.7	0.9 1.0
	4622.8	0	0	0	0	1	1	1	2 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	*0.4* 0.2	0.0 0.8	1.6 0.1
	4625.8	0	0	0	1	1	1	2	3 d	. . . .	. . . .	0.7 *0.1*	. .	0.3 . .	0.1 *0.7*	0.6 0.3	0.6 1.1	0.5 0.6
	4629.9	0	1	1	2	2	2	3	3 d	*0.9* 0.1	*0.4* 0.0	0.1 *0.2*	*0.3*	*0 2* 0.2	0.1 . .	*0.5 0.1*	*0.1* 0,1	0.4 0.2
	4633.0	0	0	0	1	2	1	1	3	. . . .	. . . .	0.5 0.7	. .	. . . .	1.2 . .	0.5 0.8	0.3 0.4	. . . .
	4635.3	0	1	1	?	0	1	1	0	*1.1 0.4*	. . . .	1.3 0.5	. .	. . . .	. . . .	0.1 . .	*0.2* 0.0	*0.5 1.0*
	4638.0	0	0	0	1	1	1	1	3	. . . .	. . . .	1.0 0.2	. .	. . . .	. . . .	*0.3 0.9*	*0.7 0.3*	0.0 *0.5*
	4640.0	0	0	0	0	1	3	3	2 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	0.4 *0.3*	0.1 0.4	0.4 0.0
	4643.7	0	0	0	0	?	1	1	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	0.1 . .	0.1 *0.1*	*0.1 0.2*
	4647.6	0	0	0	3	4	4	4	2	. . . .	. . . .	0.1 *0.2*	. .	0.1 0.4	. . . .	*2.0* 0.1	*0.1 0.5*	*0.3 0.6*
	4652.0	0	0	0	1	?	1	2	3 d	. . . .	. . . .	. . *0.2*	. .	. . . .	. . . .	*1.5* . .	0.3 0.0	0.0 0.1
	4654.8	0	0	0	1	1	1	1	4	. . . .	. . . .	*0.7 0.1*	. .	. . . .	. . *1.6*	*1.3* . .	*0.2 0.1*	*0.8 0.8*
	4657.0	0	0	0	1	2	3	4	2 g	. . . .	. . *0.5*	0.5 0.2	0.1	0.3 0.5	0.5 . .	1.9 *0.7*	*0.6* 0.0	*0.1 0.4*
	4663.7	0	0	0	1	2	2	2	2 g	. . . .	. . . .	. . *0.7*	0.3	0.2 0.1	*0.1 2.0*	*0.7 0.7*	*0.3 0.3*	*0.1 0.2*
	4668.0	0	0	1	4	5	5	5	4 g	*1.0* . .	. . . .	*0 3* 0.1	*1.2*	*0.3 0.3*	*0.4* 0.5	0.2 *0.5*	*0.1* 0.1	0.8 0.5
	4670.5	0	0	0	0	0	0	0	2 d	. . . .	. . . .	. . . .	*0.5*	0.1 *0.4*	*0.5* . .	. . . .	. . . .	. . . .
	4673.3	0	0	0	1	2	0	1	3	. . . .	. . . .	0.8 *0.1*	. .	. . . .	. . . .	0.7 0.8	. . . .	*1.5* . .
	4674.8	0	0	0	0	?	2	2	2 g	. . . .	. . . .	. . . .	. .	. . . .	. . *0.5*	. . . .	0.0 0.4	0.2 0.4
	4679.0	0	0	0	1	2	0	0	3	. . . .	. . . .	0.2 *0.4*	. .	0.9 . .	*1.0* . .	*0.8* . .	. . . .	*1.6* . .
	4680.6	0	0	0	0	?	1	?	3 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . *0.5*	. . . .	. . . .
	4682.2	0	0	0	1	2	2	3	3 g	. . . .	. . . .	0.3 . .	. .	*0.3 0.7*	. . . .	0.1 . .	*0.3 0.6*	0.2 *0.4*
	4688.0	0	0	0	0	?	1	2	2 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	0.4 *0.7*	0.1 *0.1*
	4691.6	0	0	0	1	?	1	1	3 d	. . . .	. . . .	0.4 *0.3*	. .	1.1 0.5	0.9 . .	. . . .	*0.2 0.3*	. . *0.3*
	4694.0	0	0	0	0	1	1	1	1 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	0.4 0.9	*0.1* 0.7	*0.9* 0.4
	4698.8	0	0	0	1	3	3	3	3 g	. . . .	. . . .	0.5 *0.1*	. .	0.5 0.4	0.5 *1.0*	*0.2* 0.0	*0.2* 0.1	1.2 0.6
	4703.1	0	?	1	3	3	2	2	4	0.0 . .	. . . .	0.6 0.1	. .	*0.1* 0.4	1.1 2.5	0.3 *0.1*	0.5 0.2	0.7 0.7
	4707.5	0	0	0	0	0	?	2	3 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . . .
	4709.0	0	0	0	3	3	0	0	2 g	. . . .	. . . .	*0.4 0.3*	0.1	0.0 0.1	0.0 0.9	0.6 0.0	0.3 0.3	. . . .

Desig.	Wave Length.	VI.	VII.	VIII.	XII.	XIV.	XV.	XVIII.	S. S.	470 484	1486 1507	387 493	1086	453 1717	505 634	393 429	401 475	1493 1504
	4710.2	0	0	0	0	0	2	3	2 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	*0.4 0.9*
	4714.5	0	?	0	2	3	3	3	3	. . . .	. . . .	0.6 0.2	. .	0.6 1.3	1.4 1.7	0.7 0.1	0.4 0.5	0.7 1.2
	4718.6	0	0	0	1	1	0	?	2	. . . .	. . . .	0.3 0.0	. .	. . . .	. . . .	*0.6 0.1*	. . . .	1.1 0.4
	4722.3	0	0	0	1	1	2	2	2	. . . .	. . . .	0.3 0.9	. .	. . . .	. . . .	0.6 0.8	1.5 1.0	1.1 1.4
	4727.6	0	0	0	2	3	3	3	3	. . . .	. . . .	*0.2* . .	. .	1.4 . .	. . *0.7*	*0.6 0.7*	0.6 . .	1.7 1.2
	4731.7	0	1	0	2	1	1	2	3	. . . .	0.0 0.1	. . 0.4	*0.2*	0.3 0.1	*0.3 1.4*	1.6 0.6	*0.6* . .	*0.2 0.1*
	4733.8	0	0	0	0	0	1	2	3	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	0.1 0.4	0.0 0.1
	4737.0	0	0	0	2	2	2	2	3	. . . .	. . . .	0.0 *0.2*	. .	0.7 0.1	0.3 1.0	0.1 0.0	0.4 0.2	*0.9* 0.5
	4741.1	0	0	0	1	1	2	0	2 d	. . . .	. . . .	0.4 0.5	. .	. . . .	. . . .	0.6 0.2	0.5 0.6	. . . .
	4743.0	0	0	0	0	0	?	2	1	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	*0.7 1.2*
	4746.0	0	0	0	1	?	1	1	3	. . . .	. . . .	0.0 *0.4*	. .	. . . .	. . . .	*0.1 0.6*	*0.7 0.2*	*0.6 0.3*
	4748.4	0	0	0	0	?	0	0	3	. . . .	. . . .	. . . .	. .	. . . .	. . . .	0.2 . .	. . . .	. . . .
	4750.0	0	0	0	0	0	0	1	2 g	. . . .	. . . .	. . . .	1.3	. . . .	. . . .	. . 0.7	. . . .	0.0 *0.7*
	4754.2	0	0	0	1	1	1	2	3	. . . .	. . . .	*1.1 0.1*	. .	0.2 . .	. . . .	. . . .	0.2 *0.3*	0.8 *0.2*
	4756.4	0	0	0	1	1	1	?	3 d	. . . .	. . . .	0.1 0.5	0.6	. . . .	*0.8* . .	. . . .	. . *0.1*	. . . .
	4758.7	0	0	0	0	0	1	2	2 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	1.0 *0.1*	0.3 . .	0.3 0.5
	4762.6	0	0	0	2	2	2	3	3	. . . .	. . . .	1.1 0.8	. .	. . . .	. . 0.2	*0.9* . .	0.1 . .	0.5 . .
	4764.1	0	0	0	0	0	?	0	3	. . . .	. . . .	. . . .	*0.7*	0.5 0.1	*0.3* . .	. . . .	. . 0.5	. . . .
	4766.1	0	0	0	2	2	2	4	3	. . . .	. . . .	. . 0.6	. .	. . . .	. . . .	*1.0* . .	0.2 . .	0.3 *0.5*
	4768.5	0	0	0	0	0	0	1	3	. . . .	. . . .	*0.4* . .	. .	. . . .	. . . .	. . *0.5*	. . *0.1*	1.3 . .
	4771.8	0	0	0	2	2	3	4	3 d	. . . .	. . . .	0.3 . .	. .	0.0 0.7	0.3 *0.1*	*0.1* 0.7	0.0 0.0	. . . .
	4773.0	0	0	0	0	0			3	. . . .	. . . .	. . *0.3*	. .	. . . .	. . . .	. . . .		0.6 0.1
	4776.5	0	0	0	0	1	0	0	2 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	0.1 . .	0.5 *0.3*	1.1 0.5
	4780.1	0	0	0	1	0	0	1	2	. . . .	. . . .	. . *0.3*	. .	. . . .	*0.1* 0.8	. . . .	0.4 1.0	. . . .
	4783.6	0	0	0	1	?	1	2	4	. . . .	. . . .	*0.9* 0.3	. .	. . . .	. . . .	*0.5 0.8*	*0.4* 0.1	0.5 0.6
	4786.8	0	0	0	1	1	1	1	3 d	. . . .	. . . .	. . 1.0	. .	*1.0* . .	*0.2* 0.2	*0.4* 0.1	*0.6 0.2*	. . . .
	4789.7	0	0	0	1	1	1	1	3 d	. . . .	. . . .	1.5 0.4	. .	. . . .	. . . .	0.1 *0.6*	0.3 *0.3*	. . . .
	4792.7	0	0	0	0	1	1	1	2 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	*0.2 0.4*	0.1 0.1	*0.1* 0.8
	4799.9	0	0	0	1	2	3	3	2	. . . .	. . . .	*0.9 0.6*	. .	0.2 *0.6*	*0.1* . .	*0.5* 0.1	*0.3 0.3*	0.0 *0.2*
	4805.2	0	0	0	1	1	0	2	3	. . . .	. . . .	0.0 . .	*0.2*	0.7 0.4	1.1 . .	0.0 0.9	. . . .	0.3 . .
	4808.0	0	0	0	0	1	2	2	2 g	. . . .	. . . .	. . . .	. .	. . . .	. . *0.6*	0.8 0.6	0.6 *0.9*	. . *1.1*
	4813.0	0	0	0	0	0	0	2	1 g	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	0.8 1.3	*0.8 1.0*
	4818.0	0	0	0	0	0	1	2	2	. . . .	. . . .	. . . .	*2.0*	. . . .	. . . .	. . . .	. . . .	0.3 *1.3*
	4821.0	0	0	0	0	0	0	1	2 d	. . . .	. . . .	. . . .	. .	. . . .	. . 0.9	. . . .	*0.8 0.8*	*0.4 0.5*
	4824.0	0	1	1	4	4	3	3	3 d	. . *2.9*	. . . .	*0.2* 0.7	0.6	*0.3* 0.5	0.6 . .	0.2 0.1	0.3 0.0	0.6 0.5
	4829.3	0	0	0	0	1	1	3	3 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . *0.1*	*0.4* 0.1	*0.2 0.4*
	4832.9	0	0	0	0	1	2	4	2	. . . .	. . . .	. . . .	. .	. . . .	. . . .	*0.1 0.4*	*1.1 0.8*	0.5 *0.3*
	4836.0	0	0	0	0	1	?	1	2	. . . .	. . . .	. . . .	0.9	1.4 0.2	. . . .	0.2 1.7	*0.2* 0.0	0.9 0.8
	4839.9	0	0	0	0	1	2	2	3 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	1.3 0.0	1.0 *0.4*	0.9 0.6
	4843.2	0	0	0	0	1	2	2	2 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	0.9 0.4	0.8 *0.1*	0.5 *0.4*
	4848.4	0	0	0	1	2	2	2	2	. . . .	. . . .	*1.9* 1.4	0.5	*0.1* 0.8	1.0 . .	1.3 0.3	0.8 *0.4*	0.7 0.8
	4852.3	0	0	0	0	0	?	2	2 d	. . . .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	0.3 *0.4*	*0.4 0.2*
	4855.7	0	0	0	0	3	3	2	3 d	. . . .	. . . .	. . . .	*0.1*	*0.5* 0.5	. . . .	0.5 0.1	*0.1* 0.3	0.7 0.6
H β	4861.5	65	65	60	16	10	6	4	5	. . *0.1*	. . . .	*0.3* 0.6	*0.5*	*0.5* 0.9	0.4 . .	0.4 *0.2*	*0.3 0.4*	0.4 0.4

REMARKS.

3735.0. Broad solar band omitted in table.
3749.4. Strong solar band omitted in table. Perhaps combined with Hκ.
3767.3. Strong solar line omitted in table.
3782.0. Diffuse band. Other stronger bands omitted in table.
3820.5. The line in β Persei of Group VI. is really the Orion line 3819.2, which may or may not combine with the solar line 3820.5.
3835.5. The intensity given for this line in α Canis Minoris is really that of a band which in the spectra of smaller dispersion appears to extend from wave length 3832.5 to 3840.8.
3854.6, 3856.5, 3863.9. In β Persei of Group VI., the lines present are the Orion lines 3854.2, 3856.2, and 3863.2.
3890.5. Many stronger solar lines near.
3933.8. The intensity given for this line in Group XVIII. is the average of the estimated intensities in a number of stars of the group.
3968.6. The intensity given for this line in Group XVIII. is the average of the estimated intensities in a number of stars of the group. This line as seen in stars of Group XV. forms a band fading at the edges and extending from 3963.4 to 3974.7.
4015.2. This line does not appear in the solar spectrum.
4069.4. Stronger solar lines near which are omitted in table.
4101.8. The estimated intensity of this and the remaining lines of hydrogen given in Group XVIII. is the average intensity estimated in a number of stars in the group. The intensity of these lines in α Orionis, estimated as 8, is considerably higher than in the other stars of the group.
4128.5. This is an Orion line.
4131.4. This is an Orion line.
4140.3. This is the centre of a double line, 4140.1, 4140.5, in the solar spectrum. In α Orionis 4140.1 alone is present.
4143.9. This band in the solar spectrum includes 4143.7 and 4144.0. The Orion line 4144.0 appears to fall within this band, and is present at least in Group VI. See remark on this line on p. 126.
4160.2. The principal line as seen on Rowland's map is at 4160.6, but faint accompanying lines extend to 4159.8. As the line in α Boötis appears somewhat wide and hazy, and as the micrometric measures indicate a shorter wave length than 4160.6, it is probable that the band in α Boötis includes all these lines.
4165.6. This band as seen in α Orionis probably extends to 4164.5 so that the centre would have the wave length 4165.0.
4227.0. The intensity given for Group XVIII. is the average of the estimated intensities in a number of stars in the group. The intensity in α Orionis is estimated as 15, but this is much less than in the other stars.
4233.6. This band in α Orionis is more extensive than in the Sun.
4247.3. This line is seen in photographs of α Lyræ, and not in those of α Canis Majoris.
4253.0. The lines in this group are very faint.
4289.9. This band as seen in the Sun is wide and complex. The strongest line in it is at wave length 4289.9.
4340.7. See remark on 4101.8.
4356.8. Stronger solar lines near which are omitted in table.
4387.8. Other stronger lines near in solar spectrum.
4507.0. This line is extremely faint in the solar spectrum.
4635.3. Only faint lines present in this part of the solar spectrum.
4758.7. The group in the solar spectrum includes 4758.0 and 4759.5. It was not possible to decide whether one only, or both, of these were present in α Boötis and α Orionis.
4861.5. See remark on 4101.8.

The average value of the residuals in Table V. is ± 0.03.

As regards the degree of accuracy with which the wave lengths can be obtained by the method of identification here used, and described in the Introduction, it is to be said that, since the majority of lines seen in photographs of the Sun and stars of the second type taken with the same number of prisms correspond with double or multiple bands on Rowland's map, it is impossible to determine which components are present in any given star. All that can be done is to assume the centre of the band. Then, should it be resolvable in any of the stars, or should it appear narrower and be coincident with only a portion of the solar band, distinctions can be made. This, however, could only be done where the solar band had considerable width. The degree of accuracy with which the wave lengths can be obtained of course increases with the decreasing wave length.

It will be seen from this table that the solar lines as a whole steadily increase in number and intensity from Group VI. to Group XVIII. Although the groups between VIII. and XII. could not be here represented, it is perfectly clear from the plates of lower dispersion that the increase is uniform through these groups. The same applies to Groups XIII., XVI, and XVII., not represented in the table.

The degree of increase in intensity from Group VI. to Group XVIII. is in reality greater than appears from the estimated intensities, it being almost impossible to represent all the varying degrees of intensity shown in these lines.

Since the lines seen in the stellar photographs are evidently more or less complex, the question arises whether this apparent increase in their intensity is due to a real increase in the intensity of the constituent lines, or whether it results merely from increasing complexity. It is probably due to both causes.

From the general aspect of the spectral lines in the early first type stars, it can hardly be doubted that they are almost all single. This may be best seen in α Lyræ, the lines of which are very narrow and beautifully sharp and clear. In the following groups these lines grow wider, and more dense and complex in appearance, and in Group XIV. they may, from their close resemblance to the lines of the Sun, be fairly assumed to have nearly the same components. In the groups lying beyond the Sun in the series, especially in α Orionis, the lines become denser, wider, more hazy, and generally complex in appearance, and are frequently joined by haze, not uniform in intensity, and probably composed of multitudes of indistinguishable lines. The increasing complexity throughout the series may in that case be sufficient to account for the apparent increase of intensity.

On the other hand, it seems likely, from the law governing the hydrogen and Orion lines, and from the way the intensities of the solar lines vary throughout the groups, that, if the varying intensity of every line were known, from beginning to end of the series, each would be found to have a gradual development, a maximum intensity, and a gradual decline and disappearance.

In the case of the complex lines given in this table, it can be seen that, while a few maintain a uniform intensity and the majority show steady increase, a considerable number reach their maximum in one or other of the groups of the second type, and then decline, and sometimes disappear in the group following. The changing aspect of the lines would further indicate that their constituents are changing throughout the series.

As regards the lines that reach a maximum in Group XVIII., it is probable that most of them grow fainter in stars of Group XX., and perhaps in stars intermediate between Groups XIX. and XX.

It is unfortunate that these stars, owing to their red color, could not be photographed with a sufficient dispersion to be represented in this table. It is clear, however, from the plates taken with one prism, that, while some new lines may be developing or old ones increasing among the flutings and absorption bands, the majority of the lines of α Orionis, at least in regions not covered by the bands and flutings, are fainter and less numerous in these later stars of the third type.

CHAPTER V.

Solar Lines between 4861 and 5896.

Table VI. is supplementary to Table V. It contains the lines found between the wave lengths 4861 and 5896 in the stars of the second and third types, this region being photographed by means of plates stained with erythrosin.

The first column contains the wave lengths of the lines as obtained by identification with the solar lines on Rowland's map. The second column shows the roughly estimated intensities of these lines as seen in the comparison photograph of the Sun. The third column gives the intensities as seen in α Aurigæ, which belongs to the same group as the Sun. In the fourth column are the intensities of the same lines in α Boötis of Group XV., and in the fifth, their intensities in in α Orionis of Group XVIII.

The method of obtaining the wave lengths was to identify the lines of each star with a photograph of the solar spectrum taken on the same scale, and the lines of the latter with those of Rowland's map. The intensities are estimated on a scale nearly similar to that used in Table V., but the difference in the plates, owing to the use of erythrosin, may modify the estimates. Here, as in the preceding table, a zero indicates that a line was not seen; an interrogation point, that a doubtful trace was present; a dot, that the presence or absence of a line is undetermined, owing to faintness of the image in regions where absorption is strong. A number dropped below the line in the columns of intensity indicates that the spectral lines having the two wave lengths between which it stands are united in a band having the given intensity.

Lines entered in this table have been determined from plates taken with four prisms, but the intensities of a few lines in regions where the absorption is strong have been estimated from plates taken with three prisms.

It will be seen that there appears to be less increase in the intensity of the solar lines of this region in passing from the second to the third type than was shown in the lines of shorter wave length than 4861. The change is, however, greater than appears in the table, it not having been found possible to represent the slight differences in the intensities of the lines.

It will be noted that the lines have frequently greater intensity in the Sun than in α Aurigæ. This is, however, in most cases, due to the fact that in the solar spectrum taken with the slit spectroscope the lines are clearer than in α Aurigæ, a star whose lines are not sharply defined.

The lines of α Tauri of Group XVI., not entered in this table, agree nearly with those of α Boötis, except that a few referred to in the description of that group are stronger.

The lines of α Scorpii, which has a spectrum of the composite type, the primary spectrum being of Group XVII., include all found in α Orionis, and with few exceptions agree with the latter in intensity.

The sixth column of Table VI., like the tenth of Table V., gives the estimated intensity of the lines on the photographic map of Rowland. The presence of two or more lines is indicated by the letters d and g.

TABLE VI.

SOLAR LINES BETWEEN 4861 AND 5896.

Wave Length.	Sun.	α Aurigæ.	α Boötis.	α Orionis.	S. S.
4861.5	11	11	4	6	5
4864.2	1	0	0	0	2 d
4865.4	0	3	3	2	0
4866.5	1	0	0	0	2
4868.0	1	0	1	1	2
4871.8	5	3	3	4	4 g
4876.0	1	1	1	3	2
4878.4	2	?	1	1	4
4882.1	1	0	2	5	2 g
4885.4	1	3	2	3	2 d
4886.9	1				2 g
4889.0	1	0	1	1	3 d
4891.3	5	4	3	4	4 d
4894.0	0	0	1	?	0
4896.6	1	·0	0	?	1
4900.1	1	1	2	3	2 d
4904.0	2	1	2	3	3 d
4910.5	2	2	3	3	3 g
4914.0	1	?	1	1	2 d
4919.1	2	4	4	7	3
4920.8	2				4
4924.6	1	2	1	4	3 d
4928.0	1	0	1	1	2
4930.5	1	0	1	0	2
4933.8	3	1	2	5	3 g
4939.5	3	3	3	6	3 g
4942.7	1	?	1	1	2
4946.6	2	?	1	1	3
4950.2	1	0	0	1	2
4953.1	1	0	0	0	2 d
4954.9	1	0	0	0	2 d
4957.6	7	3	4	12	5 d
4962.8	1	1	0	1	2
4966.2	1	1		3	3
4968.1	1	0	3		2
4970.4	1	1		?	2 g
4973.3	?	0	0	?	3
4978.8	1	1	1	?	3
4980.4	?	0	0	?	3
4983.1	3	4	3	4	3 g
4985.6	1		1	?	3 d
4989.2	1	0	?	0	2 d

Wave Length.	Sun.	α Aurigæ.	α Boötis.	α Orionis.	S. S.
4991.4	2	?	1	2	3 d
4994.3	1	?	1	2	3
4997.0	?	0	1	1	2 d
4999.8	1	?	1	3	3
5002.0	1		0	0	3
5006.1	3	3	2	3	4 d
5010.0	1	0	0	0	1 g
5012.3	2	0	4	4	3
5014.5	2	2			3
5018.6	2	2	0	0	4 d
5022.5	1	1	1	2	2
5027.4	2	1	1	.	3
5031.1	1	1	?	.	3
5036.1	3	1	2	3	3 g
5039.1	1	0	0	.	3 g
5041.6	5	5	5	7	4 g
5048.5	1	1	2	3	2 g
5050.0	?				3
5051.8	1	1	2	2	3
5056.7	1	1	0	0	0
5060.2	1	0	1	2	2
5065.1	2	2	2	3	3 g
5069.0	1	1	1	1	3
5072.7	2	1	1	1	2 g
5075.8	1	?	1	1	3 d
5080.2	4	3	3	3	3 g
5083.9	1	1	1	?	3 d
5097.1	1	0	0	.	3
5098.8	3	3	3	2	3 d
5107.8	1	1	1	?	3 d
5110.2	1	1	1	3	3 d
5113.5	0	0	0	1	2 d
5115.6	1	1	0	0	3
5125.3	1	1	2	2	3
5127.6	0	0	1	2	2
5129.6	1	1	0	0	3 g
5131.8	0	0	1	1	2 d
5133.9	1	1	0	?	3
5137.4	1	1	1	2	3 d
5139.5	2		1		4 d
5142.9	1	1	1	2	3 g
5148.3	1	1	1	2	3 d

Wave Length.	Sun.	α Aurigæ.	α Boötis.	α Orionis.	S. S.
5153.5	1	1	2	2	2
5159.2	1	0	1	0	2
5162.5	1	0	1	0	2
5167.6	9	7	9	10	5
5172.9	10	8	10	5	5
5176.8	0	1	1	.	2
5183.8	13	11	13	3	5
5189.0	1	1	0	1	3
5192.2	3	2	2	3	3 d
5195.6	1	1	1	1	3 g
5202.5	1	0	0	?	3
5204.8	1	2	2	4	3
5206.2	1				3
5208.7	2	2	4	4	4 d
5216.8	2	2	1	1	3 g
5227.1	5	5	5	6	4 g
5230.0	1	0	0	0	2
5233.1	2	2	2	2	3
5242.7	1	1	0	1	2
5247.5	1	1	2	3	2 d
5250.6	1	1	2	3	3 d
5255.1	1	1	2	3	2
5262.2	1	0	0	2	3 d
5264.0	0	1	1		3 d
5266.3	2	2	2	2	4 g
5270.2	5	4	5	5	5 d
5273.5	1	1	1	?	3 d
5275.7	2	2	2	1	3 g
5282.0	1	1	0	0	3
5283.8	2	2	3	3	3
5288.7	1	1	0	1	2
5294.0	1	1	0	1	1 g
5298.0	3	2	3	4	3 g
5302.5	1	2	2	3	3
5307.5	1	1	1	?	2
5316.9	1	1	0	?	3 d
5324.4	2	0	1	?	3
5328.5	6	4	5	5	4 g
5333.0	1	1	1	2	2 d
5340.6	3	2	2	2	4
5346.0	1	1	1	1	3
5349.1	1	1	1	2	3 g

Wave Length.	Sun.	α Aurigæ.	α Bootis.	α Orionis.	S. S.	Wave Length.	Sun.	α Aurigæ.	α Bootis	α Orionis.	S. S.	Wave Length.	Sun.	α Aurigæ.	α Bootis.	α Orionis	S. S.
5353.5	1	1	1	1	3	5510.1	1	0	0	0	2	5662.8	2	1	1	2	3
5363.0	1	1	1	1	3	5512.8	2	2	4	5	3 g	5667.7	1	1	1	2	2
5365.2	1	1	1	1	3 d	5528.6	4	3	3	2	4	5670.2	0	0	1	2	1 g
5370.0	4	4	4	6	3 d	5533.0	1	0	0	0	2	5675.7	1	0	0	0	2
5371.6					4	5535.3	2	2	1	2	3 d	5679.2	1	0	0	0	2
5377.8	0	0	0	1	2	5538.6	1	1	1	2	2	5682.8	2	2	2	2	3
5383.6	1	1	1	0	3	5543.8	2	1	1	0	3 d	5688.5	2	2	2	3	3
5393.3	1	1	1	1	3	5546.7	1	0	1	2	2	5695.1	1	0	0	0	2
5397.3	2	2	3	4	4	5555.0	2	1	1	1	3	5698.7	1	0	1	1	2 d
5400.7	1	1	1	1	3	5563.4	1	0	0	?	3 d	5701.9	1	1	1	2	3
5406.0	4	3	3	4	3	5565.9	1	0	0		2	5706.1	1	0	0	2	3
5410.0	2	2	2	4	3	5569.9	1	1	0	1	3	5709.8	2	3	3		4 d
5415.4	2	1	0	1	3	5573.0	2	1	1	1	3 d	5711.8	1			2	3 g
5420.6	1	1	1	1	2	5576.3	1	0	0	0	2	5718.0	?	0	0	1	3 d
5424.2	3	2	1	1	3	5582.1	1	0	0	0	2	5727.2	1	?	1	2	2 d
5429.9	3	2	2	2	4 d	5587.0	2	3	2	3	3	5732.0	1	1	1	1	3
5433.0	?	1	1	2	2 d	5589.6	1				3 g	5737.9	1	0	1	1	2
5434.8	2	2	2	2	3	5594.8	2	1	1	1	3	5742.0	1	0	1	1	2
5446.1	5	5	4	1	4 d	5598.6	2	1	0	3	3 d	5748.3	1	0	1	1	3 g
5455.8	5	4	3	5	4 d	5601.5	3	3	2		2	5753.6	3	3	3	1	4 g
5459.8	0	0	0	1	0	5603.0				1	4	5763.2	3	3	3	4	4
5463.3	4	3	1	1	3 d	5611.7	0	0	0	1	0	5773.8	1	1	1	1	3 d
5466.6	1	0	0	0	2	5615.8	5	4	3	2	4 d	5781.6	2	2	3	3	3 g
5470.8	1	0	1	0	1	5619.8	1	1	1	2	2 g	5785.0	2	2	3	3	3 g
5474.1	1	1	1	1	2	5624.8	3	2	2	2	3	5791.1	1	1	1	1	3
5476.8	5	4	3	3	3 g	5632.0	0	0	0	1	0	5798.2	1	1	1	1	3 d
5481.3	2	2	2	2	2 g	5634.1	1	0	1	0	2	5806.0	2	2	2	1	3 d
5483.4	1	1	1	?	2 d	5638.5	1	1		2	2	5816.6	2	2	2	2	3
5488.0	2	1	1	1	2	5641.6	1	1	1	1	3	5838.2	1	1	1	.	2
5490.6	1	?	1	2	1 d	5645.0	0	0	0	1	1 d	5853.0	1	1	1	.	3 d
5493.8	1	1	1	1	1	5650.5	1	1	0	?	2 g	5857.8	2	2	2	2	4 d
5497.8	2	2	2	2	3	5655.6	2	1	1	0	2 d	5890.0	7	6	7	6	5
5501.7	2	2	1	2	3	5658.5	3	2	3	3	3 g	5896.0	4	3	4	3	5
5507.0	2	2	2	2	3												

REMARKS.

4865.4. The line, as seen in the stars of this table, appears to be intermediate between the lines of the Sun 4864.2 and 4866.5. It has the appearance of a single, and not of a double line. As, however, these lines were a little defective in the solar plate, the line in the stars may agree with one or other of these lines, or possibly may cover both.

4894.0. This is the estimated position of the line in α Boötis and α Orionis, and agrees with that of a faint solar line on Rowland's map. The line in the stars probably includes also the stronger solar line 4893.0.

4957.6. This line as seen in α Orionis is wide, owing to combination with one of shorter wave length. This is probably the line 4956.2, which is faintly seen on Rowland's map.

5056.7. Only faint lines present in the solar spectrum near this position.

5098.8. The intensity given for this line in α Orionis is uncertain, owing to the faintness of the image.

5153.5. In α Boötis, in α Orionis, and less distinctly in the solar photographs, this line can be separated into two components having centres at 5151.5 and 5154.8. The first of these is double, the second quadruple, on Rowland's map. As seen in the photographs, they have about equal intensity.

5167.6, 5172.9, and 5183.8. The intensities given for these lines in α Orionis are uncertain, owing to the superposition of the absorption band, which has its edge of shorter wave length near 5167.6.

5216.8. This group appears to include the three lines 5215.4, 5216.5, and 5217.6.

5294.0. Only faint lines present in the solar spectrum near this position.

5316.9. This is the principal line in the solar corona.

5393.3. This appears to be the correct wave length, but owing to faintness of image and the crowding of lines in this region it is difficult to distinguish between this line and the lines 5391.7 and 5394.9.

5433.0. The line 5434.8 is probably combined with 5436.4, the three lines 5433.0, 5434.8, and 5436.4 merging into one dense band in the third type stars.

5459.8. The line on Rowland's map having this wave length is exceedingly faint. The line in α Orionis appears to agree with it in position. This line may, however, agree with some other faint solar line in this region.

5512.8. The intensities given to this line in α Orionis and α Boötis are large, owing to its combination with an adjacent line, probably 5514.7.

5611.7. Only faint lines present in the solar spectrum near this position.

5645.0. This appears to be the centre of a band containing lines 5644.3 and 5645.8.

5670.2. This is the centre of a faint triple band in the solar spectrum, extending from 5669.3 to 5671.0, to which the line in the stars probably corresponds. The faint line 5672.0 on the map may also belong to this band.

5718.0. The exact position of this line could not be determined. The wave length may be 5715.2.

5890.0 and 5896.0. Fraunhofer's line D. The intensities given to these lines in α Orionis have been estimated from a plate taken with a somewhat lower dispersion. They are probably too small.

CHAPTER VI.

Lines in Stars of Division *c*.

Table VII. shows the distribution and intensity of the miscellaneous stellar lines in spectra belonging to Division *c* in Groups VI., VII., VIII., XII., and XIII. Stars intermediate between Groups VI. and VII. have also been represented, since they are of interest in establishing the continuity of the series of stars belonging to Division *c* from the Orion groups to those of the first type. Aside from the Orion groups, those given above are the only groups in which stars of Division *c* were found.

The first column gives the designations of the lines of hydrogen and calcium.

The second gives the wave lengths, which have ordinarily been obtained by identification with solar lines. Seventeen faint lines, however, apparently do not coincide with solar lines or bands. Their wave lengths have been determined by interpolation and comparison with micrometric measures.

Several Orion lines which are present in Group VIII. have been included in this table, with a remark. Those not found beyond Group VII. have been omitted, as their entire distribution is shown in Table IV. The third column gives the intensities of the lines as found in β Orionis of Group VI. The fourth gives the intensity as found in the stars H. P. 551 and 4 Lacertæ, intermediate between Groups VI. and VII. The fifth gives the intensities for η Leonis of Group VII., the sixth for α Cygni of Group VIII., the seventh for ϵ Aurigæ of Group XII., the eighth for δ Canis Majoris of Group XIII. All the above stars have been photographed with four prisms, except η Leonis, and the stars intermediate between Groups VI. and VII., which were not bright enough to be satisfactorily photographed with more than two prisms. The plates taken with four prisms have, however, been supplemented by plates taken with three prisms for the region of the K line in δ Canis Majoris and ϵ Aurigæ, since this region was faint in the plates taken with four prisms. The plates having the above dispersions were too faint for lines having wave lengths shorter than 3934 in the case of δ Canis Majoris, and for those having wave lengths shorter than 3878 in the case of ϵ Aurigæ, and for those having wave lengths shorter than 3835 in the case of α Cygni. Some lines in the regions not covered by these plates have been obtained from plates taken with two prisms and with one prism; but the study of these regions is necessarily less complete, and the intensities given for the lines are somewhat uncertain. This applies more especially to the case of ϵ Aurigæ and δ Canis Majoris, since in these stars the lines are more crowded. In the case of the stars of the first type and those of the Orion type belonging to Division *c*, the number of lines found is not so greatly diminished by the use of fewer prisms as it would be in stars of Division *a*, on account of the greater intensity and clearness that prevail among the lines of Division *c*. Thus, in the star η Leonis, and in those intermediate between Groups VI. and VII., the number of lines given for the entire spectrum studied from plates taken with two prisms is probably almost as complete as in the case of the stars photographed with four prisms.

On a plate of β Orionis taken with four prisms, and used in forming this table, the spectrum extends as far as wave length 3692. The intensities have been estimated in a manner similar to that used in the construction of the preceding tables, though the scale on which the estimates are based may not be precisely the same as in those tables.

In these columns, as in the preceding tables, an interrogation point indicates that a doubtful trace of a line was seen; a zero indicates that the line was invisible in good plates; a dot, that the presence or absence of a line is undetermined, as in some portions of the ultra-violet, where the image is too faint to show the line in question.

A number placed between two lines indicates that the two spectral lines having the wave lengths between which it stands are united in a band of the given intensity.

The table shows that the number and general intensity of the lines of Division *c* increase from the Orion to the second type groups. It also shows that the relative intensity of these lines differs from those of corresponding wave lengths given in Table V. for stars of Division *a*, and that there are more lines of great intensity, while the entire number of lines present is somewhat less than in the corresponding groups of stars belonging to Division *a*.

The true identity of many of the lines of stars of Division *c* with the solar lines with which they appear to coincide is more doubtful than that of stars belonging to Division *a*, owing to disagreement in intensity between many of the lines in Division *c* and the corresponding solar lines. In such cases the wave lengths given in Tables V. and VII. sometimes differ.

The hydrogen lines from Hτ to Hλ are also present, but are not included in the table.

TABLE VII.

LINES IN STARS OF DIVISION *c*.

Desig.	Wave Length.	VI.	VI.-VII.	VII.	VIII.	XII.	XIII.	Desig.	Wave Length.	VI.	VI.-VII.	VII.	VIII.	XII.	XIII.
Hκ	3750.2	20	25	45	25	·	·		3982.0	0	0	0	1	4	6
	3758.8	2	1	2	6	·	·		3987.0	0	0	0	0	3	3
Hι	3770.8	20	25	45	25	·	·		3991.6	0	0	0	0	3	2
	3782.0	0	.	?	2	·	·		3995.5	0	0	0	0	0	3
Hθ	3798.1	20	25	45	25	13?	·		3997.6	0	0	0	1	2	6
	3814.9	0	?	2	4	7	4		3998.8	0	0	0	0		
	3819.2	6	4	2	1	0	·		4003.0	0	0	2	3	4	3
	3826.0	0	1	1	3	?	?		4005.3	0	0	0	2	4	4
Hη	3835.5	20	25	45	25	13?	11?		4009.4	0	0	0	1	1	1
	3846.0	0	0	0	2	0	0		4012.6	0	0	?	2	4	3
	3850.0	0	0	0	2	1	2		4014.7	0	0	0	0	2	3
	3854.2	4	?	?	3	0	0		4015.8	0	0	0	1	?	0
	3856.2	6	3	4	4	0	0		4018.4	0	0	0	0	0	2
	3860.0	0	0	0	2	?	3		4022.0	0	0	0	0	0	2
	3863.2	5	3	3	3	0	0		4024.8	0	0	0	2	4	5
	3865.7	0	0	0	1	?	0		4028.5	0	0	0	2	3	2
	3872.7	1	1	1	2	3	7		4030.8	0	0	0	1	2	5
	3878.5	0	0	0	2	3	5		4033.2	0	0	0	2	2	2
	3883.2	0	0	0	1	1	3?		4034.6	0	0	0	0	0	1
Hζ	3889.1	20	25	45	25	13	11?		4035.8	0	0	0	?	2	1
	3899.9	0	0	0	0	1	2		4037.2	0	0	0	0	?	1
	3900.7	0	1	2	4	7	7		4040.8	0	0	0	1	1	2
	3903.1	0	0	0	2	2	3		4045.9	0	0	0	2	4	4
	3905.6	?	1	2	4	0	0		4048.9	0	0	0	2	1	1
	3906.6	0	0	0		3	4		4050.8	0	0	0	0	1	1
	3913.6	0	1	2	4	6	3		4052.6	0	0	0	2	1	1
	3930.3	0	0	0	2				4053.8	0	0	0	2	3	2
K	3933.8	9	9	10	13	100	220		4057.8	0	0	0	1	?	0
	3936.0	0	0	0	2				4059.0	0	0	0	0	?	1
	3938.5	0	0	0	2	3			4063.7	0	0	1	2	3	7
	3944.1	0	0	0	0	0	3		4067.0	1	0	1	2	2	5
	3945.2	0	0	0	2	3			4071.9	0	0	0	2	3	4
	3949.0	0	0	0	0	0	3		4075.0	0	0	0	?	?	1
	3953.0	0	0	0	1	3	4		4077.9	0	0	?	2	4	8
	3956.6	0	0	0	0	1	2		4083.8	0	0	0	0	?	2
	3958.4	0	0	0	1	1	2		4085.4	0	0	0	0	0	1
	3961.6	0	0	0	2	2	3		4087.2	0	0	0	0	1	3
	3964.5	0	0	0	1	·			4090.2	0	0	0	0	0	1
H	3968.6	7	9	9	12	75	180		4092.7	0	0	0	0	0	1
Hε	3970.2	20	25	45	25				4096.2	0	0	0	0	0	2
	3973.8	0	0	0	2	3			4098.5	0	0	0	0	0	1
	3976.8	0	0	0	0	0	2	Hδ	4101.8	20	25	45	25	13	11
	3979.7	0	0	0	2	0	0		4106.6	0	0	0	0	0	1

Desig.	Wave Length.	VI.	VI.-VII.	VII.	VIII.	XII.	XIII.	Desig.	Wave Length.	VI.	VI.-VII.	VII.	VIII.	XII.	XIII.
	4110.4	0	0	0	0	1	4		4247.3	0	0	0	2	3	4
	4111.0	0	0	?	1	?	?		4251.0	0	0	0	1	1	2
	4113.1	0	0	0	0	1	1		4253.0	0	0	0	1	?	?
	4114.7	0	0	0	0	0	1		4254.5	0	0	0	?	1	2
	4118.9	0	0	0	1	1	4		4258.7	0	0	0	2	2	2
	4122.8	0	0	1	2	2	3		4260.5	0	0	0	0	1	2
	4128.1	3	4	4	3	2	5		4262.2	0	0	0	2	1	1
	4128.5								4270.0	0	0	0	?	1	1
	4131.4	3	4	4	3	0	0		4271.7	0	0	0	0	2	4
	4132.2	0	0	0	0	2	3		4273.8	0	0	?	1	1	1
	4134.8	0	0	0	0	0	3		4275.0	0	0	1	1	2	3
	4137.4	0	0	0	1	1	3		4278.4	0	0	1	1	1	1
	4143.9	3	3	3	1	1	5		4280.5	0	0	0	0	0	1
	4146.0	0	0	0	1	?	0		4282.9	0	0	0	0	0	1
	4149.5	0	0	0	?	2	2		4284.4	0	0	0	1	1	1
	4154.9	0	0	0	0	1	2		4288.1	0	0	0	1	2	2
	4156.7	0	0	0	0		2		4289.8	0	0	0	2	3	4
	4161.7	0	0	0	1	2	3		4294.3	0	0	0	2	2	2
	4163.9	1	1	1	2	2	2		4297.1	0	0	0	2	2	2
	4167.5	0	0	0	1	3	1		4300.2	0	2	1	3	4	5
	4172.9	0	0	0	2	6	13		4302.6	0		1	3	5	5
	4173.6	1	2	5	5				4305.8	0	0	0	0	0	1
	4177.8	0	0	0	1	7	3		4308.0	0	0	1	2	2	2
	4179.5	1	3	5	5		4		4309.5	0	0	0	0	1	2
	4182.0	0	0	0	1	0	1		4314.3	0	0	0	1	4	2
	4185.0	0	0	0		1	2		4315.2	0	0	2	3	5	5
	4187.6	0	0	0	2	1	4		4317.0	0	0	0	0	1	1
	4191.8	0	0	0	?	?	3		4317.6	0	0	0	0	0	1
	4196.8	0	0	0	0	0	3		4321.0	0	0	0	2	3	3
	4198.5	0	0	0	1	1	4		4326.0	0	0	0	2	4	5
	4202.2	0	0	0	1	1	3		4330.9	0	0	0	1	3	2
	4205.3	0	0	0	1	1	3		4333.0	0	0	0	0	0	1
	4206.9	0	0	0	0	0	2		4337.6	0	0	0	1	6	10
	4208.8	0	0	0	0	0	2	Hγ	4340.7	20	25	45	25	13	11
	4210.5	0	0	0	0	0	2		4344.7	0	0	0	1	2	1
	4212.1	0	0	0	0	0	1		4352.0	2	3	4	4	4	5
	4215.7	0	0	0	1	4	5		4355.3	0	0	0	0	0	1
	4217.6	0	0	0	0	0	1		4359.9	0	0	0	0	1	3
	4219.6	0	0	0	0	0	1		4367.9	0	0	0	?	1	1
	4222.4	0	0	0	0	0	1		4368.7	0	0	0	2	0	?
	4224.7	0	0	0	0	0	1		4370.0	0	0	?	?	1	1
	4227.0	0	0	0	0	3	5		4371.5	0	0	?	0	1	1
	4233.6	2	4	5	5	5	3		4374.7	0	0	0	1	4	9
	4236.0	0	0	0	0	1	2		4376.1	0	0	0	0	0	
	4240.0	0	0	0	0	1	3		4379.4	0	0	0	0	1	1
	4242.5	0	0	1	2	2	1		4383.7	0	0	0	1	4	8

Desig.	Wave Length.	VI.	VI.-VII.	VII.	VIII.	XII.	XIII.	Desig.	Wave Length.	VI.	VI.-VII.	VII.	VIII.	XII.	XIII.
	4385.2	0	2	4	3	4	4		4564.0	0	0	0	2	3	4
	4390.5	0	0	0	2	1	2		4572.2	.	0	?	2	3	3
	4395.3	0	0	1	3	5	7		4576.5	0	0	0	2	1	1
	4400.2	0	0	0	2	3	7		4580.0	0	0	0	1	1	1
	4405.0	0	0	0	1	1	2		4584.0	2	2	3	4	4	5
	4408.5	0	0	0	0	0	2		4586.1	0	0	0	2	2	1
	4411.5	0	0	0	?	1	2		4592.8	0	0	0	0	0	1
	4415.3	0	0	0	0	0	4		4595.9	0	0	0	0	0	2
	4417.9	0	2	3	4	7	6		4613.5	0	0	0	0	0	1
	4422.8	0	0	0	0	1	3		4616.9	0	0	0	0	1	1
	4427.4	0	0	0	0	0	2		4619.2	0	1	2	3	3	4
	4430.8	0	0	0	0	0	2		4625.8	0	0	0	0	0	1
	4435.2	0	0	0	0	0	2		4629.9	?	1	2	3	3	4
	4442.5	0	0	0	0	0	9		4634.8	0	0	2	3	2	1
	4444.0	0	0	1	3	6			4639.1	0	0	0	0	0	1
	4447.7	0	0	0	0	0	1		4646.3	0	0	0	0	0	1
	4450.6	0	0	0	2	3	3		4648.9	0	0	0	0	0	1
	4455.0	0	0	0	1	1	2		4657.0	0	0	0	2	2	4
	4460.0	0	0	0	0	0	1		4663.7	0	0	0	0	1	2
	4462.0	0	0	0	1	1	2		4668.0	0	0	1	1	1	3
	4464.8	0	0	0	0	1	1		4670.0	0	0		1	1	3
	4469.5	0	0	0	3	4	3		4679.0	0	0	0	0	0	1
	4471.0	0	0	0	0	0	2		4682.2	0	0	0	0	0	1
	4471.8	4	3	2	2	0	0		4691.6	0	0	0	0	0	1
	4473.0	0	0	0	0	0	1		4698.8	0	0	0	0	0	2
	4476.2	0	0	0	0	0	1		4703.1	0	0	0	0	0	2
	4482.0	5	5	5	5	5	4		4709.0	0	0	0	0	1	3
	4489.6	0	1	3	3	2	3		4714.5	0	0	0	0	0	1
	4491.6	0			3	1	3		4720.5	0	0	0	0	0	1
	4494.8	0	0	0	0	1	2		4727.6	0	0	0	0	0	1
	4497.0	0	0	0	0	0	2		4731.7	0	0	0	2	2	1
	4501.5	0	0	0	2	4	4		4737.0	0	0	0	0	0	1
	4508.5	1	2	3	3	4	3		4754.2	0	0	0	0	0	1
	4515.4	?	1	2	3	3	2		4756.4	0	0	0	0	?	?
	4520.3	?	2	3	3	2	1		4764.1	0	0	0	0	2	8
	4522.9	1	2	3	3	2	1		4771.8	0	0	0	0	0	1
	4525.3	0	0	0	0	0	1		4780.1	0	0	0	0	2	1
	4528.8	0	0	0	0	2	2		4786.8	0	0	0	0	0	1
	4531.2	0	0	0	0	0	1		4798.7	0	0	0	0	0	2
	4534.2	0	1	2	3	3	4		4805.2	0	0	0	0	2	3
	4541.6	0	1	1	2	2	2		4808.0	0	0	0	0	0	2
	4544.9	0	0	0	0	0	2		4824.0	0	0	1	2	2	5
	4549.7	2	3	4	4	4	3		4836.0	0	0	0	0	1	1
	4554.2	0	0	0	0	?	5		4848.4	0	0	?	2	2	3
	4556.0	0	0	2	3	4			4855.7	0	0	0	0	1	3
	4558.9	0	0	0	2	2	1	Hβ	4861.5	20	25	45	25	13	11

REMARKS.

3758.8. The wave length of this line is somewhat uncertain.

3782 0. The wave length of this line is somewhat uncertain.

3819.2. This is an Orion line.

3854.2. This is an Orion line. Its intensity in η Leonis of Group VII., and in stars intermediate between Groups VI. and VII., could not be determined, because in the photographs of these stars, which were not of the greatest dispersion, it could not be distinctly separated from the line 3856.2.

3856.2. This is an Orion line.

3860.0. The wave length of this line is somewhat uncertain.

3863.2. This is an Orion line.

3872.7. The Orion line 3872.4 is indistinguishable from this solar line. The Orion line is the one present in the stars of Groups VI. and VII., and in those intermediate between VI. and VII. It is uncertain whether it is present in combination with 3872.7 in the remaining groups given in the table.

3906.6. The intensity given for this line in Group XIII. was obtained from a plate taken with four prisms. In the plate taken with two prisms it appeared as a band having intensity 8, this intensity being due to combination with a line of greater wave length.

3916.4, 3918.6, 3920.4, and 3923.0 are well defined in γ Cygni and faint in δ Canis Majoris. 3923.0 occurs also in ε Aurigæ.

3933.8. The intensity of this line in ε Aurigæ of Group XII. is the average intensity as seen in plates having different dispersions. The estimated intensity or width varies from 50 to 100, according to dispersion, being least under the greatest dispersion. It is, however, uncertain how far the apparent narrowness of the band, as seen in the plate taken with four prisms, is due to photographic effect. In ε Aurigæ the lines 3930.3 and 3936.0 are included in the K band. In δ Canis Majoris lines 3930.3, 3936.0, and 3938.5 are included.

3968.6 and 3970.2. The intensity of this compound band given for ε Aurigæ of Group XII. is the average of the estimates from plates taken with three different dispersions. As in the case of the K line, the estimated width varies greatly according to the dispersion, being greatest under the smallest dispersion. Its apparent narrowness in the plate taken with four prisms may be due to photographic defect. In δ Canis Majoris the lines 3964.5 and 3973.8 are included in the band.

4128.1 and 4128.5. The second of these is an Orion line; the two are so close that it is hardly possible to distinguish them. In β Orionis it is the Orion line which is present. In ε Aurigæ and δ Canis Majoris it appears to be the solar line 4128.1. In the stars of the remaining groups it is doubtful which is present, and both may be included.

4131.4 This is an Orion line.

4143.9. In stars of Groups VI. and VII., and in those intermediate, the line present is the Orion line, 4144.0, which is indistinguishable from the double solar line whose centre is at 4143.9. The latter is assumed to be present in the stars of Group XIII. In stars of Groups VIII. and XII. it is uncertain which is present.

4172.9 and 4173.6. The band in which these two lines are combined is wider in δ Canis Majoris than in ε Aurigæ or α Cygni.

4208.8. This line is present in γ Cygni, but not in δ Canis Majoris.

4359.9. In ε Aurigæ the line is faint and hazy, and its centre appears to have the wave length 4360.2.

4367.9 and 4370.0. In α Cygni these lines may be present in combination with 4368.7.

4471.8. This is an Orion line.

4482.0. The Orion line 4481.4 is here combined with the solar line 4482.5. In the stars of Groups VI. and VII., and those intermediate between the two, it is the Orion line which is present. In the remaining stars the two may be united.

4613.5. This line is clearly visible in γ Cygni. In δ Canis Majoris it is absent or extremely faint.

CHAPTER VII.

Relative Intensities of Lines.

Table VIII. shows roughly the relation of the intensities of the four classes of lines to one another in stars of Division *a* from Group II. to Group XVIII.

The first column gives the group numbers. The second column gives for each group the estimated intensity of the hydrogen lines in hundredths of their maximum intensity as seen in α Canis Majoris. The third gives the sum of the estimated intensities of the Orion lines of each group. The fourth gives the sum of the intensities of the solar lines between $H\beta$ and $H\epsilon$ for as many groups as are represented in Tables IV. and V. The fifth column gives the estimated intensity of the K line in each group.

It is to be regretted that the sum of the intensities of the solar lines could not be obtained for all the groups, owing to the fact that in some of them there were no stars bright enough to be satisfactorily photographed with four prisms, and therefore these groups could not be rendered comparable with the others.

A comparison of the spectra of all the groups photographed with one or two prisms, however, leaves no doubt that the increase in the sum of the intensities is continuous throughout.

It should be stated that the numbers here given do not adequately represent the amount of this increase, because the estimates for the individual lines did not represent all the intermediate degrees of intensity.

The table shows that the intensity of the lines of hydrogen increases, attains a maximum in Groups VI. and VII., and then steadily decreases. It further shows that the aggregate intensity of the Orion lines is at a maximum in Group III., then decreases at first somewhat suddenly, and that these lines disappear in Group VIII., except that one faint line persists as far as Group XII.

The aggregate intensity of the solar lines is shown to increase steadily from Groups II. to XVIII., while the estimated intensity of K, except in Group III., shows a steady increase to Groups XV. and XVI., and afterwards a probable slight decrease.

It should be stated of the doubtful lines 4144.0 and 4481.4, that the former has been included among the solar, the latter among the Orion lines.

TABLE VIII.

RELATIVE INTENSITIES OF LINES.

Group.	Intensity of Hydrogen.	Intensity of Orion Lines.	Intensity of Solar Lines.	Intensity of K Line.	Group.	Intensity of Hydrogen.	Intensity of Orion Lines.	Intensity of Solar Lines.	Intensity of K Line.
II.	20	148	1	2	XI.	60	1	...	83
III.	35	162	1	1	XII.	25	1	432	135
IV.	45	151	2	3	XIII.	20	0	...	160
V.	90	51	3	4	XIV.	16	0	568	160
VI.	100	36	43	6	XV.	9	0	712	200
VII.	100	5	99	8	XVI.	7	0	...	200?
VIII.	95	1	164	13	XVII.	7	0	...	200?
IX.	95	1	...	28	XVIII.	6	0	860	170?
X.	90	1	...	58					

CHAPTER VIII.

Classification of Spectra.

Table IX. shows the classification, in order of groups, of the six hundred and forty bright stars included in the series. The eight stars of the fourth and fifth types, the true position of which in the series is not known with certainty, have been appended as Groups XXI. and XXII.

In the first column the group number is given. When a number is placed in Italics, it indicates that the stars lie between that and the following group. The second column gives the letter designating each of the divisions *a*, *b*, and *c*, and the intermediate divisions *ab* and *ac*. The expression *a*, *b* signifies that it is doubtful to which of the divisions *a* or *b* the star in question belongs. The letter *P* signifies that a star is peculiar. The division letter has been repeated for every star, the absence of such letter implying that the division is undetermined. It is also omitted in the case of stars of the fourth and fifth types, since these have not been included in the series.

The third column of the table gives the designation of each star in the Harvard Photometry, or for stars not included in that catalogue, the zone and number from the Bonn or Cordoba Durchmusterung. A number in Italics denotes a pair of adjacent stars. The fourth column gives the constellation, and the fifth, the letter or Flamsteed number designating the star. The numbers in the sixth column refer to the series of Remarks on Individual Stars, beginning on page 94.

TABLE IX.

CLASSIFICATION OF SPECTRA.

Group.	Div.	Cat. No.	Constellation.	Desig.	Remarks.	Group.	Div.	Cat. No.	Constellation.	Desig.	Remarks.
I.	*b*	1256	Monocer.	S	1	IV.	*a*	1090	Orion	57	
"	*b*	1027	Orion	ι	2	"	*a*	799	Eridanus	ν	26
"	*b*	*1019*	Orion	λ		"	*a*	418	Cetus	δ	10
"	*b*	1023	Orion	41	3	"	*a*	1368	Can. Maj.	27	10
"	*b*	652	Perseus	ξ	4	"	*a*	3051	Hercules	102	10
"	*b*	3750	Cygnus	A		"	*b*	2338	Urs. Maj.	η	
"	*b*	3821	Cepheus	—	5	"	*b*	3199	Sagittar.	σ	
II.	*a*	1029	Orion	ε		"	*b*	657	Taurus	λ	
"	*a*	1068	Orion	κ		"	*b*	2959	Hercules	ι	
"	*a*	1017	Orion	ϕ^1	2,6	"	*b*	2662	Scorpius	ρ	23
"	*a*	649	Perseus	ε	2	"	*b*	3530	Vulpec.	—	
"	*b*	1005	Orion	δ		"	*b*	3622	Delphin.	—	
"	*b*	*1045*	Orion	ζ		"	*b*	3207	Lyra	δ^1	
"	*b*	2788	Ophiuch.	ζ	2,7	"	*b*	1047	Orion	—	
"	*b*	1039	Orion	σ	8	"	*b*	647	Perseus	—	23
"	*b*	1043	Orion	—	9	"	*b*	4153	Cassiop.	—	
"	*a, b*	4086	Cassiop.	1	10	"	*a, b*	1153	Orion	ξ	
"	*a, b*	2738	Scorpius	σ	10	"	*a, b*	1132	Orion	ν	
"	*a, b*	2783	Scorpius	τ	2	"	*a, b*	3342	Cygnus	2	11
"	*a, b*	71	Cassiop.	κ	11	"	*a, b*	*1445*	Argo	κ	11
"	*a, b*	934	Auriga	—	12	"	*a, b*	2601	Scorpius	o	20
"	*P*	1859	Leo	ρ	13	"	*a, b*	1157	Monocer.	—	20
"	*P*	+56° 3115	Cassiop.	—	14	"	*a, b*	3191	Lyra	8	
III.	*a*	1201	Can. Maj.	β		"	*a, b*	− 5° 1334	Orion	—	20
"	*a*	975	Orion	η	15	"	*a, b*	+58° 2546	Cassiop.	—	
"	*a*	638	Perseus	ζ	16	"	*a, b*	+59° 2629	Cassiop.	—	20
"	*a*	3798	Cepheus	β		"	*a, b*	− 4° 1186	Orion	—	20
"	*a*	1325	Can. Maj.	ε	17	*IV.*	*a*	845	Orion	π^4	
"	*b*	2263	Virgo	α	18	"	*a*	857	Orion	π^5	
"	*b*	*2690*	Scorpius	β	19	"	*a*	668	Taurus	40	
"	*b*	2671	Scorpius	π		"	*b*	1195	Can. Maj.	ζ	
"	*b*	2698	Scorpius	ω^1		"	*b*	3291	Lyra	η	
"	*b*	1024	Orion	43	20,21	"	*b*	1518	Argo	16	23
"	*a, b*	1021	Orion	—	22	"	*ab*	896	Auriga	η	
"	*a, b*	600	Perseus	o		"	*ab*	287	Cassiop.	ε	27
"	*a, b*	1025	Orion	c	23	"	*ab*	1599	Hydra	η	28
"	*a, b*	1001	Auriga	χ	24	"	*a, b*	107	Cassiop.	o	
"	*a, b*	3736	Cepheus	—	20	"	*a, b*	1012	Orion	35	
"	*a, b*	−4° 1196	Orion	—	20	"	*a, b*	2587	Libra	—	
"	*a, b*	−6° 1255	Orion	—	20	"	*a, b*	105	Cassiop.	—	
"	*c*	1122	Orion	χ^2		"	*a, b*	2890	Hercules	u	
"	*P*	2674	Scorpius	δ	25	"	*a, b*	555	Perseus	34	20
IV.	*a*	979	Orion	γ		"	*a, b*	522	Perseus	31	20
"	*a*	23	Pegasus	γ		"	*a, b*	2899	Ophiuch.	θ	
"	*a*	82	Cassiop.	ζ		"	*a, b*	552	Perseus	—	

Group.	Div.	Cat. No.	Constellation.	Desig.	Remarks.
IV.	a, b	521	Perseus	29	20
“	a, b	+8° 1016	Orion	—	
V.	a	618	Taurus	η	
“	a	2878	Draco	ζ	10
“	a	3592	Delphin.	ε	10
“	a	1340	Can. Maj.	γ	10
“	a	613	Taurus	20	
“	a	610	Taurus	q	
“	a	608	Taurus	17	29
“	a	615	Taurus	23	29
“	a	2745	Hercules	τ	
“	b	948	Orion	τ	
“	b	591	Perseus	δ	
“	b	69	Cassiop.	λ	30
“	b	77	Cassiop.	—	30
“	b	+3° 420	Cetus	—	23
“	a, b	625	Taurus	27	
“	a, b	537	Perseus	—	
“	a, b	470	Perseus	—	
“	a, b	+49° 944	Perseus	—	
“	a, b	+24° 4471	Pegasus	—	31
“	a, b	+23° 505	Taurus	—	
“	a, b	+ 1° 886	Orion	—	30
“	a, b	+ 9° 1927	Cancer	—	20
“	c	1399	Can. Maj.	η	
“	c	1337	Can. Maj.	o^2	
“	c	3017	Ophiuch.	67	
VI.	a	496	Perseus	β	
“	a	978	Taurus	β	32
“	a	3157	Sagittar.	φ	
“	a	2078	Corvus	γ	33
“	b	1797	Leo	α	
“	b	1403	Can. Min.	β	
“	b	2539	Libra	β	
“	b	554	Taurus	ξ	
“	b	579	Eridanus	τ^5	
“	b	3520	Vulpec.	20	23
“	b	145	Cassiop.	—	2,23
“	ab	445	Aries	41	
“	ab	4013	Pegasus	ζ	2
“	a, b	1119	Orion	64	
“	a, b	+22° 563	Taurus	—	
“	a, b	+23° 563	Taurus	—	30
“	a, b	+24° 553	Taurus	—	
“	a, b	+24° 556	Taurus	—	30
“	a, b	+46° 773	Perseus	—	20
“	a, b	+47° 844	Perseus	—	20
“	a, b	+47° 846	Perseus	—	12
“	a, b	+24° 546	Taurus	—	34
“	c	936	Orion	β	
VI.	c	3062	Sagittar.	μ	
VI.	b	3994	Aquarius	η	
“	b	3624	Delphin.	α	
“	ab	4007	Pisc. Aus.	ε	
“	c	551	Camelop.	—	35
“	c	553	Camelop.	—	36
“	c	3962	Lacerta	4	37
“	c	3069	Sagittar.	15	38
VII.	a	1275	Can. Maj.	α	39
“	a	3147	Lyra	α	40
“	a	2638	Serpens	μ	41
“	a	2844	Hercules	ε	42
“	a	2381	Draco	α	43,44
“	a	3950	Aquarius	γ	
“	a	2506	Libra	δ	
“	a	1965	Leo	σ	42
“	a	3514	Aquila	θ	43
“	a	2713	Hercules	φ	45
“	a	3232	Lyra	γ	42,46,41
“	a	3361	Cygnus	7	30
“	a	3445	Aquila	58	22,30
“	b	3048	Hercules	o	
“	b	3259	Aquila	ζ	47
“	b	2120	Corvus	δ	48
“	b	1676	Hydra	θ	
“	b	1554	Monocer.	30	43,49
“	b	361	Triangul.	γ	49
“	b	2979	Ophiuch.	γ	
“	b	3023	Ophiuch.	68	20
“	b	3419	Cygnus	δ	50,42
“	b	3260	Aquila	λ	42,51
“	b	2787	Hercules	σ	52,43,53
“	b	356	Triangul.	7	
“	b	3552	Capricor.	ν	23
“	b	2914	Hercules	ρ	
“	b	+82° 235	Camelop.	—	30
“	b	+48° 722	Perseus	—	
“	b	−11° 2925	Hydra	—	54
“	a, b	1150	Orion	68	55,42
“	a, b	906	Eridanus	66	20
“	a, b	1613	Hydra	ρ	23
“	a,	2852	Hercules	33	20
“	a,	23° 553	Taurus	—	30
“	a, b	+23° 569	Taurus	—	20
“	a, b	+23° 561	Taurus	—	20
“	a, b	+23° 536	Taurus	—	23,30
“	a, b	+24° 562	Taurus	—	20
“	a, b	+44° 634	Perseus	—	30
“	a, b	+47° 847	Perseus	—	43
“	a, b	+23° 1347	Gemini	—	23

Group.	Div.	Cat. No.	Constellation	Desig.	Remarks.
VII.	a, b	+82° 253	Camelop.	—	20
"	c	1793	Leo	η	
"	P	3120	Draco	φ	43, 44
VIII.	a	*1423*	Gemini	α	
"	a	1100	Auriga	β	56
"	a	*2264*	Urs. Maj.	ζ	56
"	a	1923	Urs. Maj.	β	32
"	a	1249	Gemini	γ	
"	a	665	Taurus	ν	
"	a	1951	Leo	θ	32
"	a	3647	Aquarius	ε	
"	a	306	Cassiop.	50	
"	a	2773	Ophiuch.	λ	57
"	a	1810	Urs. Maj.	λ	
"	a	2893	Hercules	e	58
"	a	2088	Virgo	η	
"	a	2645	Serpens	ε	59
"	a	2868	Ophiuch.	η	
"	a	3913	Pegasus	θ	60
"	a	763	Taurus	68	
"	a	1925	Leo	b	61
"	a	4015	Pegasus	o	62
"	a	3550	Cygnus	36	
"	a	+41° 1044	Auriga	—	60
"	a	−10° 704	Eridanus	—	63
"	a	− 7° 3946	Libra	—	54
"	b	2036	Urs. Maj.	γ	32
"	b	1100	Auriga	β	56
"	b	*2264*	Urs. Maj.	ζ	56
"	b	1645	Urs. Maj.	κ	
"	b	1715	Urs. Maj.	26	54
"	b	4080	Pegasus	α	32, 64
"	b	2468	Virgo	109	32
"	b	1588	Hydra	δ	32, 50
"	b	433	Cetus	γ	
"	b	180	Cepheus	—	
"	b	2880	Hercules	δ	2
"	b	3424	Sagitta	ζ	60
"	b	1359	Monocer.	22	32
"	b	3600	Delphin.	ζ	54, 60
"	b	332	Aries	κ	23
"	b	3987	Lacerta	7	
"	b	3515	Vulpec.	18	
"	b	−24° 4553	Can. Maj.	—	23
"	b	−24° 4565	Can. Maj.	—	23
"	ab	2594	Corona	α	51
"	ab	2625	Corona	γ	51
"	ab	1681	Lynx	38	55, 60
"	a, b	172	Cetus	28	65
"	a, b	+58° 608	Camelop.	—	23, 2?
VIII.	a, b	+43° 3132	Lyra	—	20, 22
"	a, b	+44° 3017	Lyra	—	20
"	a, b	+65° 335	Camelop.	—	
"	a, b	+65° 338	Camelop.	—	
"	c	3631	Cygnus	α	
"	P	2191	Urs. Maj.	ε	66
"	P	5	Androm.	α	67
"	P	929	Lepus	μ	68
"	P	*2195*	Can. Ven.	12	69
"	P	1104	Auriga	θ	70
"	P	2298	Urs. Maj.	81	71
"	P	*291*	Aries	γ	72
VIII.	ac	1462	Argo	τ	
IX.	b	2077	Urs. Maj.	δ	32, 177
"	b	2294	Virgo	ζ	177
"	b	3527	Cygnus	30	23, 177
"	b	910	Eridanus	β	178
"	b	2025	Leo	β	178
"	b	1949	Leo	δ	178
"	b	2267	Urs. Maj.	g	178
"	b	2566	Urs. Min.	γ	178
"	b	2632	Serpens	β	73, 178
"	ab	4057	Pisc. Aus.	α	177
"	ab	2480	Libra	α	177
"	ab	1295	Gemini	θ	178
"	a, b	3045	Ophiuch.	72	177
"	a, b	304	Cassiop.	A	177
"	a, b	1065	Lepus	ζ	23, 177
"	a, b	487	Eridanus	τ^3	177
"	a, b	1373	Gemini	λ	177
"	a, b	4047	Aquarius	δ	32, 177
"	a, b	4099	Cassiop.	2	177
"	a, b	756	Taurus	64	177
"	a, b	+83° 20	Cepheus	—	177
"	a, b	1973	Crater	γ	178
"	a, b	148	Androm.	μ	178
"	a, b	783	Taurus	—	30, 178
"	a, b	3365	Cygnus	ι	74, 178
"	a, b	3896	Aquarius	32	178
"	a, b	3053	Hercules	101	178
"	a, b	3635	Delphin.	δ	20, 178
"	a, b	4076	Androm.	2	178
"	—	752	Taurus	63	
"	—	1409	Gemini	64	20
"	—	3192	Lyra	ν	65
"	—	+44° 3889	Cygnus	—	
"	—	− 4° 1167	Orion	—	
X.	a	336	Triangul.	β	75, 179
"	a	295	Aries	β	32, 76, 179
"	b	3429	Aquila	α	180

Group.	Div.	Cat. No.	Constellation.	Desig.	Remarks.	Group.	Div.	Cat. No.	Constellation.	Desig.	Remarks.
X.	b	3757	Cepheus	α	180	XII.	a	289	Triangul.	α	
"	b	2944	Ophiuch.	α	180	"	a	1969	Leo	ι	
"	ab	219	Cassiop.	δ	179	"	a	3907	Pegasus	ι	
"	ab	1636	Urs. Maj.	ι	180	"	a	2457	Virgo	μ	
"	a, b	4001	Lacerta	9	179	"	a	1641	Urs. Maj.	10	84
"	a, b	3319	Sagittar.	ρ	180	"	a	*3970*	Aquarius	ζ	32
"	a, b	776	Taurus	θ^2	180	"	a	4024	Pegasus	ξ	
"	a, b	2947	Serpens	ξ	180	"	a	3171	Hercules	110	2
"	a, b	806	Eridanus	c	180	"	a	4238	Pisces	ω	
"	a, b	2070	Draco	—	77,180	"	a	1101	Lepus	η	85
"	a, b	+47° 850	Perseus	—	20,180	"	a	701	Eridanus	o^1	32,86
"	a, b	3942	Cephius	ε	181	"	a	3071	Draco	40	87
"	a, b	437	Cetus	μ	2,181	"	a	3072	Draco	41	87
"	a, b	854	Eridanus	ω	181	"	a	915	Eridanus	68	
"	a, b	3848	Capricor.	δ	181	"	a	1162	Orion	71	2
"	a, b	+23° 556	Taurus	—	20,181	"	a	1821	Leo	40	31
XI.	ab	2436	Boötes	γ	182	"	a	2479	Libra	8	31
"	ab	1377	Gemini	δ	182	"	a	1272	Gemini	ξ	
"	ab	−0° 1634	Monocer.	—	182	"	a	1831	Camelop.	—	88
"	ab	*2155*	Virgo	γ	183	"	a	3420	Cygnus	17	
"	a, b	3343	Aquila	δ	182	"	a	+37° 1347	Auriga	—	20
"	a, b	2747	Hercules	γ	182	"	a	+60° 1136	Urs. Maj.	—	31
"	a, b	1405	Gemini	ρ	182	"	a	+23° 2207	Leo	—	31
"	a, b	4104	Androm.	7	182	"	a	+47° 466	Perseus	—	20
"	a, b	1026	Orion	c	182	"	ab	9	Cassiop.	β	
"	a, b	2481	Boötes	—	20,182	"	c	877	Auriga	ε	
"	a, b	+24° 4540	Pegasus	—	182	"	ac	602	Perseus	ν	
"	a, b	1701	Urs. Maj.	h	78,183	*XII.*	c	3551	Cygnus	35	89
"	a, b	2207	Urs. Maj.	78	183	"	ac	541	Perseus	α	
"	ac	13	Androm.	22	183	"	ac	3583	Cygnus	41	
"	ac	3010	Hercules	ν	183	XIII.	a	1089	Orion	χ^1	
"	P	2572	Corona	β	79,182	"	a	2028	Virgo	β	
"	—	+12° 1275	Gemini	—	80,182	"	a	120	Cassiop.	η	90
XI.	ab	1812	Leo	ζ		"	a	1608	Hydra	ε	
"	a, b	3741	Cygnus	τ		"	a	2426	Boötes	θ	
"	a, b	2442	Boötes	σ	30	"	a	1057	Lepus	γ	
"	ac	1014	Lepus	α		"	a	2696	Draco	θ	
"	ac	3270	Sagittar.	π		"	a	3122	Draco	χ	
"	ac	1753	Urs. Maj.	υ		"	a	*1521*	Cancer	ζ	
"	—	2128	Corvus	η	30,81	"	a	*2688*	Scorpius	ξ	
"	—	4002	Cepheus	31	81	"	a	840	Orion	π^3	
"	—	3407	Cygnus	—	30,81	"	a	1655	Urs. Maj.	σ^2	32
"	—	+27° 1374	Gemini	—	22,31	"	a	3047	Hercules	b	20
"	—	+79° 36	Cepheus	—	20	"	a	1709	Urs. Maj.	θ	32
"	—	− 0° 1646	Monocer.	—	20	"	a	2666	Serpens	γ	32,91
XII.	a	1442	Can. Min.	α		"	a	179	Cetus	30	34
"	a	1515	Argo	ι	82	"	a	136	Cassiop.	—	
"	a	3843	Pegasus	κ		"	a	1225	Camelop.	—	
"	a	3605	Delphin.	β	83	"	a	913	Camelop.	—	
"	a	3393	Cygnus	θ		"	a	3926	Cepheus	—	

Group.	Div.	Cat. No.	Constellation	Desig.	Remarks.	Group.	Div.	Cat. No.	Constellation.	Desig.	Remarks.
XIII.	*a*	1582	Hydra	—	30	*XIV.*	*a*	1312	Can. Maj.	o^1	109
"	*c*	1350	Can. Maj.	δ		"	*a*	550	Taurus	o	
"	*c*	4224	Cassiop.	ρ		"	*a*	3541	Cygnus	o^2	110
"	*c*	3564	Cygnus	γ		"	*a*	+56° 2746	Cepheus	—	105
"	*c*	3136	Draco	d		"	*a*	2141	Draco	6	
"	*ac*	213	Urs. Min.	α		"	*a*	+ 5° 104	Pisces	—	
XIII.	*a*	429	Perseus	θ		"	*P*	3779	Capricor.	ζ	111
XIV.	*a*	932	Auriga	α	39,92	XV.	*a*	2400	Boötes	α	
"	*a*	—	—	—	The Sun, 186	"	*a*	2541	Boötes	δ	184
"	*a*	2360	Boötes	η	93	"	*a*	4114	Pisces	γ	32,184
"	*a*	2807	Hercules	ζ	94	"	*a*	1459	Gemini	β	184
"	*a*	*1959*	Urs. Maj.	ξ		"	*a*	3648	Cygnus	ε	184
"	*a*	702	Perseus	μ	95	"	*a*	*1823*	Leo	γ	107,184
"	*a*	994	Lepus	β	96	"	*a*	2774	Hercules	β	32,184
"	*a*	4020	Pegasus	η	97	"	*a*	1926	Urs. Maj.	α	184
"	*a*	2232	Com. Ber.	43		"	*a*	93	Pisces	55	184
"	*a*	1558	Urs. Maj.	o	2	"	*a*	3450	Aquila	β	184
"	*a*	2937	Draco	β		"	*a*	4174	Androm.	λ	112,184
"	*a*	3537	Capricor.	α^1	20	"	*a*	1963	Crater	δ	184
"	*a*	360	Triangul.	δ		"	*a*	2736	Ophiuch.	ε	184
"	*a*	3795	Aquarius	β		"	*a*	3656	Cepheus	η	184
"	*a*	309	Pisces	112		"	*a*	2589	Libra	γ	184
"	*a*	1811	Leo	35	20	"	*a*	1961	Urs. Maj.	ν	112,184
"	*a*	2700	Scorpius	ω^2		"	*a*	3090	Serpens	η	184
"	*a*	1383	Can. Maj.	—	65	"	*a*	1086	Lepus	δ	112,184
"	*a*	3225	Lyra	—		"	*a*	3037	Ophiuch.	70	112,184
"	*ac*	3436	Aquila	η		"	*a*	1093	Auriga	δ	184
"	*ac*	3899	Aquarius	α		"	*a*	3447	Draco	ε	184
"	*ac*	876	Camelop.	10		"	*a*	812	Eridanus	53	184
"	*ac*	1492	Argo	e		"	*a*	4034	Pegasus	μ	184
"	*ac*	3981	Cepheus	δ	98	"	*a*	1999	Draco	2	184
"	*ac*	1205	Monocer.	T		"	*a*	+20° 85	Pisces	—	184
"	*ac*	1334	Gemini	ζ		"	*a*	94	Cassiop.	α	
"	*P*	1747	Leo	ε	99	"	*a*	2627	Serpens	α	185
"	*P*	1474	Argo	ξ	100	"	*a*	103	Cetus	β	185
XIV.	*a*	1457	Gemini	κ	101	"	*a*	183	Cetus	η	185
"	*a*	2976	Hercules	μ	102	"	*a*	2962	Ophiuch.	β	185
"	*a*	239	Pisces	η	101	"	*a*	3007	Hercules	ξ	185
"	*a*	2134	Corvus	β	103	"	*a*	1902	Leo Min.	46	185
"	*a*	2249	Hydra	γ	104,101	"	*a*	2838	Ophiuch.	κ	185
"	*a*	2515	Boötes	β	104,101	"	*a*	1760	Leo	μ	185
"	*a*	2851	Urs. Min.	ε	105	"	*a*	2208	Virgo	ε	185
"	*a*	1263	Gemini	ε		"	*a*	498	Perseus	κ	185
"	*a*	2057	Virgo	o	104	"	*a*	3328	Draco	τ	185
"	*a*	3780	Capricor.	35	101	"	*a*	45	Cetus	ι	185
"	*a*	*3645*	Delphin.	γ	106,107	"	*a*	1800	Hydra	λ	185
"	*a*	1580	Urs. Maj.	π^1		"	*a*	1452	Monocer.	26	185
"	*a*	1605	Cancer	ι	108	"	*a*	333	Aries	α	113,185
"	*a*	530	Eridanus	15		"	*a*	3084	Sagittar.	δ	185
"	*a*	696	Eridanus	37		"	*a*	2569	Draco	ι	2,185

Group.	Div.	Cat. No.	Constellation.	Desig.	Remarks.	Group.	Div.	Cat. No.	Constellation.	Desig.	Remarks.
XV.	a	3003	Draco	ξ	114?,185	XV.	a	1918	Crater	α	
"	a	220	Cetus	θ	115,185	"	a	443	Perseus	η	
"	a	1695	Draco	—	114,185	"	a	2555	Urs. Min.	11	
"	a	155	Cepheus	*2*	114?,185	"	a	2586	Libra	37	
"	a	1453	Gemini	σ	185	"	a	1244	Auriga	51	
"	a	4182	Cepheus	γ	185	"	a	1906	Leo Min.	47	
"	a	92	Androm.	δ	185	"	a	1972	Leo	—	
"	a	251	Perseus	υ	114,185	"	a	4259	Pisces	33	
"	a	3732	Cygnus	ζ	185	"	a	1030	Orion	ϕ^2	121
"	a	1629	Hydra	ζ	185	"	a	1500	Argo	12	20
"	a	2063	Corvus	ε	185	"	a	+80° 127	Cepheus	—	
"	a	775	Taurus	θ^1	185	"	a	+83° 287	Camelop.	—	
"	a	122	Pisces	62	185	"	a	+ 9° 1921	Cancer	—	
"	a	750	Taurus	δ	185	"	a	+58° 2314	Cepheus	—	122
"	a	560	Perseus	σ	185	"	a	+47° 460	Perseus	—	
"	a	2056	Draco	—	185	"	a	+24° 4473	Pegasus	—	
"	a	3836	Pegasus	ε	2,116,185	"	a	+ 0° 923	Orion	—	
"	a	3519	Vulpec.	19	2,117,185	"	*P*	576	Eridanus	ε	123
"	a	3460	Cygnus	η		*XV.*	a	1533	Cancer	β	
"	a	3316	Cygnus	κ		"	a	1698	Hydra	α	
"	a	3807	Cygnus	ρ	118	"	a	3418	Aquila	γ	
"	a	3654	Cygnus	T		"	a	862	Auriga	ι	
"	a	3708	Cygnus	—		"	a	2437	Urs. Min.	5	
"	a	2378	Hydra	π		"	a	2885	Hercules	π	
"	a	1734	Hydra	ι		XVI.	a	797	Taurus	α	
"	a	3005	Ophiuch.	ν		"	a	2500	Urs. Min.	β	32
"	a	2018	Urs. Maj.	χ		"	a	3466	Sagitta	γ	
"	a	1584	Urs. Maj.	π^2		"	a	3009	Draco	γ	
"	a	1941	Urs. Maj.	ψ	119,120	"	a	1685	Lynx	40	
"	a	1907	Urs. Maj.	46		"	a	1827	Urs. Maj.	μ	
"	a	4139	Aquarius	b^1		"	a	2343	Boötes	υ	
"	a	4093	Aquarius	c^2		"	a	1837	Hydra	μ	
"	a	401	Cassiop.	—		"	a	4031	Aquarius	τ	
"	a	2673	Corona	ε		"	a	4145	Aquarius	b^2	
"	a	3307	Draco	δ	119,120	"	a	1288	Camelop.	—	
"	a	119	Androm.	ζ		"	a	2636	Serpens	κ	
"	a	2595	Scorpius	*39*		"	a	2167	Com. Ber.	27	32
"	a	1394	Gemini	ι		"	a	375	Cetus	69	
"	a	1266	Gemini	30		"	a	653	Eridanus	γ	
"	a	3538	Capricor.	α^2		"	a	901	Lepus	ε	
"	a	4026	Pegasus	λ		"	a	1430	Gemini	υ	
"	a	2810	Hercules	η	119,120	"	a	1651	Urs. Maj.	σ^1	
"	a	3107	Hercules	109		"	a	1663	Argo	—	
"	a	464	Eridanus	η		"	a	3716	Cygnus	ξ	
"	a	2433	Boötes	ρ		"	a	*3717*	Cygnus	61	124
"	a	2488	Boötes	—		"	a	125	Pisces	δ	
"	a	4037	Cepheus	ι	119	"	a	315	Cetus	υ	
"	a	704	Cepheus	—		XVII.	a	185	Androm.	β	
"	a	3252	Sagittar.	ο		"	a	1893	Hydra	ν	125
"	a	1302	Lynx	15		"	a	482	Cetus	α	

Group.	Div.	Cat. No.	Constellation.	Desig.	Remarks.	Group.	Div.	Cat. No.	Constellation.	Desig.	Remarks.
XVII.	*a*	4040	Aquarius	λ	2	XVIII.	*a*	3649	Aquarius	3	34
"	*a*	2019	Virgo	ν		"	*a*	4217	Pegasus	φ	
"	*a*	3845	Cepheus	μ	126	"	*a*	2356	Draco	i	
"	*a*	1072	Auriga	υ		"	*a*	4120	Androm.	8	65
"	*a*	2201	Com. Ber.	36	32	"	*a*	2124	Draco	4	
"	*a*	1782	Leo	π		"	*a*	2802	Hercules	42	32
"	*a*	3357	Vulpec.	6		XIX.	*a*	489	Perseus	ρ	
"	*a*	3065	Hercules	A		"	*a*	533	Eridanus	τ^4	
"	*a*	30	Cetus	7		"	*a*	2510	Urs. Maj.	—	
"	*a*	3498	Draco	e		"	*a*	1360	Camelop.	—	
"	*a*	2563	Serpens	τ^1	65	"	*a*	1361	Gemini	51	20
"	*a*	3792	Pegasus	2		"	*a*	3210	Lyra	δ^2	
"	*a*	1988	Draco	λ	32 ?	*XIX.*	*a*	2879	Hercules	α	
"	*a*	1292	Cepheus	—		"	*a*	3224	Lyra	R	
"	*a*	2726	Ophiuch.	δ	127	"	*a*	2772	Hercules	g	129
"	*a*	855	Orion	5	20	"	*a*	+44° 3877	Cygnus	—	130
XVIII.	*a*	1091	Orion	α	128	XX.	*a*	370	Cetus	o	131
"	*a*	1160	Gemini	η		"	*a*	1752	Leo	R	132
"	*a*	4078	Pegasus	β	2	"	*a*	4234	Cassiop.	R	133
"	*a*	1102	Auriga	π		"	*a*		Orion	U	134
"	*a*	1952	Leo	72		"	*P*	3434	Cygnus	χ	135
"	*a*	1194	Gemini	μ	2	"	*P*	+67° 1291	Cepheus	T	136
"	*a*	821	Eridanus	54		XXI.	—	4198	Pisces	19	137
"	*a*	850	Orion	o^1		"	—	+38° 1539	Auriga	—	138
"	*a*	612	Camelop.	—	32	"	—	2164	Can. Ven.	—	139
"	*a*	2849	Hercules	*32*	65	"	—	1869	Hydra	U	140
"	*a*	2193	Virgo	δ		XXII.	—	1311	Can. Maj.	—	
"	*a*	2514	Scorpius	γ		"	—	+37° 3821	Cygnus	—	141
"	*a*	1638	Urs. Maj.	ρ		"	—	+36° 3987	Cygnus	—	142
"	*a*	4247	Pisces	30		"	—	+38° 4010	Cygnus	—	143

The stars whose spectra appear to be composite are enumerated in Table X. The first column gives the number in the Harvard Photometry, the second the constellation, and the third the Bayer letter. The fourth column gives the group to which the spectrum of the brighter star appears to belong. The spectrum of the fainter star appears to be almost always of the first type. The Orion lines are present in the case of ζ Aurigæ, and in the case of α Scorpii the spectrum of the companion is probably intermediate between the first and second types. A reference to the Remarks beginning on page 94 is contained in the fifth column.

TABLE X.

STARS OF COMPOSITE TYPE.

H. P.	Constellation.	Desig.	Group.	Remarks.	H. P.	Constellation.	Desig.	Group.	Remarks.
324	Andromeda . . .	γ	XV.	144	3739	Equuleus	α	XIII.	153
3362	Cygnus	β	XV.	145	650	Cepheus	—	XIII.	154
3528	Cygnus.	o^1	XV.	146	2764	Scorpius	α	XVII.	155
879	Auriga	ζ	XV.	147	4073	Andromeda . . .	o	V.	156
3421	Sagitta	δ	*XVII.*	148	1740	Leo	o	XII.	157
483	Perseus	γ	XIV.	149	2920	Ophiuchus	—	XII.	158
2467	Boötes	ε	XV.	150	*320*	Pisces	α	IX.	159
3554	Capricornus . . .	β	XIV.	151	3818	Capricornus . . .	γ	*XI.*	160
454	Perseus	τ	XIV.	152	1658	Ursa Major . . .	τ	XII.	161

Table XI. contains the stars of Orion type having bright lines. The first column gives the number from the Harvard Photometry, or for stars not contained in that catalogue, the zone and number in the Bonn Durchmusterung. The second column gives the constellation; the third, the letter or Flamsteed number designating the star. The fourth column gives the group and division to which the star in question would belong were its lines all dark. Where the agreement with any regular group of the series was not satisfactory, the group has been omitted, a statement of the phenomena being given in the Remarks. In the case of β Lyræ and υ Sagittarii the spectra of which are of composite type, the group and division has been given for both the primary and the secondary spectrum. The numbers of the Remarks are given in the fifth column.

TABLE XI.

STARS OF ORION TYPE HAVING BRIGHT LINES.

Cat. No.	Constellation.	Desig.	Group.	Rem.	Cat. No.	Constellation.	Desig.	Group.	Rem.
142	Cassiopeia .	γ	—	162	3747	Cygnus	υ	IV.*b*	169
269	Perseus . .	φ	—	163	*1220*	Monoceros . . .	11	IV.*b*	170
3960	Aquarius . .	π	—	164	2135	Draco	κ	V.*b*	171
3547	Cygnus . . .	P	—	165	578	Perseus	ψ	V.*b*	172
3193	Lyra	β	IV., VII.*c*	166	+23° 558	Taurus	—	V.*b*	173
3321	Sagittarius .	υ	VIII.*a*, IV.*b*	167	516	Camelopardalus	—	IV.*b*	174
1370	Canis Major	28	IV.*b*	168	1124	Orion	—	IV.*b*	175

REMARKS.

1. The lines of hydrogen are exceedingly wide.
2. This star approaches the following group.
3. This star combined with H. P. 1024 = θ Orionis. In both spectra the lines are exceedingly wide, especially those of hydrogen. The spectrum of the nebula is superposed, and appears as a number of separate images or irregular bright bands. Three of these correspond in position to the hydrogen lines Hβ, Hγ, and Hδ, while a fourth, which has great intensity, may be the hydrogen line Hλ, or may have shorter wave length. The hydrogen line Hϵ is probably represented by a trace of a bright band. An additional bright band having wave length greater than Hβ, and doubtless 5007.0, is present. Other indistinct bright bands are seen, and there may be dark lines also.
4. A distinct bright band borders the dark line 4649.2 on the side of shorter wave length. The Orion line 4096.9 is very strong in this star.
5. The only good photograph shows uncertain traces of a bright band bordering the dark line Hβ on the edge of shorter wave length. This, however, is unconfirmed, as the photographs taken with the eight-inch telescope did not show the bright band.
6. This star has been photographed only with one prism, but as the lines appear very sharp it is assumed to be of Division *a*.
7. The lines are exceedingly wide, and possibly double.
8. Plates very poor: the star is probably intermediate between this and the following group.
9. This star nearly resembles those of Group II., Division *b*, but is in several respects peculiar. In the great intensity of line 4120.5 and in the small intensity of line 4116.2 it is like stars of Group III. In the somewhat increased intensity of line 4387.8 and the slightly diminished intensity of 4089.2 it also approaches that group. It however approaches Group I. in the greater intensity of line 4685.4. See Remark 25. δ Scorpii resembles the star here described in some of its peculiarities, more especially in the small intensity of line 4116.2.
10. This star has been photographed only with one prism. It appears to be of Division *a*.
11. This star has been photographed only with one prism. It appears to be of Division *b*.
12. The image is very poor. The star may belong to this group.
13. In this star the line 3805.1 has unusually great intensity, and the lines 3982.8 and 3994.9 are somewhat stronger than in other stars of the group. In these respects the star resembles those of Division *c*, but in its remaining features it is not allied to that division.
14. This star appears to have the line K strong, and lines 3982.8 and 3994.9 somewhat conspicuous. The lines of hydrogen appear narrow in one of the photographs. The star may be of Division *c*. The plates, however, are poor.
15. The lines of this star, as seen in the photograph taken with four prisms, are somewhat hazy. This is probably due to imperfect focus.
16. The Orion line 3805.1 is stronger than in the typical star.
17. In the best photograph taken with four prisms, the lines, though narrow, appear hazy on the edge of greater wave length. This may indicate the presence of the lines of a companion star. See Remark 18. The remaining plates are either too poor or of insufficient dispersion to prove or disprove the presence of the companion lines. The star is assumed to be of Division *a*.
18. The spectrum of this star has two phases. At times it is of the ordinary type of Division *b*, having wide lines uniformly hazy, but well defined on their edges. At other times the lines are narrower, but hazy on the edge of shorter wave length. In the stronger lines of the spectrum the ragged border is replaced by distinct companion lines. These are probably due to the presence of the accompanying star, discovered by Vogel, the motions of which may give rise to the above described change in the spectrum. See Remark 19.
19. The hydrogen and Orion lines of this star appear to have companion lines similar to those found in α Virginis. See Remark 18. They occupy, as in that star, the position of shorter wave length. These may be due to the known companion. It has not been determined whether the spectrum changes like that of α Virginis.
20. Plates poor. The star probably belongs to this group.
21. The spectrum of the nebula is superposed. See Remark 3.
22. This star is probably of Division *a*.
23. This star is probably of Division *b*.
24. The plates are poor. The star probably belongs either to this group or to Group IV. A line having wave length 4416 approximately is stronger than in other stars of the group. This is probably due in part to combination with the Orion line 4437.9, which does not usually appear in stars of this group when photographed with one prism.
25. The peculiarities of this star can nearly be explained by supposing a combination of the spectra of Group III., Division *a*, and Group II., Division *b*. All the principal lines of Group III., Division *a*, are present, and they have the usual intensity, except in the following cases: lines 4069.4, 4072.0, 4089.2, 4649.2, and 4685.4 have the same intensity as in Group II., Division *b*, and the lines 4026.4, 4471.8, and 4712.8 are a little more intense than in either of the groups mentioned. The spectrum cannot be classed as of Division *a*, since the hydrogen lines and the principal Orion lines appear wide. Yet it differs from all ordinary spectra of Division *b* in having the faint lines of its group clearly present. In the plate taken with four prisms, the lines appeared double; the plate was, however, not very good. The star resembles in many respects those having composite spectra, but cannot be clearly classed as such because the line 4116.2, strong in stars of Group II., appears only as a faint line. In this last peculiarity the star resembles H. P. 1043 of Group II. See Remark 9.
26. The intensity of the Orion line 4649.2 is somewhat greater than in the typical star, and approaches that shown in the preceding group.
27. In the intensity of the lines between Hζ and Hη this star

agrees with those of Group V. Thus the Orion line 3863.2 is shown even under the dispersion of one prism, and 3856.2 is the strongest line between $H\zeta$ and $H\eta$.

28. This star has been photographed only with one prism. It may belong to Division *b*.
29. In the photograph taken with two prisms the lines appear slightly hazy. It is uncertain whether this is due to photographic defect, or is inherent in the nature of the spectrum. In the latter case, the star should be classed in Division *ab*.
30. This star may belong to the following group.
31. Plates poor. The star is either of this or the following group.
32. This star approaches the preceding group.
33. This star approaches the following group in the faintness of its Orion lines, yet has fewer solar lines than the typical star of the present group. It is also slightly peculiar in the relative intensity of its solar lines.
34. This star may belong to the preceding group.
35. The Orion lines are stronger and the metallic lines are weaker than in η Leonis, the typical star of Group VII., Division *c*, and the intensity of the hydrogen lines is intermediate between that found in Group VI., Division *c*, and Group VII., Division *c*. The Orion lines present are 4026.4, 4471.8, 4387.8, and 4267.4.
36. The star resembles H. P. 551. See Remark 35.
37. See Remark 35. The Orion lines present are 4026.4, 4471.8, 4387.8, 4009.5, 3819.2, 4267.4.
38. Plates very poor. The star appears to be of Division *c*, and probably lies between Groups VI. and VII. It is, however, uncertain to what group it belongs.
39. The lines of this star are not so narrow and sharply defined as those of the other typical star of Division *a* in this group.
40. The intensity of the hydrogen lines is perhaps a little greater than in α Canis Majoris. The remaining lines are sharper and more clearly defined than in that star, but are in general less intense, while a few of the faintest lines seen in that star are lost. The Orion line 4471.8, absent in α Canis Majoris, is present. The only remaining differences observed are that the solar line 4067.0, which appears with moderate intensity in α Canis Majoris, is here seen only as a faint trace, and that the solar line 4247.3, absent in that star, is here well defined.
41. The lines are perhaps a little hazy.
42. The Orion line 4026.4, and a trace of 4471 8, are present.
43. The Orion line 4026.4 is present.
44. This star differs from other stars of Division *a* in the greater intensity shown in the lines 4128.5 and 4131.4. It also has fewer solar lines, and the relative intensity of those present is slightly peculiar. The star in some degree resembles θ Aurigæ and 12 Canum Venaticorum of Group VIII., but differs from them in not having the line K weaker than is normal for the group. The lines of the spectrum may be very slightly hazy.
45. This star is peculiar. The Orion lines 4026.4 and 4471.8 are present, yet the general intensity of the solar lines approaches that found in the following group. A few of the solar lines are peculiar in intensity. The line K has the same intensity as in other stars of Group VII., Division *a*.
46. The relative intensity of the solar lines differs slightly from that shown in the typical star.
47. The lines are exceedingly wide.
48. A trace of the Orion line 4026.4 is probably present.
49. In the intensity of the solar lines, the star slightly approaches the following group.
50. In one photograph the line K appeared double. The best plates, however, give the line K single, and the apparent doubling is probably due to defective focus.
51. The lines are but little wider than in stars of Division *a*.
52. In several photographs of this star, the line K appeared indistinctly double. The duplicity has, however, not been satisfactorily confirmed.
53. In the intensity of the line K and of the solar lines the star approaches the following group.
54. The star is probably of this group and division.
55. The lines are probably slightly widened.
56. The periodic doubling of the lines of this star will be discussed in another publication of the Observatory. When the lines are single, the spectrum is of Division *a*. Before doubling, the lines widen, and the spectrum assumes the character of typical stars belonging to Division *b*.
57. In two of the photographs of this star the lines appear slightly hazy. This may be due to poor definition in the photograph.
58. The solar lines shown are few in number for this group. This may perhaps be due to the poor quality of the plate, as the line K is as strong as in typical stars of the group.
59. In the intensity of the solar lines this star resembles those of the following group. The width of the line K, however, as seen under the dispersion of one prism, is normal for this group. In one photograph the lines appear slightly hazy. This is perhaps due to poor definition, as in the remaining plates the lines are sharply defined.
60. In the intensity of line K this star approaches the following group.
61. In the narrowness of line K this star approaches the preceding group. The solar lines, however, are nearly the same as in typical stars of Group VIII.
62. The violet end of the spectrum of this star appears on a plate showing the spectrum of η Pegasi. The star is probably of Group VIII., but approaching Group VII.
63. The plate is poor. The star is probably of Group VIII., Division *a*, but may belong to Group VII., Division *b*.
64. The line K appeared double in one of the photographs, but this duplicity has not been confirmed.
65. Plates poor. The star belongs either to this or to the preceding group.
66. In its general aspect this star resembles those of Group VIII., which approach Group VII. A few of its faint lines, however, are peculiar, some in intensity and others in wave length. The line K is even weaker than in stars of the preceding group. In this respect the star resembles those having composite spectra.
67. This star is peculiar in the intensity and wave length of some of its lines. It may for convenience be classed with stars of Group VIII., approaching Group VII., but in the details of its spectrum it is not like those of either group. The hydrogen lines are the same as in the above men-

tioned groups, and the majority of the remaining lines are those of Group VIII., Division *a*. Many of the solar lines which are present in that group, however, are absent, especially in the region having wave length shorter than 4101.8, where the lines are few and weak. On the other hand, some well marked lines appear, which are either faint or absent in normal stars of the group. The Orion lines 4026.4, 4471.8, and 4267.4 are present. The line K is rather fainter than in stars of Group VII. The lines are narrow, as in Division *a*.

68. This star resembles α Andromedæ, (see Remark 67,) so far as can be ascertained from plates taken with two prisms.

69. This star most nearly resembles those of Group VIII., Division *a*. It has, however, marked peculiarities. Thus, the line K is extremely faint, and the lines 4131.4 and 4128.5 have greater intensity than in any other stars except those of Division *c* in Group VIII. Some of the fainter lines appear to be peculiar in wave length, while others differ in intensity from the corresponding lines of the stars in Division *a*. In the weakness of the line K alluded to, this star resembles those of composite type, and its peculiarities may perhaps be due to its known duplicity. If, however, in the companion star the line K is so faint, it is difficult to explain the absence of the Orion lines.

70. This star closely resembles 12 Canum Venaticorum. See Remark 69. It differs from that star only in the altered intensity of several faint lines, and in the presence of several others not seen in 12 Canum Venaticorum.

71. The spectrum of this star resembles the spectra of 12 Canum Venaticorum and θ Aurigæ. See Remarks 69, 70. The photographs are somewhat faint, and as they have not been taken under the greatest dispersion a more detailed comparison with those stars cannot be made. Some differences probably exist among the faint lines.

72. In the general intensity of the solar lines the star lies between Group VIII., Division *a*, and Group VII., Division *a*. The line K, however, is fainter even than in stars of the latter group. In this respect the star resembles those having composite spectra, and its peculiarities may be due to its duplicity. The lines of hydrogen are somewhat wider than in stars belonging to Division *a*, yet the remaining lines do not show the widening seen in stars belonging to Division *b*. A slight variation is shown in the relative intensity of the solar lines, and this, together with the weakness of the line K alluded to, causes the star to resemble in some degree θ Aurigæ and 12 Canum Venaticorum.

73. The photographs show a slight variation in the width of the line K and the solar lines. This is probably due to the difference in density of the image, as shown in the several photographs.

74. The photographs of this star show fewer solar lines than those of the other stars with which this is classed. The star may be in this respect peculiar, or may belong to Division *b*. As, however, only one of the photographs is good, the absence of the fainter lines may result simply from the quality of the plate.

75. In the photograph taken with the greatest dispersion, the solar lines appear with an intensity somewhat faint for the group. As this does not appear in the plates taken with fewer prisms, it may be due to the quality of the plate.

76. The lines are probably as narrow as in stars of Division *a*. If any slight widening exists, it is not enough to appear in the photographs taken with two prisms.

77. The lines of hydrogen and the line K appear somewhat narrower than in the remaining stars of this group. The line K has a trace of a bright border on the edge of shorter wave length.

78. The star may in some degree resemble those of Division *ac*.

79. This star is very peculiar in the relative intensity of its solar lines.

80. The star approaches, and may belong to, the preceding group.

81. This star is probably of Division *a* or Division *b*.

82. In the only photograph of this star which has been taken with four prisms the lines of hydrogen and those of calcium appear narrower than in typical stars of Division *a*. Yet the star approaches neither Division *c* nor the following group. These peculiarities are much less apparent in the photograph of smaller dispersion, and are therefore at present unconfirmed. The solar lines present are the same as in α Canis Minoris, except that 4006.9 does not appear. Their relative intensity is the same as in that star.

83. The band K is somewhat wider than in the typical star.

84. The band at 4307 is somewhat strong for a star of this group.

85. The band at 4307 and the line at 4326.0 are not clearly shown. The image, however, is dense and ill defined.

86. The line 4326.0 does not appear in the photograph, and the solar lines in general seem somewhat faint. The plate, however, is poor.

87. The spectra of 40 and 41 Draconis can readily be separated. They are indistinct in the photographs taken, but appear to be nearly or quite similar, and to belong either to this or the following group. The hydrogen lines Hβ, Hγ, and Hδ, and the band at 4307, can be distinctly seen in each of the spectra.

88. The lines of this star appear uncommonly narrow and weak. As there is but one photograph, this aspect may be accidental.

89. This star is probably intermediate between ε Aurigæ of Group XII., Division *c*, and δ Canis Majoris of Group XIII., Division *c*. It was at first classed with stars of Division *ac*, intermediate between the groups, but its resemblance to such stars is not satisfactory. In the intensity of its metallic lines it resembles δ Canis Majoris, while in its comparatively narrow K band it is allied to ε Aurigæ. Its lines of hydrogen are intermediate in intensity between those of the two stars. As in stars of Group XIII., Division *c*, when photographed with a single prism, the apparent intensity of the lines Hβ and Hγ is greater than that of the remaining lines of hydrogen, owing to the combination of Hβ and Hγ with adjacent strong lines. The bands H and K of calcium are nearly equal, and the latter does not differ greatly in intensity from the band K of ε Aurigæ.

90. The spectrum of this double star has a peculiar hazy appearance. The line K, however, does not appear nar-

row or obscure, as in composite spectra combining the first and second types.

91. The lines of hydrogen have as great intensity as in Group XII. The band at 4307 is strong.

92. The intensity of the lines of this star agrees with that shown in the photograph of the solar spectrum, except in the following details: lines 4171.2, 4195.6, 4200.9, and 4783.6 are nearly or quite invisible; lines 4012.6, 4067.0, 4077.9, 4090.2, 4104.3, 4196.8, 4205.3, 4321.0, 4401.6, 4408.5, 4450.6, 4508.5, 4515.4, 4629.9, 4698.8, and 4848.4 are stronger than in the Sun; and lines 4076.8, 4206.9, 4318.9, 4323.7, 4405.0, and 4703.1 are weaker than in the Sun. Those among the last two classes enumerated which differ markedly from the solar intensity are 4077.9, 4196.8, 4205.3, and 4698.8 of the first class, and 4076.8, 4323.7, and 4703.1 of the second class. The comparison with solar intensities was, however, difficult to make with accuracy, owing partly to the fact that the solar spectrum, unlike that of the star, had been obtained by the use of a slit spectroscope, and partly also to the fact that the lines of α Aurigæ are slightly wide and hazy.

93. The spectrum of this star, unlike that of α Aurigæ, has perfectly clear and narrow lines. It agrees with that of the Sun, except in the following details: lines 4014.7, 4171.2, and 4204.2 are absent; lines 4012.6, 4035.8, 4048.9 to 4049.7, 4156.7, 4161.7, 4205.3, 4258.7, 4321.0, 4401.6, 4408.5 ?, 4450.6?, 4508.5 ?, 4513.0, 4629.9 ?, 4698.8, and 4848.4 are stronger than in the Sun; lines 4034.6, 4405.0, and 4703.1 are weaker than in the Sun. Those exhibiting marked differences from the solar intensity are 4321.0 and 4513.0.

94. The spectrum is relatively faint in the region having wave length shorter than 3889.0. In this respect the star approaches the following group.

95. The line 4077.9 is somewhat stronger than in α Aurigæ.

96. The general absorption is great for wave lengths less than 3889.0, and begins to be visible in the region between wave lengths 4144 and 4216. In these respects, as well as in the general intensity of its lines, the star approaches the following group. The intensity of the hydrogen lines is, however, about the same as in the present group. The line 4077.9 appears stronger than in α Aurigæ. This is, however, very likely due to a greater intensity of the line 4076.8, which, under the dispersion used, combines with 4077.9. The former line is weaker in α Aurigæ than in the Sun.

97. General absorption is somewhat strong in the region having wave length shorter than 3889.0, and is faintly visible between 4144 and 4216. The line 4077.9 is strong. The star slightly approaches the following group.

98. The lines Hβ, Hγ, Hδ, and Hε of the star H. P. 3982 appear superposed on the spectrum of H. P. 3981.

99. This star resembles ζ Capricorni of Group XV., but is less peculiar. See Remark 111. In the intensity of its hydrogen lines it agrees with stars of Group XIV., Division *a*, and in the relative intensity of its solar lines it nearly resembles them. In the aggregate intensity, however, of the solar lines, as also in the brightness of the bands 4315 to 4368, 4470 to 4525, and 4614 to 4648, and in the amount of absorption in the region of wave length shorter than 3889.0, it is like the star α Cassiopeiæ of Group XV. The width of the calcium bands also, is at least as great as in Group XV. The amount of absorption in the region between 4144 and 4216 is intermediate between that shown in Group XIV. and in Group XV. The solar lines 4077.9, 4374.7 to 4376.1, 4654.8 to 4657.0, 4663.7, and 4668.0 are somewhat stronger than in stars of Group XIV., and other differences probably exist.

100. This star is nearly like ε Leonis, (see Remark 99,) but the amount of general absorption, both in the region between 4144 and 4216 and in that having wave length shorter than 3889.0 equals or exceeds that shown in stars of Group XV. The band containing the solar lines 4663.7 and 4668.0, seen as one line under this dispersion, is stronger than in ε Leonis. The calcium lines are not well shown, but are probably the same as in the above mentioned star.

101. This star resembles α Cassiopeiæ more nearly than α Boötis in the amount of general absorption in the region having shorter wave length than 4300, and in the intensity between lines 4215.7 and 4227.0.

102. The band containing the solar lines 4196.8, 4198.5, 4202.2, and 4205.3, irresolvable under this dispersion, is stronger than in other stars of this group.

103. The solar line 4323.7 is stronger than in typical stars of Groups XIV. and XV. The line 4337.6 has probably also a greater intensity.

104. This star closely approaches Group XV.

105. This star closely approaches Group XIV.

106. The hydrogen lines are as strong as in Group XIV. The line Hζ, indeed, appears in the only good photograph to be even stronger than in stars of that group.

107. The spectra of the components of the double star are inseparable.

108. The spectrum of the faint star +29° 1823, which is of the first type, is superposed.

109. The degree of general absorption shown in the violet region is as great as in stars of Group XV.

110. In one of the photographs the line K appears weak. The plates are very poor.

111. The spectrum of this star is very peculiar. It perhaps most nearly resembles that of stars lying between Groups XIV. and XV., but the general absorption in the region having shorter wave length than 4307 is as great as in α Cassiopeiæ of Group XV., while the hydrogen spectrum is as strong as in Group XIV. The solar lines 4076.8 to 4077.9, 4215.7, 4668.0, and 4670.0 are stronger than in stars of either of the above groups, while 4405.0 is weak or absent. A line of great intensity is seen, which probably includes the solar lines 4554.2 and 4556.0. Other peculiarities are shown among the fine lines of the spectrum.

112. The line 4227.0 appears somewhat stronger than in α Boötis.

113. The amount of absorption in the violet is probably a little greater than in α Cassiopeiæ.

114. The line 4227.0 is a little stronger than in α Cassiopeiæ.

115. The star −8° 243, which is in the same right ascension, is superposed. This star is of the first type, and its superposition narrows the line K of the principal star. This effect, though slight, is interesting in its bearing on the theory of composite spectra.

116. The hydrogen lines appear as strong as in stars lying between Groups XIV. and XV.

117. The line or band containing the hydrogen line Hγ and the line 4337.6, irresolvable under this dispersion, is as strong as in the preceding group. The hydrogen lines Hβ and Hδ are not shown, as the plates are poor. A faint star of the first type is superposed.

118. In the intensity of the hydrogen lines the star approaches the preceding group.

119. The amount of general absorption is probably intermediate between that found in α Boötis and that found in α Cassiopeiæ.

120. The space between the lines 4215.7 and 4227.0 appears bright as in α Cassiopeiæ.

121. The line 4227.0 has relatively great intensity.

122. Plates poor. The star probably approaches, and may belong to, the following group.

123. The star is peculiar in the intensity of some of the solar lines in the region between 4227.0 and the line H. The line K is as narrow as in stars of Group XI.; but as the hydrogen lines are not stronger than in stars of Group XV., this star cannot be classed with those having composite spectra.

124. The spectrum appears as though a faint star of the first type were superposed. This may perhaps be due to the adjacent star.

125. On a plate of fair quality, taken under the dispersion of two prisms, the star was classed in Group XV. The photograph taken with four prisms, which was of good quality, showed it to be certainly of Group XVII. Both plates agreed in right ascension and declination, and the plate taken with two prisms was identified also by means of additional stars in the field. These were too faint to appear in the plate taken with four prisms.

126. The line 4227.0 is no stronger than in stars of Group XV., and the star is otherwise peculiar.

127. The absorption bands characteristic of third type stars are not as well defined as in most stars of this group. In this respect the star approaches the preceding group.

128. The lines of hydrogen and the line 4227.0 have an intensity similar to that seen in the preceding group. A similar increase in the intensity of the hydrogen lines and diminution in the width of 4227.0 are seen in stars having composite spectra.

129. The brightness is nearly uniform from 3970 to 4762. In this respect the star agrees with those of Group XX., but the lines of hydrogen are not bright.

130. The distribution of light is probably the same as in g Herculis. See Remark 129. The photographs, however, are too faint to show this with certainty. The absorption band having its edge of shorter wave length at 4586 is well shown.

131. The hydrogen lines Hγ, Hδ, Hζ, Hη, Hθ, Hι, Hκ, Hλ, Hμ, and Hν are bright, the last line being stronger than the three preceding. In some photographs the line Hβ is seen as a very narrow bright line. In other good plates it is not seen.

132. The hydrogen lines Hγ, Hδ, Hζ, Hη, Hθ, and Hι are bright.

133. The hydrogen lines Hγ, Hδ, Hζ, Hη, Hθ, and Hι are bright.

134. The hydrogen lines Hγ and Hδ are bright. The other hydrogen lines are not seen, owing to the faintness of the image.

135. The hydrogen lines Hβ, Hγ, Hδ, Hζ, Hη, Hθ, Hι, and perhaps Hκ, are bright. The line Hβ is less intense than Hγ. An additional bright line is seen at about 3900. This is faintly visible in *o* Ceti. The distribution of light differs from that of the typical star of the group. See page 46.

136. The hydrogen lines Hγ, Hδ, Hζ, and perhaps Hη, are bright. The star resembles χ Cygni, except that the line Hβ is not bright. This may be due to the faintness of the image. The distribution of light differs from that of the typical star of the group. See page 46.

137. The photographs show clearly the two absorption bands characteristic of the photographic spectrum of stars of the fourth type. The band of shorter wave length is well defined, and a bright border is faintly seen on either edge. The band of greater wave length is well defined on the edge of greater wave length, and fades gradually in the other direction. The photograph taken by means of erythrosin shows the strong dark line near the region of the sodium line D, which is characteristic of stars of the fourth type. Eight or nine fainter lines lying between 5900 and the absorption band of greatest wave length are also present. Traces of dark lines are seen elsewhere in the spectrum, the two principal lines being those on either side of the absorption band of shortest wave length. The photographic spectrum extends from about 4307 to beyond 5900.

138. This star resembles H. P. 4198. See Remark 137. It shows both absorption bands and the strong line in the yellow near the region of D. The image is too faint to show whether the remaining lines seen in the yellow of H. P. 4198 are present. Indistinct traces of four or five lines appear in the region having shorter wave length than 4860. The absorption band in this region is well defined on the edge of greater wave length, where it is bordered by a bright space having about half the width of the band. The edge of shorter wave length of the absorption band is more indistinct. The other absorption band is not well defined on either edge. The image is somewhat poor and faint. The spectrum extends from about 4530 to 5900, or beyond.

139. The absorption band having its edge of greater wave length at about 4861 is well defined, has a bright border at this wave length, and fades gradually toward the violet. As the star has not been photographed on plates stained with erythrosin, the region of the second band and of the line D are not shown. The photograph is too poor to show definite lines.

140. This star closely resembles +38° 1539, No. 19 of Dunér's second list, but, as the photograph is clearer, more lines are shown. In addition to the strong line in the yellow, five or six other lines appear which agree with the principal lines of 19 Piscium. The stars H. P. 1869, H. P. 4198, +38° 1539, and H. P. 2164 are thus in all probability closely similar.

141. The image is faint. The bright bands of H. P. 1311, at wave lengths 4059, 4102, and 4688, with traces of others, are seen superposed on the faint continuous spectrum.

142. The image is faint and ill defined. The bright bands of H. P. 1311 at wave lengths 4059, 4102, 4614, and 4688, and possibly others, are seen superposed on the faint continuous spectrum.

143. The image is very faint and ill defined. Of the bright bands of H. P. 1311, that at wave length 4688 only can be clearly seen on the continuous spectrum.

144. The spectrum of this double star presents the combination of a normal spectrum of Group XV., like that of α Cassiopeiæ, with one of a fainter first type star. By the superposition of the latter, the K band of the second type star is nearly obliterated, and only the narrow K line of the first type star appears. The ultra-violet hydrogen lines Hζ, Hη, Hθ and Hι, belonging to the first type star, are well shown. In this region of the ultra-violet, the spectrum of the first type star predominates, obliterating many of the fainter lines of the star of the second type. In the region between 3970 and 4860 the spectrum of the second type nearly obliterates the other, the presence of which is detected only by a slightly increased intensity in the hydrogen lines Hβ, Hγ, and Hδ. The spectra are nearly inseparable, the difference in right ascension being little, and that in declination still less. The photographic image, however, of the first type star, on one edge extends beyond that of the second type star, and the former can thus be shown to have the greater right ascension. The peculiarities above described are interesting in their bearing on the general question of composite spectra. The narrow K line is slightly hazy, as in stars belonging to Division *b*.

145. The spectrum of the star H. P. 3363, which is of the first type, or perhaps of the later Orion type, is superposed on H. P. 3362, but is readily separable from it, owing to its difference in right ascension and declination. When the images are coincident, that of the first type star predominates in the ultra-violet, that of the second type star in the blue and violet. The strong hydrogen lines Hζ, Hη, Hθ, Hι, Hκ, and Hλ are well shown, while Hβ, Hγ, and Hδ are nearly concealed. The above mentioned details are of interest as bearing on the question of composite spectra; the important fact, however, is that the spectrum of H. P. 3362 has itself a composite character. It is in general like that of α Cassiopeiæ, of Group XV., but has the strong hydrogen lines and the weak and narrow K line of a star of the first type. The hydrogen lines Hδ, Hζ, Hη, and Hθ are conspicuous, and Hβ and Hγ are stronger than in normal stars of Group XV. The compound band H is of course well marked. In the ultra-violet the fainter lines characteristic of stars of Group XV. are obliterated. As the appearances here described are equally well shown in those portions of the image where H. P. 3363 is not superposed, they are certainly not due to that star. They could be explained on the supposition that H. P. 3362 is itself double, one component being a star of the second type belonging to Group XV., the other a star of the first type approaching the second type.

146. The spectrum of this double star resembles that of γ Andromedæ, which combines the features of Group XV. with those of the first type. In the present case, however, the images are coincident throughout. The hydrogen lines Hδ, Hε, Hζ, and Hη appear as in a first type star, and the lines Hβ and Hγ are stronger than in normal stars of Group XV. The band K is reduced to an inconspicuous haze, and in the violet region many of the fainter lines characteristic of second type stars are lost.

147. This star is one of the most beautiful examples of composite spectra found among stars not known to be double. It resembles 31 Cygni, but shows still more strikingly the features of the first type. The spectrum predominant in the blue is of Group XV., agreeing with that of α Boötis, except in the hydrogen lines Hβ and Hγ, which are far too strong for the group. The spectrum predominant in the violet and ultra-violet appears to be of the Orion type, and may probably be classed in Group V. The hydrogen lines Hε, Hζ, Hη, Hθ, Hι, Hκ, Hλ, and Hν have the great intensity characteristic of stars of the later Orion type or earlier first type, while that of the line Hδ is but little reduced. The band K appears merely as an inconspicuous haze, or in the best plate as a more distinct but narrow line. In the region having wave length shorter than 4000, solar lines are few as compared with the number found in normal stars of the second type. This is more noticeable in the photograph taken with one prism. The Orion line 3819.2 is well shown, and excepting those of hydrogen it is the only well marked line in that region. The Orion line 4026.4 is also present.

148. The spectrum of this star presents the most marked contrast shown among the composite spectra studied in this investigation. Here the spectrum of a star of the third type intermediate between Groups XVII. and XVIII., and nearly resembling that of α Orionis, is combined with that of a star of the first type. The absorption bands characteristic of the third type may be seen in the region between 4762 and 5900, while in the violet and ultra-violet the hydrogen lines Hδ, Hε, Hζ, Hη, and Hθ are as strongly marked as in the first type. Hβ, and Hγ are somewhat strong, but not of corresponding intensity. The line K, when appearing at all in the photographs, is seen as a somewhat wide and indefinite haze.

149. This star combines a spectrum of Group XIV., that is, resembling that of the Sun, with a spectrum of the first type, belonging perhaps to Group IX. The hydrogen lines Hβ, Hγ, Hδ, Hζ, Hη, Hθ, Hι, Hκ, Hλ, and Hμ are well shown. The line K appears as a rather narrow line of moderate intensity, and somewhat hazy on the edge of shorter wave length. The compound band Hε and H is the same as in Group XIV. Many of the lines in the ultra-violet region characteristic of second type stars are present. The star of the first type probably approaches the second type.

150. This double star combines a spectrum of Group XV., like that of α Cassiopeiæ, with one of the first type approaching the second. The hydrogen lines Hβ, Hγ, Hδ, Hζ, Hη, Hθ, Hι, Hκ, Hλ, and Hμ are seen, together with ultra-violet lines characteristic of second type stars. These hydrogen lines, however, are only of moderate intensity, as in stars intermediate between the first and second types. The line K is narrow but clear. It is of equal intensity with the lines of hydrogen, yet this intensity is scarcely two tenths that of the band H, which is normal for a second type star. This wide difference in the intensities of the lines H and K is difficult to explain, inasmuch as the moderate width of the hydrogen lines requires the assumption that the companion star approaches the second type. It is, however, not improb-

able that the apparent width of the hydrogen lines is diminished and that of the K line increased by superposition on the spectrum of the second type, or it may be that the star of the first type has the narrow lines of Division *c*.

151. The spectrum of this star closely resembles that of the double star ε Boötis. See Remark 150. In the present star, however, the principal component is of Group XIV., while the hydrogen lines are more pronounced and the line K weaker than in the above mentioned star. The secondary spectrum may be of Group IX. or Group VIII. The hydrogen lines from Hβ to Hλ inclusive are seen.

152. The spectrum is nearly like that of α Aurigæ, of Group XIV., but the intensity of the hydrogen lines is too great for this group, and the line K has not more than half the width of H. If this spectrum, which thus is evidently composite, is assumed to be that of a double star, the component of the earlier type should be intermediate between the first and second types. It is difficult to say whether it should be classed in Group X., XI., or XII., since it is uncertain how much the apparent width of the hydrogen lines would be reduced by superposition on the spectrum of the second type.

153. The spectrum of this star combines the features of Group XIII. with those of stars intermediate between the first and second types. The hydrogen lines Hβ, Hγ, Hδ, Hζ, Hη, and Hθ are well shown, and a trace of Hι appears. The line K is equal in width to Hζ, but has only half the width of H. The assumed companion star should probably be of Group X. or XI.

154. This double star shows a spectrum of Group XIII. combined with one of a first type star which may belong to Group IX. or X. The line K has about the same width as the lines of hydrogen, but only half that of the line H.

155. The spectrum is substantially that of a star of Group XVII. approaching Group XVIII. There are, however, indications of a faint superposed spectrum intermediate between the first and second types, and belonging perhaps to Group XI. or XII. The ultra-violet hydrogen lines Hζ, Hη, and Hθ are shown, and Hβ, Hγ, and Hδ are too strong for a star of the third type. The band K is hazy, and has a central line of clearer definition. These appearances are probably due to the faint companion. Some excellent photographs of the region between 4860 and 5900 have been obtained by means of plates stained with erythrosin. These have the dispersion of four prisms, and show all the lines found in α Orionis in this region, and enumerated in Table VI. These lines have, with a few slight exceptions, about the same intensity as in α Orionis. As, however, the star is a little earlier in the series, the absorption bands characteristic of the third type are not so well developed as in α Orionis, and the dark lines covered by them are therefore more clearly shown.

156. This star is very peculiar. It combines the spectrum of a star belonging to Division *c* of Group VII., approaching Group VIII., with that of a star of the Orion type, belonging to Group V. In plates taken with two prisms, only the spectrum of the Orion type appears, but in those taken with one prism the lines of Group VII., Division *c*, approaching Group VIII., Division *c*, come into prominence, and have the same relative intensity as in α Cygni. The loss of these well marked lines when more prisms are used appears to show that they belong to the spectrum of a fainter star. This would furnish an exception to the nearly universal rule that in binaries the fainter star is of the earlier type. As all lines appearing in the plates taken with two prisms are hazy, the spectrum of the brighter star must be of Division *b*, unless its lines are affected by the otherwise invisible spectrum of the fainter star.

157. This star appears to combine a spectrum of Group XII. with one of earlier type, belonging probably to Group X. The line K has only seven tenths the width of the compound line Hε and H, yet the band 4307, though faint, is visible in the plates taken with one prism.

158. This star combines a spectrum of Group XII. or XIII. with the strong hydrogen lines of a star of the first type. The line K is very weak and hazy.

159. This double star appears to combine a spectrum of Group IX. with one of earlier type, which may be Group VII., Division *b*. The number and intensity of the solar lines is the same as in Group IX., while the line K is faint and hazy, having the width and intensity shown in stars of Group VII., Division *b*. The hydrogen lines are wide, as in stars of Division *b*. No Orion lines can be detected.

160. This star appears to have a composite spectrum. In the number and intensity of its solar lines it lies between Groups XI. and XII., while the intensity of the line K and the hydrogen lines would place it in Group X. The line 4077.9 has an intensity unusually great even for a star of Group XII. See Remark 161.

161. This star probably has a composite spectrum, and nearly resembles γ Capricorni. See Remark 160. From the number and intensity of its solar lines it should be classed in Group XII. The width of the lines K and H, however, and the intensity of the hydrogen spectrum, would place it in Group X. The band 4307 is weak for a star of Group XII., and appears to be the same as in stars intermediate between that and the preceding group. The portion of the spectrum immediately bordering the line K on the edge of shorter wave length is brighter than in stars of the regular groups, and resembles a bright band. The star has been photographed only with one prism.

162. This star is one of the most interesting among those of the Orion type having bright lines. Its most important peculiarity is shown in the double reversal of its hydrogen lines. Each of these, typically considered, consists of a bright band of moderate width superposed on a very wide and hazy dark band, and having superposed upon itself centrally a very fine dark line. The intensity of the bright band is great in the line Hβ, and diminishes with each succeeding hydrogen line of shorter wave length. In the line Hε the bright band is nearly neutral, or but little brighter than the background of the spectrum, while in the lines beyond Hζ no bright lines are seen. The underlying dark bands and the fine central dark lines become more conspicuous as the bright bands decrease. Thus, while in the line Hβ these dark elements are barely visible, in the lines beyond Hζ they compose the entire line. The width of the underlying dark bands is greater than is seen among the stars of Division *b*, in which the lines are

widest. It should be noted that the hydrogen line Hκ is comparatively narrow, and appears to be displaced in the direction of greater wave length. This may be due to the disappearance of the more refrangible half of the dark band. Compare Remark 163. The hydrogen lines beyond Hκ, if present, are indistinct; traces are seen which may be the lines Hν and Hξ. Other bright bands are seen in this spectrum besides those of hydrogen, the most important of these being in the region between 4860 and 5900. The strongest of them are the Orion line 5023 and one having somewhat greater wave length. Four fainter lines follow, having still greater wave length. Other bright regions appear elsewhere in the spectrum which are not well defined bright bands, like those previously described, but have rather the nature of bright spaces between dark lines, or of bright borders to these lines. Among these may be noted that between the Orion lines 4576.5 and 4591.6 and one near 4531.4 on the side of shorter wave length, and many others are more or less distinctly visible elsewhere in the spectrum. These, however, vary greatly under different dispersions, an increase of dispersion frequently rendering the wider bands invisible, and bringing new and narrower bands into prominence. The entire region from the Orion line 4154.7 to line 3927.1 appears brighter than the rest of the spectrum, this brightness not being, however, homogeneous, but greater in the spaces between certain of the dark lines. This wide region of increased brilliancy has also been noticed in the normal stars of Groups I. and II. It does not appear in the later Orion groups, nor elsewhere in the series. It may be of interest to note that in γ Cassiopeiæ the strongest of the Orion lines are without distinct bright borders. All the dark lines in this spectrum appear as wide and hazy bands. This system of dark lines is more closely related to those of Group II. than to the spectra of any other group. A number of the more prominent lines of Group II. are present, those clearly shown being 3819.2, 3867.6, 3912.2, 3927.1, 3994.9, 4009.5, 4026.4, 4069.4, 4072.0, 4089.2, 4116.2, 4120.5, 4144.0, 4254.1, 4267.4, 4285.1, 4387.8, 4471.8, 4568.6, 4641.1, 4649.2, 4661.7, 4675.3, 4685.4, and 4712.8. All of these but 4116.2, which is very faint, and 4649.2, which has a comparatively small intensity, agree fairly well in relative intensity with normal stars of Group II. The actual intensity of the lines, however, is less than in the normal stars, owing to the obscure aspect of the entire system of dark lines. Some dark lines may be present which are not among the known Orion lines, but it is extremely difficult in a spectrum of this kind to distinguish between true dark lines and spaces between bright lines.

163. The spectrum of this star nearly resembles that of γ Cassiopeiæ. See Remark 162. The most important difference is that the first reversal of the hydrogen lines is less marked than in γ, while the second is more so; that is, the bright bands are fainter and the central dark lines stronger. The wide underlying dark bands also, except in the line Hγ, are weak, and in most of the hydrogen lines are replaced by fine and delicate lines lying on either side of the bright band. Thus the lines Hδ, Hϵ, Hζ, Hη, Hθ, and Hι appear triple, with a stronger central component and a fine yet hazy line on either side. In Hζ the central line is sharp and narrow, but of great intensity, while the companion lines are very faint. In Hκ the companion line of shortest wave length disappears, (compare the apparent displacement of this line seen in γ Cassiopeiæ,) and in general one or other of these fine companion lines may be extremely faint or invisible. In the case of Hγ the underlying dark band retains its wide and unbroken character, but in the case of Hβ the bright band alone appears, without either underlying dark band or dark companion lines. Of the bright bands, those of Hβ and Hγ have great intensity, the former being the brightest. In Hδ, Hϵ, Hζ, and Hη the bright band may be said to be neutral, or of the same intensity as the continuous spectrum. It however appears brighter where it borders the dark central line on the edge of greater wave length, the central dark line then appearing faintly and narrowly bright edged. In the remaining hydrogen lines, which include Hλ and possibly others of shorter wave length, no traces of bright lines are seen. The star further agrees with γ Cassiopeiæ in the bright bands and spaces seen elsewhere in the spectrum, some of these being even more distinct than in γ. As the spectrum of this star has not been photographed by the use of erythrosin, it is uncertain whether the portion whose wave length exceeds that of Hβ also resembles the spectrum of γ Cassiopeiæ. The dark bands or lines present are nearly the same as in γ, but the Orion lines 4089.2, 4072.0, and 4069.4, seen in γ, are absent, and the lines 4387.8, 4712.8, 4120.5, and 4116.2, and the band covering 4675.3, 4661.7, and 4649.2, are faint or invisible. The Orion line 4925.7, not seen in γ, is perhaps present, and partially reversed.

164. This star resembles γ Cassiopeiæ and ϕ Persei, showing the same double reversal of the lines of hydrogen. See Remarks 162 and 163. The bright bands here present, however, are less intense, distinct brightness appearing only in the lines Hβ and Hγ. The underlying dark bands and fine central dark lines are well shown in Hβ and Hγ, and the former are more distinct on the edge of greater wave length of the bright band. The line Hδ appears indistinctly triple, while in Hϵ the central dark line alone is clearly defined, and the entire line appears narrow in consequence. The remaining lines of hydrogen are probably hazy bands of considerable width; the photographs, however, are poor in the ultra-violet. The bright bands and spaces seen elsewhere in the spectra of γ Cassiopeiæ and ϕ Persei are present in this star, but are less distinct, owing partly to the faintness of the image. The dark spectrum is on the whole more distinct than in the two above mentioned stars, and presents in many respects an agreement with normal spectra of Group III. The following Orion lines are shown in the photographs of π Aquarii: 4026.4, 4471.8, 4387.8, 4144.0, 4009.5, 3819.2, 3927.1, 4712.8, 4675.3, 4649.2, 4641.1, 4568.6, 4531.4, 4120.5, 4069.4 to 4072.0, and a faint band covering 4598.2 and 4591.6. The line 4531.4 is strong.

165. This star is in some degree allied to those of Group III., but is remarkable for a partial but very conspicuous reversal of the hydrogen lines and of some of the Orion lines. In these cases the dark lines are bordered by bright

lines on the side of greater wave length. The width of the bright lines or bands may be less than, or may, as in the case of Hβ, Hγ, and Hζ, exceed that of the dark line. The lines of hydrogen showing these bright borders or bands are Hγ, Hβ, Hδ, Hζ, Hε, Hη, and probably Hθ, Hκ, and Hι, the intensity of the bands declining in about the order given. The Orion lines having bright bands are 4471.8, 4026.4, 4712.8, 3819.2, 4925.7, 4120.5, 5023, and 3994.9, the intensity of the bands decreasing in about the order given. Two lines of unknown wave length, one near 4416, but of slightly greater wave length, and the other of still greater wave length, and probably a third of greater wave length than the Orion line 4387.8, have narrow bright borders. The line 4387.8 appears to be bright on the edge of shorter wave length. This, however, has not been confirmed with certainty. The above description applies rather to the spectrum as photographed with two prisms. With one prism the width and aspect of bright and dark bands vary, and the latter are frequently obliterated by the superposition of the former. Here, too, the bright bands Hγ and Hδ have dark borders on the edge of greater wave length. As these are not clearly seen in the photographs taken with two prisms, it is uncertain whether they are true borders of the hydrogen lines or additional dark lines. The dark lines of the spectrum bear considerable resemblance to those of the typical star of Group III., Division *a*, but show differences in relative intensity, while some anomalous lines are present. The line K and line 3994.9 are much too strong for the group if the star is assumed to be of Division *a*, but would be normal were it of Division *c*. As all the lines are narrow, sharp, and conspicuous, the star is probably of this division. It is unfortunate that no star of Division *c* has been found belonging to Group III., or the adjacent groups, bright enough to be photographed with two prisms. Otherwise it might appear that the anomalous intensities and wave lengths in some of the lines of P Cygni were characteristic of that division. It is at least to be noted that this star alone of all those of Orion type with bright lines studied in this investigation has the dark lines narrow. The Orion lines shown in the photographs are 5023, 4925.7, 4712.8, 4675.3, 4661.7, 4649.2, 4641.1, 4576.5, 4568.6, 4553.4, 4471.8, 4387.8, 4144.0, 4120.5, 4116.2, 4089.2, 4072.0, 4069.4, 4026.4, 4009.5, 3994.9, 3927.1, and 3819.2, besides nine lines of unknown wave length, three of which have bright borders. It is important to note that the dark Hζ appears to be slightly displaced in the direction of shorter wave length, while a line of moderate intensity is present having wave length a little less than that of the Orion line 3964.6. This line and the displaced Hζ are the most conspicuous of the dark lines which change their positions in the spectrum of β Lyræ.

166. This variable star, which has a spectrum of the Orion type, but containing also bright lines, is remarkable for a series of changes which occur in the same period as the variations in light. Bright bands accompany the hydrogen lines Hβ, Hζ, Hγ, and Hδ, the first three being strong, the last of less intensity. Similar bands accompany the Orion lines 4471.8, 4712.8, 4026.4, 4387.8, 4144.0, 5023, 3819.2, 4925.7, 4120.5, and 3856.2, the first in order being about equal in width and brilliancy to the bright bands of Hβ and Hγ, the rest being less bright and decreasing in the order named. It has been announced in a previous publication of the Observatory, that from primary minimum to secondary minimum these bright bands have somewhat greater wave length than the dark lines, while at other times they are of shorter wave length than the dark lines. At or about the secondary minimum they lie centrally upon the dark lines, while at primary minimum their position, though not yet ascertained with certainty, is probably nearly the same. It is further found that the width and brightness of the bands vary, and that shortly before the primary minimum they become for the most part invisible. These changes in the bright bands may thus be briefly described. About a day after the primary minimum, or some hours later, the entire number is present. They are strong, but not very wide. Later, they widen gradually, and after the secondary minimum those in the region having wave length greater than 4340.7 are extremely wide. The latter are also very bright, but those of shorter wave length than 4340.7 are weak or invisible. After the second maximum all the bright bands, now wide and ill defined, fade by degrees, so that on the day before primary minimum nothing is seen of them but a faint brightness about Hβ, and sometimes a trace accompanying Hζ. Some hours before the primary minimum they begin to reappear, brightening gradually till they regain their former intensity. A singular series of changes taking place meanwhile in the dark lines of the star points to the conclusion that there are at least three revolving bodies. Of these one appears to have a spectrum belonging to Division *c* in Group VII., approaching Group VI., the second to be approximately of Group IV., and the third to be a star of the Orion type, whose more precise nature has not yet been determined. The second of these spectra contains the bright bands. Its spectrum resembles that of P Cygni in an apparent displacement of the hydrogen line Hζ by shortening its wave length, and also in the presence of a conspicuous line nearly coincident with Orion line 3964.6, but apparently having shorter wave length. The phenomena shown among the dark lines of the spectrum during each light cycle may be thus briefly described. A few hours after secondary minimum the dark lines of the star, many of which lie under the bright bands, are single and extremely narrow. The spectrum is then that of a star belonging to Division *c* in Group VII., approaching Group VI. in the presence of Orion lines. The only features not proper to these groups are the bright bands, the slightly displaced Hζ, and the line above mentioned, occupying nearly the position of Orion line 3964.6. This phase probably lasts but a few hours, after which the dark lines increase in width as the bright bands diminish in wave length. A new set of delicate dark lines then becomes visible underneath the bright bands. As the latter widen and fade, the dark lines become more and more clearly revealed. At the same time the original dark lines of the spectrum again decrease in width till the two spectra are equal. About the time of the second maximum this double character of the spectrum is beautifully shown, the components of the double lines being then equal, narrow, clearly

defined, and widely separated. Now it is a fact of importance that all the lines of the spectrum, as seen at the secondary minimum, do not participate in this doubling. Those which are seen double are Hγ, Hδ, Hε, K, and the Orion lines 4026.4, 4471.8, 4387.8, 4144.0, 4481.4, and perhaps 4712.8, 4120.5, and 4009.5. Hβ appeared triple, owing probably to the presence of the dark border common in stars of the Orion type having bright lines, while Hζ was widely separated from the displaced Hζ previously united with it, the doubling being clearly shown even in the plates taken with one prism. It is evident that the double lines here enumerated are those common to stars of Group VII., Division *c*, approaching Group VI., Division *c*, and stars belonging to Group IV. Also, that they include all the principal lines of Group IV. spectra which would be clearly shown in the photographs of so faint a star when taken with two prisms. On the other hand, the lines which are peculiar to Group VII., Division *c*, remained single. These include a number of solar lines and the conspicuous Orion lines 4131.4 and 4128.5. The latter are very useful in distinguishing between the spectra and identifying that of Group VII., Division *c*, throughout its motions. It is thus made evident that after the single phase following secondary minimum the bright bands and the lines belonging to Group IV., together with the displaced line Hζ and the anomalous line near the Orion line 3964.6, were simultaneously diminishing in wave length. The maximum separation of the two spectra is reached at, or a little beyond, the time of second maximum, when it is very well marked. After this it decreases slowly to the end of the cycle, photographs taken a few hours before minimum showing the spectra nearly coincident. It is to be regretted that, owing chiefly to the faintness of the star, no good photographs have been obtained exactly at minimum with a sufficient dispersion to show the condition of the dark lines. Photographs taken within twelve hours after minimum show a singularly altered phase. The dark lines now appear either indistinctly triple, or dense, wide, and obscurely separable into two very unequal and hazy components, that of greater wave length being twice as wide and dense as the other. The triple character is well shown in the line Hδ and the Orion line 4026.4. The separate spectra were identified by matching the lines peculiar to the star belonging to Group VII., Division *c*, with the corresponding lines of a comparison star of similar type, β Orionis being found the most convenient for this purpose. It then appeared that the lines in the spectrum of Group IV., with the displaced line Hζ and the other peculiar line, had increased in wave length since the phase before minimum, and nearly coincided with that of the star of Group VII., Division *c*. Whether, as seemed likely, owing to the altered position of the bright bands, the spectrum of the former star had crossed that of the latter, could not be determined, owing to the ragged and hazy aspect of the compound lines. No doubt was left that the third set of lines, which were those of shortest wave length, belonged to neither of the two stars. It therefore appeared that the spectrum of a new body, previously invisible, had come into view. This was confirmed by the marked increase in the average intensity of the lines of the spectrum, by the reversal of relative intensities suddenly shown in some of the lines, and by the appearance of other lines not before seen. The widening which has been described as occurring in the lines of the star belonging to Group VII., Division *c*, after secondary minimum and their subsequent diminution in width, neither of which phenomena was due to the component whose spectrum is of Group IV., may have been caused by the revolution of such a third body. The triple phase occurring after primary minimum is of very short duration, the dark lines becoming clearly single about twelve hours after minimum. The aspect of the spectrum, however, in this phase of singleness, is very different from that seen at secondary minimum. The lines, instead of being fine and delicate, are now strong and dense. The altered intensity shown in some of them during the triple phase persists, though in a less degree. The bright bands, it will be remembered, are at this time of greater wave length than the dark lines. This phase is of comparatively long duration, lasting until about half a day before first maximum. At this time a new phase appears, in which the dark lines are certainly double, and probably triple. In those which appear double the division is, as a rule, unequal. The slight degree of separation, and the generally obscure character of the entire spectrum, render the separation of the compound lines difficult. Hβ, Hγ, Hδ, K, and perhaps 4009.5, however, have been found double in the best photographs, while Hε, 4026.4, and 4387.8 have appeared triple. The encroachment of the strong bright bands, which, though lying chiefly on the side of greater wave length, yet overspread the compound system of dark lines, may prevent the detection of the third component. The clear and simple doubling of the line K, however, which is entirely without a bright band, cannot be thus explained; so that if a third body is present the line K must be very faint or absent in its spectrum. An identification of the separate spectra by means of a comparison star showed that the spectrum belonging to Group VII., Division *c*, occupies in this phase the position of shorter wave length, while that belonging to Group IV., with its bright bands, occupies the position of greater wave length. The relative positions of the two bodies are therefore reversed since the preceding maximum. This double or triple phase lasts for a short period, not yet precisely ascertained, within three days after the first maximum. The spectrum then passes into the phase occurring near primary minimum, with which this description began. This completes the record of the more striking phenomena occurring in each light cycle of the variable. The fact appears to be established that the bright bands accompany a spectrum approximately of Group IV., which oscillates periodically over one of Group VII., Division *c*. The fact that the bright bands have a residual motion of their own, which places them sometimes toward the red and sometimes toward the violet end of their own system of dark lines, and at other times upon the lines of one or both spectra, is not yet explained, nor is the reason given for the fading of the bright bands. The supposition of a third body explains most of the remaining phenomena, and is rendered more probable by the fact that the times of recurrence of the phases vary within limits in different light cycles of the star. It would also explain the fact that deviations from the normal phases frequently occur, these deviations consisting generally in an altered width of the lines of the spectrum belonging to Group VII., Division *c*. Other peculiarities, however, as, for example, the occasional obliteration of the line Hγ of the above mentioned spectrum, cannot be thus explained, and in fact the rapid and complex transformations of this variable will probably not be fully understood till they are continuously followed.

167. This star combines the spectra of Group VIII., Division *a*, and Group IV., Division *b*, but has additional peculiarities. The aspect of the hydrogen lines is very singular, and probably subject to change. In the best photograph taken with two prisms the line Hβ is invisible, and this is not due to faintness of the image. In this plate the lines Hγ and Hδ are extremely narrow, and Hϵ shows an apparent diminution in wave length. (Compare line Hκ in γ Cassiopeiæ and ϕ Persei.) The narrowness of Hδ in this photograph may be due to the disappearance of the component of shorter wave length seen in another photograph, which shows the line Hδ double. The width of the hydrogen lines is somewhat greater in the remaining photographs, and probably varies. The line Hβ is present in all the other plates, and the line Hϵ is probably of normal wave length. Anomalous lines of slightly greater wave length than Hδ and Hϵ are present, but apparently not close enough to be associated with the hydrogen system. In the photograph taken with less dispersion traces of a bright band are seen bordering Hγ on the side of shorter wave length. The photographs are too faint to furnish a clear interpretation of the phenomena.

168. The system of dark lines in the spectrum of this star belongs to Group IV., Division *b*. The lines are wide. The line Hβ has a strong bright band centrally superposed, and the line Hγ has a similar central band, which is however narrower and of less intensity. The dispersion is not sufficient to show whether there is a double reversal in the lines of hydrogen.

169. The system of dark lines in the spectrum of the star belongs to Group IV., Division *b*. The width of the lines, however, exceeds that of ordinary stars of Division *b*, and equals that seen in γ Cassiopeiæ. As in that star also, a double reversal is shown in the lines of hydrogen. On the wide dark band Hβ a strong bright band is centrally superposed, while a similar but fainter bright band is superposed on Hγ. This latter bright band is centrally divided by a fine dark line. The lines Hδ and Hϵ do not show a distinctly bright band, but appear triple, with the central component strongest. The remaining lines of hydrogen are wide and dense. The Orion lines 4026.4, 3819.2, 4471.8, and probably others, are double. The bright band of γ Cassiopeiæ, lying between the Orion lines 4576.5 and 4591.6, besides several other fainter bright bands of that star, are present.

170. The system of dark lines in the spectrum of this star belongs to Group IV., Division *b*, but the lines are extremely wide. The dark line Hβ is accompanied by a bright band which was observed by Mrs. Fleming to lie on the edge of greater wave length in photographs taken December 14, 1888, December 23, 1889, and January 22, 1890, and to lie on the side of shorter wave length in those taken February 16 and 18, 1892, and March 7 of the same year. In plates taken December 17, 1891, and January 5 and 21, 1892, it is also on the edge of shorter wave length. The remaining lines of hydrogen show no bright components. They appear obscurely double in the plates taken with one prism, while in those taken with two prisms Hγ, Hδ, and Hϵ appear as strong but narrow central lines, having delicate and hazy companions on the side of greater wave length, and traces of still more hazy companions on the other side. As all these plates taken with two prisms show the phase in which the bright band of the line Hβ is of shorter wave length, the position of the extremely faint dark companions of Hγ and Hδ corresponds with that of the bright band. This object and β Lyræ are the only stars in which the bright bands are with certainty known to move from side to side of the dark lines. The fact that this star is triple is interesting in this connection. Many of the additional bright bands or spaces seen in γ Cassiopeiæ are faintly shown.

171. The system of dark lines in the spectrum of this star is of Group V., Division *b*, but the lines are extremely wide, and the star resembles in some degree γ Cassiopeiæ in the condition of the hydrogen lines. A bright band lies centrally on the wide dark band Hβ. The lines Hγ, Hδ, Hϵ, and perhaps Hζ, are without distinct bright components, but appear hazily triple, with the central component strong and the component of shorter wave length hazy and indistinct. Several of the bright spaces or bands seen in γ Cassiopeiæ, between Hβ and Hγ, are faintly visible in this star. The Orion lines are perhaps double.

172. The system of dark lines in the spectrum of this star belongs to Group V., Division *b*; but a bright band is superposed on the very wide dark band Hβ. This bright band is suspected of motion, since, while in most photographs it lies centrally on the dark band, in a few it lies on one or the other side of the centre. The remaining lines of hydrogen which appear in the plates taken with two prisms are either clearly triple, or, as is more common, show a strong but narrow central line, with haze on either side. This haze is, in the photographs studied, more abundant on the side of greater wave length, where fine dark lines are more or less clearly discernible in the midst of it. In a plate taken with two prisms, which showed the bright band of slightly shorter wave length than the centre of the dark band, the portion of the latter on the side of greater wave length than the bright band appeared obscurely double. This however needs confirmation.

173. The system of dark lines in the spectrum of this star belongs to Group V., Division *b*, but the lines are extremely wide. A bright band is superposed centrally on the wide dark band Hβ, and a less intense bright band lies upon Hγ. This last, being narrow as well as faint, gives the dark Hγ the appearance of being double. As the star is too faint to be photographed with a large dispersion, it is not certain whether the double reversal seen in γ Cassiopeiæ and other stars of this class takes place in the hydrogen lines of this star. The hydrogen lines having wave length shorter than Hγ are very dense, as well as wide, and would doubtless appear compound under higher dispersion. This star is Pleione.

174. The system of dark lines in the spectrum of this star belongs to Group IV., Division *b*, but all the lines are exceedingly wide. A distinct bright band lies almost centrally on the wide dark band $H\beta$. A fainter and narrower bright band or line lies upon $H\gamma$, its position being commonly of slightly greater wave length than the centre. The lines $H\delta$ and $H\epsilon$ appear in most photographs unequally divided, with the strong component occupying the true central position for each hydrogen line, and the weak and hazy component having the greater wave length. In some plates, however, both these lines and $H\gamma$ appear triple. Other lines of the spectrum sometimes appear unequally divided, with the stronger component of shorter wave length.

175. The line $H\beta$ appears bright, and the remaining lines of hydrogen are very wide and obscurely double. The star also shows several of the bright bands of γ Cassiopeiæ between 4100 and 4860. The system of dark lines in the spectrum of this star probably belongs to Group IV., Division *b*.

176. This star is probably peculiar. The plate, which is very poor, shows only a continuous spectrum. This may possibly indicate that the lines are very narrow or partially reversed.

177. The line K has about four or five tenths of the intensity of $H\delta$.

178. The line K has from six to eight tenths of the intensity of $H\delta$.

179. The line K has about nine tenths of the intensity of $H\delta$.

180. The line K and the line $H\delta$ are approximately equal.

181. The line K has about one and one tenth of the intensity of $H\delta$.

182. The line K has about one and five tenths times the intensity of $H\delta$. The lines of hydrogen have about seven tenths the intensity of those of α Canis Majoris.

183. The line K has about two and five tenths times the intensity of $H\delta$. The hydrogen lines have about seven tenths the intensity of those of α Canis Majoris.

184. This star resembles α Boötis in the absorption shown in the region having wave length shorter than 4307, and in the absence of increased brightness between the lines 4227.0 and 4215.7. See page 39 of Detailed Description.

185. This star resembles α Cassiopeiæ in the general absorption shown in the region having wave length shorter than 4307, and in the apparent brightness between lines 4227.0 and 4215.7. The line 4227.0 is also a little stronger than in α Boötis. See page 39 of Detailed Description.

186. The spectrum of the Sun so closely resembles that of stars of Group XIV. that it has been assumed as typical of that group. The slight differences which have been noticed in the intensity of individual lines of the Sun as compared with those of α Aurigæ and η Boötis, the other two typical stars of the group, have been stated in Remarks 92 and 93. The photographs of the Sun show a further difference in the distribution of light. This, however may be due to the different means, described on page 2, by which the photographs of the solar spectrum were obtained.

CHAPTER IX.

General Catalogue.

Table XII. gives in the order of right ascension the stars whose spectra have been examined and classified in the preceding chapters. The stars here given are identical with those in Tables IX., X., and XI., with the exception of B. D. +56° 2623, whose position for 1900 is R. A. = $21^h\ 37^m.3$, Dec. = +57° 8′. See Remark 176.

The first column of this table contains the number taken from the Harvard Photometry. The second column gives the constellation, and the third, the Bayer letter and Flamsteed number. The fourth column gives the number from the Bonn or Cordoba Durchmusterung, this being in Italics when the star has been transferred by precession to the adjacent zone. The fifth and sixth columns give the position for 1900. The seventh column gives the group and division, the symbols here used being the same as those in Table IX. and elsewhere. The Roman numerals refer to groups; a number in Italics indicates that a star is intermediate between that and the next group. The letters *a*, *b*, *c*, refer to the three divisions known by these letters, the expression *ab* to stars intermediate between divisions *a* and *b*, *ac* to those intermediate between divisions *a* and *c*. The expression *a, b* indicates that it is not known to which of the divisions *a* or *b* the star belongs. The omission of the division letter indicates that the division is unknown. Stars of Groups XXI. and XXII., which are not included in the series, have not been assigned to any division. The letter *P* indicates that a star is peculiar. The letter *L* denotes a star of the Orion type having bright lines. To this a group number and division letter have been assigned when it was clear to what group the star would belong were the bright lines dark. The letter *C* denotes that the spectrum of the star is composite. The number denoting the group to which the principal spectrum belongs is then inserted. When the seventh column is vacant, the peculiarities of the star will be found in the remarks beginning on page 94, to which reference is made by the corresponding numbers given in the eighth column. The ninth column gives the number of plates employed in the study of each spectrum, and the tenth column the numbers by which these plates were designated, if not more than four plates were used. When more than four plates were used, the numbers of all after the first four are given in Table XIII. The eleventh column gives the number of prisms employed in making the photographs. When more than one number is given, some of the plates were taken with each number of prisms.

Numbers and letters referring to each of two lines are placed between them.

TABLE XII.

GENERAL CATALOGUE.

H. P.	Constellation.	B. Fl.	D.M.	R. A. 1900. h. m.	Dec. 1900. ° ′	Group.	Remark.	No. of Pls.	Plate Number.	No. of Dispersions.
4259	Pisces	33	6357	0 0.3	− 6 16	XV.*a*	—	1	3071	1
5	Androm.	α 21	4	3.2	+28 33	VIII. *P.*	67	9	244, 630, 633, 643	4,2,1
9	Cassiop.	β 11	3	3.8	+58 36	XII.*ab*	—	8	351, 680, 865,2305	4,2,1
13	Androm.	22	17	5.1	+45 31	XI.*ac*	183	2	731, 758	1
23	Pegasus	γ 88	14	8.1	+14 38	IV.*a*	—	2	1638,2371	3,1
30	Cetus	7	21	9.6	−19 30	XVII.*a*	—	1	777	1
45	Cetus	ι 8	48	14.4	− 9 23	XV.*a*	185	1	2127	1
69	Cassiop.	λ 14	82	26.2	+53 59	V.*b*	30	1	1408	1
71	Cassiop.	κ 15	102	27.3	+62 23	II.*a, b*	11	1	1566	1
77	Cassiop.	—	102	30.5	+53 38	V.*b*	30	1	1408	1
82	Cassiop.	ζ 17	105	31.3	+53 21	IV.*a*	—	3	1377,1408,2164	2,1
92	Androm.	δ 31	91	33.9	+30 19	XV.*a*	185	1	1412	1
—	Pisces	—	85	34.2	+20 43	XV.*a*	184	2	736,1654	1
93	Pisces	55	87	34.6	+20 54	XV.*a*	184	2	736,1654	1
94	Cassiop.	α 18	*139*	34.8	+56 0	XV.*a*	—	8	625, 730,2373,5105	4,3,2,1
103	Cetus	β 16	115	38.5	−18 32	XV.*a*	185	4	640, 874,5111,5182	4,2,1
105	Cassiop.	—	181	38.8	+47 19	IV.*a, b*	—	1	2268	1
107	Cassiop.	ο 22	183	39.2	+47 44	IV.*a, b*	—	1	2268	1
119	Androm.	ζ 34	106	42.0	+23 43	XV.*a*	—	1	732	1
—	Pisces	—	*104*	42.2	+ 6 12	*XIV.a*	—	1	2258	1
120	Cassiop.	η 24	150	43.0	+57 17	XIII.*a*	90	3	862,1450,2379	3,1
122	Pisces	62	105	43.1	+ 6 45	XV.*a*	185	2	2252,2258	1
125	Pisces	δ 63	*107*	43.5	+ 7 2	XVI.*a*	—	3	761,2222,2258	1
136	Cassiop.	—	124	47.1	+60 34	XIII.*a*	—	2	197,2227	2,1
142	Cassiop.	γ 27	*144*	50.7	+60 10	*L.*	162	10	683, 884, 953,1032	4,2,1
145	Cassiop.	—	146	50.8	+59 50	VI.*b*	2,23	1	2227	1
148	Androm.	μ 37	175	51.1	+37 57	IX.*a, b*	178	2	2925,2955	1
—	Cepheus	—	*20*	52.8	+84 4	IX.*a, b*	177	1	847	1
155	Cepheus	*2*	19	54.9	+85 43	XV.*a*	114?,185	1	1648	1
172	Cetus	28	230	1 1.1	−10 23	VIII.*a, b*	65	1	1627	1
179	Cetus	30	238	2.7	−10 19	XIII.*a*	34	1	1627	1
183	Cetus	η 31	240	3.5	−10 43	XV.*a*	185	1	1627	1
180	Cepheus	—	*34*	3.6	+79 8	VIII.*b*	—	4	855,3093,6355,6480	2,1
185	Androm.	β 43	*198*	4.1	+35 5	XVII.*a*	—	12	721, 725, 945, 965	4,2,1
—	Cepheus	—	36	7.6	+79 23	*XI.*	20	4	855,3093,6355,6480	2,1
219	Cassiop.	δ 37	248	19.2	+59 43	X.*ab*	179	2	833,2293	4,1
213	Urs. Min.	α 1	8	22.0	+88 46	XIII.*ac*	—	7	437,1602,1610,2209	4,2,1
220	Cetus	θ 45	244	19.0	− 8 42	XV.*a*	115,185	1	1639	1
239	Pisces	η 99	231	26.2	+14 50	*XIV.a*	101	1	1629	1
—	Perseus	—	*460*	30.3	+48 12	XV.*a*	—	1	1697	1
—	Perseus	—	466	31.6	+47 55	XII.*a*	20	1	1697	1
251	Perseus	υ 51	*467*	31.8	+48 7	XV.*a*	114,185	2	1697,2323	1
269	Perseus	φ 54	*444*	37.4	+50 11	*L.*	163	3	848,1594,1615	1
287	Cassiop.	ε 45	*320*	47.2	+63 11	*IV.ab*	27	3	753, 917,1743	2,1
289	Triangul.	α 2	*312*	47.3	+29 6	XII.*a*	—	2	1607,1621	1
291	Aries	γ 5	243	48.0	+18 48	VIII. *P.*	72	2	5983,7028	2

H. P.	Constellation.	B. Fl.	D. M.	R. A. 1900.	Dec. 1900.	Group.	Remark.	No. of Pls.	Plate Number.	No. of Dispersions.
				h. m.	° ′					
295	Aries	β 6	306	1 49.1	+20 19	X.a	32,76,179	4	2120,5996,6046,6055	2,1
304	Cassiop.	A 48	153	53.8	+70 25	IX.a, b	177	2	841,2397	1
306	Cassiop.	50	117	54.9	+71 56	VIII.a	—	1	2511	1
309	Pisces	112	311	55.0	+ 2 38	XIV.a	—	1	2317	1
315	Cetus	υ 59	358	55.3	−21 34	XVI.a	—	1	829	1
320	Pisces	α 113	317	56.9	+ 2 17	IX.C	159	3	771,2128,2317	1
324	Androm.	γ 57	395	57.7	+41 51	XV.C	144	10	367,1448,2254,2381	4,3,2,1
332	Aries	κ 12	279	2 1.0	+22 11	VIII.b	23	1	3041	1
333	Aries	α 13	306	1.5	+23 0	XV.a	113,185	6	981,1547,3041,5154	4,2,1
336	Triangul.	β 4	381	3.5	+34 31	X.a	75,179	6	2354,6128,6153,6161	3,2
356	Triangul.	7	409	10.0	+32 54	VII.b	—	5	2426,2490,6207,6379	1
360	Triangul.	δ 8	395	10.8	+33 46	XIV.a	—	2	2426,2490	1
361	Triangul.	γ 9	397	11.3	+33 23	VII.b	49	5	2426,6207,6265,6379	2,1
370	Cetus	o 68	353	14.3	− 3 26	XX.a	131	16	245, 280, 288, 742	4,2,1
375	Cetus	69	355	16.8	− 0 4	XVI.a	—	1	759	1
401	Cassiop.	—	140	28.5	+72 23	XV.a	—	2	882, 897	1
—	Perseus	—	722	33.6	+49 8	VII.b	—	2	1611,1663	1
418	Cetus	δ 82	406	34.4	− 0 6	IV.a	10	1	1632	1
429	Perseus	θ 13	746	37.3	+48 48	XIII.a	—	2	1611,1663	1
433	Cetus	γ 86	422	38.1	+ 2 48	VIII.b	—	2	2141,2390	3,1
437	Cetus	μ 87	359	39.5	+ 9 41	X.a, b	2,181	1	2322	1
443	Perseus	η 15	714	43.4	+55 29	XV.a	—	1	1640	1
445	Aries	41	471	44.1	+26 51	VI.ab	—	6	2324,6002,6054,6463	2,1
454	Perseus	τ 18	641	47.2	+52 22	XIV.C	152	2	1616,2320	1
464	Eridanus	η 3	553	51.5	− 9 18	XV.a	—	1	1623	1
470	Perseus	—	665	53.7	+51 57	V.a, b	—	1	1616	1
482	Cetus	α 92	419	57.1	+ 3 42	XVII.a	—	6	291,1561,5172,5193	4,2,1
—	Cetus	—	420	57.1	+ 3 58	V.b	23	2	291,5248	2,1
483	Perseus	γ 23	654	57.6	+53 7	XIV.C	149	2	842,2942	1
487	Eridanus	τ^3 11	1387	58.0	−24 1	IX.a, b	177	1	3033	1
489	Perseus	ρ 25	630	58.8	+38 27	XIX.a	—	5	283, 695, 967,1453	2,1
496	Perseus	β 26	673	3 1.6	+40 34	VI.a	—	15	674, 684, 709, 724	4,2,1
498	Perseus	κ 27	631	2.7	+44 29	XV.a	185	2	1649,1655	1
—	Perseus	—	634	4.5	+44 39	VII.a, b	30	2	1649,1655	1
—	Camelop.	—	335	7.5	+66 0	VIII.a, b	—	3	4469,5385,6321	2,1
—	Camelop.	—	338	8.8	+65 17	VIII.a, b	—	4	850,4469,5385,6321	2,1
516	Camelop.	—	340	11.2	+65 17	IV.b, L.	174	16	850, 853,3858,4469	2,1
521	Perseus	29	899	11.5	+49 51	IV.a, b	20	2	2257,6208	2,1
522	Perseus	31	902	12.0	+49 43	IV.a, b	20	3	2253,2257,6208	2,1
530	Eridanus	15	1146	13.9	−22 52	XIV.a	—	1	3048	1
533	Eridanus	τ^4 16	584	15.1	−22 7	XIX.a	—	1	3048	1
537	Perseus	—	899	16.1	+48 51	V.a, b	—	3	2253,2257,6208	2,1
541	Perseus	α 33	917	17.1	+49 30	XII.ac	—	8	371,1543,2113,2253	4,2,1
550	Taurus	o 1	511	19.4	+ 8 40	XIV.a	—	7	1074,6047,6168,6397	4,2,1
552	Perseus	—	920	20.9	+48 43	IV.a, b	—	4	2235,5207,5257,6254	2,1
551	Camelop.	—	660	21.0	+59 36	VI.c	35	6	2159,3023,6067,6075	2,1
—	Perseus	—	944	21.7	+49 31	V.a, b	—	2	2253,2257	1
554	Taurus	ξ 2	439	21.8	+ 9 23	VI.b	—	7	1074,2124,6066,6168	4,2,1
553	Camelop.	—	607	21.9	+58 32	VI.c	36	3	3023,6075,6081	2,1
555	Perseus	34	945	22.2	+49 10	IV.a, b	20	6	2235,2253,2257,5207	2,1

H. P.	Constellation.	B. Fl.	D.M.	R. A. 1900.	Dec. 1900.	Group.	Remark.	No. of Pls.	Plate Number.	No. of Dispersions.
				h. m.	° ′					
—	Camelop.	—	*608*	3 22.2	+59 2	VIII.*a*, *b*	23,2 ?	1	6081	2
560	Perseus	σ 35	843	23.5	+47 39	XV.*a*	185	1	2464	1
—	Perseus	—	844	23.5	+47 46	VI.*a*, *b*	20	1	2464	1
—	Perseus	—	846	24.5	+47 31	VI.*a*, *b*	12	1	2464	1
—	Perseus	—	847	25.0	+47 41	VII.*a*, *b*	43	1	2464	1
—	Perseus	—	850	26.2	+47 36	X.*a*, *b*	20,180	2	2464,4453	1
576	Eridanus	ε 18	697	28.2	− 9 48	XV.*P.*	123	2	1685,3030	1
—	Perseus	—	773	28.9	+46 46	VI.*a*, *b*	20	1	2464	1
578	Perseus	ψ 37	857	29.4	+47 51	V.*b* *L.*	172	7	2464,2966,3029,4326	3,2,1
579	Eridanus	τ^5 19	*628*	29.4	−21 58	VI.*b*	—	3	3094,6394,6466	2,1
—	Eridanus	—	704	29.8	−10 12	VIII.*a*	63	1	1685	1
591	Perseus	δ 39	876	35.8	+47 28	V.*b*	—	4	2966,3029,4305,6678	2,1
600	Perseus	o 38	642	38.0	+31 59	III.*a*, *b*	—	2	1569,1737	2,1
602	Perseus	ν 41	815	38.4	+42 16	XII.*ac*	—	1	3870	4,1
—	Taurus	—	505	38.9	+23 59	V.*a*, *b*	—	2	294,1631	
608	Taurus	17	507	39.0	+23 48	V.*a*	29	3	201, 294,1631	2,1
—	Taurus	—	546	39.2	+24 32	VI.*a*, *b*	34	2	294,1631	1
610	Taurus	q 19	547	39.3	+24 10	V.*a*	—	3	201, 294,1631	2,1
613	Taurus	20	*516*	39.9	+24 4	V.*a*	—	3	201, 294,1631	2,1
—	Taurus	—	553	40.0	+24 15	VI.*a*, *b*	—	1	1631	1
—	Taurus	—	556	40.1	+24 13	VI.*a*, *b*	30	1	1631	1
612	Camelop.	—	369	40.4	+65 13	XVIII.*a*	32	1	778	1
615	Taurus	23	522	40.4	+23 39	V.*a*	29	3	201, 294,1631	2,1
—	Taurus	—	562	41.1	+24 13	VII.*a*, *b*	20	1	1631	1
—	Taurus	—	536	41.5	+23 48	VII.*a*, *b*	23,30	1	1631	1
618	Taurus	η 25	541	41.6	+23 48	V.*a*	—	3	201, 294,1631	2,1
—	Taurus	—	*563*	42.5	+23 8	VI.*a*, *b*	—	2	294,1631	1
—	Taurus	—	*553*	42.6	+24 3	VII.*a*, *b*	30	1	1631	1
—	Taurus	—	556	43.0	+23 34	X.*a*, *b*	20,181	1	1631	1
625	Taurus	27	557	43.3	+23 45	V.*a*, *b*	—	3	201, 294,1631	2,1
—	Taurus	—	558	43.3	+23 51	V.*b*, *L.*	173	1	1631	
—	Taurus	—	*561*	43.4	+24 5	VII.*a*, *b*	20	1	1631	1
—	Taurus	—	563	43.8	+23 25	VI.*a*, *b*	30	1	1631	1
—	Taurus	—	569	44.1	+23 33	VII.*a*, *b*	20	1	1631	1
638	Perseus	ζ 44	666	47.8	+31 35	III.*a*	16	2	1389,1733	2,1
647	Perseus	—	768	50.0	+34 47	IV.*b*	23	2	2496,6154	2,1
649	Perseus	ε 45	895	51.1	+39 43	II.*a*	2	3	3049,3072,7042	2,1
652	Perseus	ξ 46	775	52.4	+35 30	I.*b*	4	2	2496,6154	2,1
650	Cepheus	—	125	53.3	+80 26	XIII. *C.*	154	3	856,2467,2503	1
653	Eridanus	γ 34	781	53.4	−13 48	XVI.*a*	—	2	762, 766	1
657	Taurus	λ 35	539	55.2	+12 13	IV.*b*	—	3	679, 702, 792	1
665	Taurus	ν 38	581	57.8	+ 5 42	VIII.*a*	—	5	3073,6155,6216,6260	2,1
668	Taurus	40	584	58.4	+ 5 9	*IV.a*	—	4	273,6155,6216,6260	2,1
—	Cepheus	—	127	4 1.1	+80 17	XV.*a*	—	2	2467,2503	1
696	Eridanus	37	758	5.5	− 7 11	*XIV.a*	—	1	1669	1
701	Eridanus	o^1 38	764	7.0	− 7 6	XII.*a*	32,86	1	1669	1
702	Perseus	μ 51	1063	7.5	+48 9	XIV.*a*	95	1	1681	1
704	Cepheus	—	133	9.6	+80 35	XV.*a*	—	2	2467,2503	1
750	Taurus	δ 61	712	17.2	+17 18	XV.*a*	185	1	2326	1
752	Taurus	63	586	17.7	+16 32	IX.	—	1	2326	1

H. P.	Constellation.	B. Fl.	D.M.	R. A. 1900.	Dec. 1900.	Group.	Remark.	No. of Pls.	Plate Number.	No. of Dispersions.
				h. m.	° ′					
756	Taurus	64	714	4 18.4	+17 13	IX.a, b	177	1	2326	1
763	Taurus	68	719	19.8	+17 42	VIII.a	—	1	2326	1
775	Taurus	θ^1 77	631	22.8	+15 44	XV.a	185	2	2181,3082	3,1
776	Taurus	θ^2 78	632	22.9	+15 39	X.a, b	180	1	2181,3082	3,1
783	Taurus	—	637	24.8	+15 59	IX.a, b	30,178	1	3082	1
797	Taurus	α 87	629	30.2	+16 19	XVI.a	—	14	199,1042,1442,1503	4,3,2,1
799	Eridanus	ν 48	834	31.3	− 3 34	IV.a	26	2	2992,4323	2,1
806	Eridanus	c 51	963	32.6	− 2 40	X.a, b	180	1	2992	1
812	Eridanus	53	933	33.6	−14 30	XV.a	184	1	1606	1
821	Eridanus	54	988	36.1	−19 52	XVIII.a	—	1	779	1
840	Orion	π^3 1	762	44.3	+ 6 47	XIII.a	—	3	1475,1624,4328	2,1
845	Orion	π^4 3	745	45.9	+ 5 26	*IV.a*	—	3	1650,2540,4328	2,1
850	Orion	o^1 4	777	46.9	+14 5	XVIII.a	—	1	813	1
854	Eridanus	ω 61	1068	48.0	− 5 37	X.a, b	181	4	1603,3024,3086,3099	1
855	Orion	5	800	48.2	+ 2 20	XVII.a	20	2	1580,1762	1
857	Orion	π^5 8	810	49.1	+ 2 17	*IV.a*	—	3	1580,1595,2476	1
862	Auriga	ι 3	*855*	50.4	+33 0	*XV.a*	—	6	1027,2213,6058,6145	4,2,1
876	Camelop.	10	856	54.5	+60 18	XIV.ac	—	4	849,1786,2602,2610	1
877	Auriga	ε 7	1166	54.8	+43 41	XII.c	—	6	1086,1460,1466,2310	4,3,2,1
879	Auriga	ζ 8	1142	55.5	+40 56	XV.C.	147	9	567,1730,2491,2497	2,1
—	Auriga	—	1044	56.2	+41 18	VIII.a	60	6	1567,2497,2527,6500	2,1
—	Orion	—	923	56.7	+ 0 34	XV.a	—	1	1768	1
—	Orion	—	886	56.8	+ 1 28	V.a, b	30	1	1768	1
896	Auriga	η 10	1058	59.5	+41 7	*IV.ab*	—	6	1567,1730,2491,2527	2,1
901	Lepus	ε 2	1000	5 1.2	−22 30	XVI.a	—	1	1754	1
906	Eridanus	66	1044	1.8	− 4 47	VII.a, b	20	1	2224	1
910	Eridanus	β 67	1162	2.9	− 5 13	IX.b	178	2	1081,2224	4,1
915	Eridanus	68	1056	3.8	− 4 35	XII.a	—	2	2224,2231	1
913	Camelop.	—	169	6.1	+79 7	XIII.a	—	1	859	1
929	Lepus	μ 5	1072	8.4	−16 19	VIII.P.	68	2	1756,6082	2,1
932	Auriga	α 13	1077	9.3	+45 54	XIV.a	39,92	13	191, 393, 429,1199	4,3,2,1
934	Auriga	—	980	9.7	+34 12	II.a, b	12	1	1694	1
936	Orion	β 19	1063	9.7	− 8 19	VI.c	—	12	399, 415,1492,1707	4,2,1
948	Orion	τ 20	*1028*	12.7	− 6 57	V.b	—	3	1763,6403,6467	2,1
975	Orion	η 28	1235	19.4	− 2 29	III.a	15	2	1055,1721	4
979	Orion	γ 24	919	19.7	+ 6 16	IV.a	—	6	386,3051,6380,6432	4,2,1
978	Taurus	β 112	795	20.0	+28 32	VI.a	32	5	236, 379,1128,1549	4,2
994	Lepus	β 9	1096	24.0	−20 51	XIV.a	96	2	1744,2225	2,1
1001	Auriga	χ 25	1024	26.2	+32 8	III.a, b	24	3	4673,4683,4701	1
1005	Orion	δ 34	983	26.9	− 0 23	II.b	—	4	422,1120,1468,6433	4,2,1
1012	Orion	35	947	28.2	+14 15	*IV.a, b*	—	1	1794	1
1014	Lepus	α 11	1166	28.3	−17 54	*XI.ac*	—	2	1088,2243	4,1
—	Orion	—	1167	29.4	− 4 52	IX.	—	1	1664	1
1017	Orion	ϕ^1 37	877	29.4	+ 9 25	II.a	2,6	1	1617	1
1019	Orion	λ 39	879	29.6	+ 9 52	I.b	—	3	335,1617,2436	4,1
1021	Orion	—	1234	30.1	− 6 5	III.a, b	22	3	805, 979,1664	2,1
1023	Orion	θ 41	1315	30.3	− 5 27	I.b	3	5	805, 979,1656,1664	2,1
1024	Orion	43	1319	30.4	− 5 29	III.b	20,21		805, 979,1656,1664	
1025	Orion	c 42	1085	30.4	− 4 54	III.a, b	23	4	979,1656,1664,1688	2,1
—	Orion	—	1186	30.5	− 4 26	IV.a, b	20	1	1664	1

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1027	Orion	ι 44	*1241*	5 30.5	− 5 59	I.*b*	2	3	805, 979,1664	2,1
1026	Orion	c 45	1188	30.7	− 4 55	XI.*a, b*	182	5	805, 979,1656,1664	2,1
1029	Orion	ε 46	969	31.2	− 1 16	II.*a*	—	5	120, 398,3977,6343	4,2,1
—	Orion	—	1334	31.3	− 5 43	IV.*a, b*	20	1	1664	1
1030	Orion	ϕ^2 40	898	31.4	+ 9 15	XV.*a*	121	2	1617,2436	1
—	Orion	—	1255	31.7	− 6 8	III.*a, b*	20	3	805,1656,1688	1
—	Orion	—	1016	31.9	+ 8 53	*IV.a, b*	—	1	1617	1
—	Orion	—	1196	32.9	− 4 52	III.*a, b*	20	1	1664	1
1039	Orion	σ 48	1326	33.7	− 2 39	II.*b*	8	3	241, 442, 446	4,2
1043	Orion	—	1166	34.5	− 3 37	II.*b*	9	3	6210,6434,6616	2
1045	Orion	ζ 50	1338	35.8	− 2 0	II.*b*	—	6	241, 442, 446,6210	4,2
1047	Orion	—	1004	35.8	− 1 11	IV.*b*	—	3	6210,6434,6616	
1057	Lepus	γ 13	1211	40.4	−22 28	XIII.*a*	—	3	3035,3050,3095	1
1065	Lepus	ζ 14	1232	42.4	−14 51	IX.*a, b*	23, 177	1	2492	1
1068	Orion	κ 53	1235	43.0	− 9 42	II.*a*	—	5	439,1115,2244,2281	4,2,1
1072	Auriga	υ 31	1336	44.2	+37 16	XVII.*a*	—	1	774	1
—	Auriga	—	1347	46.7	+37 19	XII.*a*	20	1	774	1
1086	Lepus	δ 15	1211	47.0	−20 54	XV.*a*	112,184	2	1608,2521	1
1089	Orion	χ^1 54	1162	48.5	+20 16	XIII.*a*	—	2	286,3273	2,1
1090	Orion	57	1126	49.1	+19 44	IV.*a*	—	2	286,3273	2,1
1091	Orion	α 58	1055	49.8	+ 7 23	XVIII.*a*	128	11	803,1043,1182,1203	4,3,2,1
—	Orion	U	—	49.9	+20 10	XX.	134	2	286,3273	2,1
1093	Auriga	δ 33	970	51.3	+54 17	XV.*a*	184	1	2616	1
1100	Auriga	β 34	1328	52.2	+44 57	VIII.*a*	56	14	413,1131,2264,2277	4,3,2,1
1101	Lepus	η 16	1286	51.8	−14 11	XII.*a*	85	1	1670	1
1102	Auriga	π 35	1217	52.5	+45 56	XVIII.*a*	—	1	775	1
1104	Auriga	θ 37	1380	52.9	+37 13	VIII.*P.*	70	10	443,1734,2311,6083	4,2,1
1119	Orion	64	1186	57.6	+19 41	VI.*a, b*	—	3	1801,2468,2502	1
1122	Orion	χ^2 62	1233	58.0	+20 8	III.*c*	—	3	1801,2468,2502	1
1124	Orion	—	1391	59.4	− 6 42	IV.*b, L.*	175	1	4499	1
1132	Orion	ν 67	1152	6 1.8	+14 47	IV.*a, b*	—	1	2483	1
1150	Orion	68	1253	6.0	+19 49	VII.*a, b*	55,42	3	2482,6389,6404	2,1
1153	Orion	ξ 70	1187	6.2	+14 14	IV.*a, b*	—	1	2483	1
1157	Monocer.	—	1446	7.0	− 6 31	IV.*a, b*	20	1	2576	1
1160	Gemini	η 7	1241	8.8	+22 33	XVIII.*a*	—	5	878,1465,1481,2599	1
1162	Orion	71	1270	9.0	+19 12	XII.*a*	2	3	2482,6521,6626	1
1195	Can. Maj.	ζ 1	3038	16.5	−30 2	*IV.b*	—	1	1738	2
1194	Gemini	μ 13	1304	16.9	+22 34	XVIII.*a*	2	2	773,2219	1
1201	Can. Maj.	β 2	1467	18.3	−17 55	III.*a*	—	7	1545,1722,2590,4539	4,3,1,2
—	Gemini	—	1347	19.4	+23 23	VII.*a, b*	23	1	2219	1
1205	Monocer.	T	1273	19.8	+ 7 8	XIV.*ac*	—	1	2504	1
1220	Monocer.	11	1574	24.0	− 6 58	IV.*b, L.*	170	10	1587,1671,2327,2435	2,1
1225	Camelop.	—	212	29.2	+79 41	XIII.*a*	—	1	2621	1
—	Auriga	—	1539	29.7	+38 31	XXI.	138	1	1573	1
1244	Auriga	51	1690	31.8	+39 29	XV.*a*	—	1	1573	1
1249	Gemini	γ 24	1223	31.9	+16 29	VIII.*a*	—	7	467,2265,4231,6344	4,2,1
1256	Monocer.	S 15	1220	35.5	+10 0	I.*b*	1	11	703, 716, 738, 746	1,2
1263	Gemini	ε 27	1406	37.8	+25 13	*XIV.a*	—	1	1641	1
1266	Gemini	30	1390	38.3	+13 20	XV.*a*	—	2	1686,2578	1
1272	Gemini	ξ 31	1396	39.7	+13 0	XII.*a*	—	3	1637,1686,2578	1

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—	Gemini	—	1275	6 40.3	+12 49	XI.	80,182	1	1686	1
1275	Can. Maj.	α 9	1591	40.7	−16 34	VII.*a*	39	10	340, 356, 370, 411	4,2,1
1288	Camelop.	—	266	45.5	+77 6	XVI.*a*	—	1	879	1
1295	Gemini	θ 34	1481	46.2	+34 5	IX.*ab*	178	6	1056,1731,2418,3126	4,3,2,1
—	Can. Maj.	—	4553	49.2	−24 34	VIII.*b*	23	2	760, 834	
—	Can. Maj.	—	4565	49.8	−24 25	VIII.*b*	23	2	760, 834	
1292	Cepheus	—	51	53.9	+87 12	XVII.*a*	—	1	2629	1
1302	Lynx	15	982	48.6	+58 34	XV.*a*	—	1	2255	1
1312	Can. Maj.	o^1 16	4567	49.9	−24 4	*XIV.a*	109	4	760, 797, 831, 834	1
1311	Can. Maj.	—	4553	50.0	−23 48	XXII.	—	5	760, 797, 826, 831	4,3,2,1
1325	Can. Maj.	ε 21	3666	54.7	−28 50	III.*a*	17	5	1082,1785,6255,6357	4,2
1334	Gemini	ζ 43	1687	58.2	+20 43	XIV.*ac*	—	4	697, 704, 739,1469	1
1337	Can. Maj.	o^2 24	4797	58.8	−23 41	V.*c*	—	2	1039,2575	2,1
1340	Can. Maj.	γ 23	1625	59.2	−15 29	V.*a*	10	1	1755	1
1350	Can. Maj.	δ 25	3916	7 4.3	−26 14	XIII.*c*	—	9	453,1717,2245,2437	4,3,2,1
—	Monocer.	—	1634	6.3	− 0 8	XI.*ab*	182	4	1581,6148,6212,6219	2,1
1359	Monocer.	22	1636	6.8	− 0 19	VIII.*b*	32	4	1581,6148,6212,6219	2,1
1361	Gemini	51	1417	7.7	+16 20	XIX.*a*	20	1	808	1
—	Monocer.	—	1646	8.2	− 0 7	*XI.*	20	3	1581,6148,6212	2,1
1360	Camelop.	—	201	10.0	+82 36	XIX.*a*	—	1	1699	1
1368	Can. Maj.	27	4057	10.2	−26 10	IV.*a*	10	2	1665,2512	1
1370	Can. Maj.	28	4073	10.7	−26 35	IV.*b L.*	168	2	1665,2512	1
1373	Gemini	λ 54	1443	12.4	+16 43	IX.*a, b*	177	1	2532	1
1377	Gemini	δ 55	1645	14.2	+22 10	XI.*ab*	182	4	1575,1735,2220,2591	2,1
1383	Can. Maj.	—	4164	14.8	−26 25	XIV.*a*	65	1	1665	1
—	Gemini	—	1374	18.3	+27 50	*XI.*	22,31	2	1040,1749	4,2
1394	Gemini	ι 60	1385	19.5	+28 0	XV.*a*	—	3	1040,1749,2242	4,2,1
1399	Can. Maj.	η 31	4328	20.2	−29 7	V.*c*	—	6	1033,1776,2455,6358	4,3,2
1403	Can. Min.	β 3	1774	21.8	+ 8 29	VI.*b*	—	3	448,1745,2314	4,2,1
1405	Gemini	ρ 62	*1562*	22.7	+31 59	XI.*a, b*	182	1	1757	1
1409	Gemini	64	1396	23.1	+28 19	IX.	20	1	2242	1
1423	Gemini	α 66	1581	28.2	+32 7	VIII.*a*	—	5	395, 470, 484,2261	4,2,1
1430	Gemini	υ 69	1424	29.8	+27 7	XVI.*a*	—	1	1618	1
1442	Can. Min.	α 10	1739	34.1	+ 5 30	XII.*a*	—	6	387, 493,1518,2214	4,2,1
1445	Argo	κ	4707	34.7	−26 34	IV.*a, b*	11	1	1764	1
1452	Monocer.	26	2172	36.5	− 9 19	XV.*a*	185	1	1852	1
1453	Gemini	σ 75	1590	37.0	+29 7	XV.*a*	185	2	1869,5289	4,2,1
1457	Gemini	κ 77	1759	38.4	+24 38	*XIV.a*	101	1	1710	1
1459	Gemini	β 78	1463	39.2	+28 16	XV.*a*	184	6	394,1172,1187,1869	4,3,2,1
1462	Argo	τ 3	4774	39.8	−28 43	*VIII.ac*	—	4	1865,2522,6157,6604	2,1
1474	Argo	ξ 7	6030	45.1	−24 37	XIV.*P.*	100	3	2477,2541,3101	1
1492	Argo	e 11	2087	52.6	−22 37	XIV.*ac*	—	1	1524	1
1500	Argo	12	*2104*	54.8	−23 2	XV.*a*	20	1	1524	1
1515	Argo	ι 15	*6828*	8 3.3	−24 1	XII.*a*	82	2	1028,2328	4,1
1518	Argo	16	2190	4.5	−18 57	*IV.b*	23	1	1787	1
—	Camelop.	—	235	5.2	+82 44	VII.*b*	30	7	2315,2451,2533,2534	1
1521	Cancer	ζ 16	*1867*	6.5	+17 56	XIII.*a*	—	1	1712	1
1533	Cancer	β 17	1917	11.1	+ 9 30	*XV.a*	—	1	1657	1
—	Cancer	—	1921	12.1	+ 9 11	XV.*a*	—	1	1657	1
—	Cancer	—	1927	12.9	+ 9 28	V.*a, b*	20	1	1657	1

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1554	Monocer.	30	2339	8 20.7	− 3 35	VII.*b*	43,49	2	991,2493	2,1
1558	Urs. Maj.	ο 1	1054	22.0	+61 3	XIV.*a*	2	2	838,1666	1
—	Urs. Maj.	—	1136	22.9	+60 15	XII.*a*	31	1	1666	1
—	Camelop.	—	253	28.4	+82 36	VII.*a*, *b*	20	7	2315,2451,2533,3121	1
1580	Urs. Maj.	π^1 3	643	30.3	+65 22	*XIV.a*	—	1	2408	1
1582	Hydra	—	*1997*	30.5	+ 6 58	XIII.*a*	30	4	5441,6426,6468,6522	2,1
1584	Urs. Maj.	π^2 4	698	31.5	+64 40	XV.*a*	—	1	2408	1
1588	Hydra	δ 4	2001	32.3	+ 6 3	VIII.*b*	32,50	7	2531,5409,5441,6426	2,1
1599	Hydra	η 7	2039	38.0	+ 3 46	*IV.ab*	28	1	1770	1
1605	Cancer	ι 48	1824	40.6	+29 7	*XIV.a*	108	1	1651	1
1608	Hydra	ε 11	2036	41.5	+ 6 48	XIII.*a*	—	1	1795	1
1613	Hydra	ρ 13	2040	43.1	+ 6 13	VII.*a*, *b*	23	1	1795	1
1629	Hydra	ζ 16	2060	50.1	+ 6 19	XV.*a*	185	1	1802	1
1636	Urs. Maj.	ι 9	1707	52.4	+48 27	X.*ab*	180	5	1076,1848,2404,5427	2
1638	Urs. Maj.	ρ 8	551	53.5	+68 1	XVIII.*a*	—	2	804,1700	1
1641	Urs. Maj.	10	1956	54.2	+42 11	XII.*a*	84	2	1861,1904	1
1645	Urs. Maj.	κ 12	1633	56.9	+47 34	VIII.*b*	—	8	1848,2404,2628,4544	2,1
1651	Urs. Maj.	σ^1 11	573	59.6	+67 17	XVI.*a*	—	2	1700,1765	1
1655	Urs. Maj.	σ^2 13	577	9 1.6	+67 32	XIII.*a*	32	2	1700,1765	1
1658	Urs. Maj.	τ 14	*723*	2.7	+63 55	XII.*C.*	161	2	843,2321	1
1663	Argo	—	6895	3.7	−25 27	XVI.*a*	—	1	832	1
1676	Hydra	θ 22	2167	9.1	+ 2 44	VII.*b*	—	5	1758,2484,6445,6561	2,1
1681	Lynx	38	1965	12.6	+37 14	VIII.*ab*	55,60	3	1822,2505,5393	2,1
1685	Lynx	40	*1979*	15.0	+34 49	XVI.*a*	—	2	1576,1740	4,2,1
1698	Hydra	α 30	2680	22.6	− 8 13	*XV.a*	—	6	962,1029,1121,2517	4,3,2,1
1695	Draco	—	302	22.8	+81 46	XV.*a*	114,185	1	1695	1
1701	Urs. Maj.	h 23	845	23.6	+63 30	XI.*a*, *b*	78,183	3	845,1844,2586	3,1
1709	Urs. Maj.	θ 25	1401	26.3	+52 8	XIII.*a*	32	1	1746	4,2
1715	Urs. Maj.	26	1402	28.0	+52 30	VIII.*b*	54	1	1746	2
1734	Hydra	ι 35	2231	34.8	− 0 42	XV.*a*	—	2	1597,1833	1
1740	Leo	ο 14	2044	35.8	+10 21	XII.*C*	157	1	1619	1
1747	Leo	ε 17	2129	40.2	+24 14	XIV.*P*	99	4	1750,2312,6630,6640	4,2,1
1752	Leo	R	*2096*	42.2	+11 53	XX.*a*	132	2	2470,2478	1
1753	Urs. Maj.	υ 29	1268	44.0	+59 30	*XI.ac*	—	2	1678,2553	1
1760	Leo	μ 24	2019	47.1	+26 29	XV.*a*	185	1	1841	1
1782	Leo	π 29	2301	54.9	+ 8 32	XVII.*a*	—	2	1788,1854	1
1793	Leo	η 30	2171	10 1.9	+17 15	VII.*c*	—	4	1771,5489,6530,6581	2,1
1797	Leo	α 32	2149	3.1	+12 28	VI.*b*	—	13	460, 471, 479, 490	4,2,1
1800	Hydra	λ 41	2120	5.7	−11 51	XV.*a*	185	1	1625	1
1810	Urs. Maj.	λ 33	2005	11.0	+43 25	VIII.*a*	—	2	1772,5517	2,1
1811	Leo	35	2207	11.0	+24 0	XIV.*a*	20	1	2524	2,1
1812	Leo	ζ 36	*2209*	11.1	+23 55	*XI.ab*	—	3	948,1747,2524	4,2,1
—	Camelop.	—	287	11.7	+83 19	XV.*a*	—	1	1691	1
—	Leo	—	2207	11.8	+23 37	XII.*a*	31	1	2524	1
1821	Leo	40	*2466*	14.3	+19 59	XII.*a*	31	2	449, 964	4,2
1823	Leo	γ 41	2467	14.4	+20 21	XV.*a*	107,184	5	449, 964,1122,5436	4,2
1827	Urs. Maj.	μ 34	2115	16.4	+42 0	XVI.*a*	—	3	867,1041,2233	4,1
1831	Camelop.	—	297	19.0	+83 4	XII.*a*	88	1	1691	1
1837	Hydra	μ 42	3052	21.2	−16 20	XVI.*a*	—	2	1589,1817	1
1859	Leo	ρ 47	*2166*	27.5	+ 9 49	II. *P.*	13	3	1658,1842,2514	1

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1869	Hydra	U	3218	10 32.6	−12 51	XXI.	140	3	1582,1823,2485	1
—	Hydra	—	2925	33.9	−11 56	VII.*b*	54	2	1582,1823	1
1893	Hydra	ν 4	3138	44.7	−15 40	XVII.*a*	125	2	1100,6545	4,2
1902	Leo Min.	46	2172	47.7	+34 45	XV.*a*	185	2	1677,1845	1
1906	Leo Min.	47	2178	49.4	+34 34	XV.*a*	—	2	1677,1845	1
1907	Urs. Maj.	46	2181	50.2	+34 2	XV.*a*	—	1	1845	1
1918	Crater	α 7	3273	54.9	−17 46	XV.*a*	—	1	1804	1
1923	Urs. Maj.	β 48	*1302*	55.9	+56 55	VIII.*a*	32	5	420, 468,1160,2266	4,2,1
1925	Leo	b 60	2547	57.0	+20 43	VIII.*a*	61	2	1035,6705	4,2
1926	Urs. Maj.	α 50	1161	57.6	+62 18	XV.*a*	184	3	480,2665,5527	4,3,2
1941	Urs. Maj.	ψ 52	1897	11 4.0	+45 3	XV.*a*	119,120	3	1071,1094,2525	4,1
1949	Leo	δ 68	2298	8.8	+21 5	IX.*b*	178	10	418,1035,1078,1777	4,3,2,1
1951	Leo	θ 70	*2234*	9.0	+15 59	VIII.*a*	32	6	1084,1741,1966,6458	2
1952	Leo	72	2322	9.9	+23 39	XVIII.*a*	—	1	1818	1
1959	Urs. Maj.	ξ 53	2132	12.9	+32 6	XIV.*a*	—	1	1679	1
1961	Urs. Maj.	ν 54	2098	13.1	+33 39	XV.*a*	112,184	1	1831	1
1963	Crater	δ 12	*3345*	14.4	−14 14	XV.*a*	184	1	1759	1
1965	Leo	σ 77	2437	16.0	+ 6 35	VII.*a*	42	5	1809,6531,6690,6740	2,1
1969	Leo	ι 78	2348	18.7	+11 5	XII.*a*	—	1	1626	1
1972	Leo	—	*2335*	19.8	+11 59	XV.*a*	—	1	1626	1
1973	Crater	γ 15	*3244*	19.9	−17 8	IX.*a*, *b*	178	2	1797,2506	1
1988	Draco	λ 1	*665*	25.5	+69 53	XVII.*a*	32?	4	814,2579,2594,4939	2,1
1999	Draco	2	*670*	30.2	+69 52	XV.*a*	184	1	814	1
2019	Virgo	ν 3	2479	40.7	+ 7 6	XVII.*a*	—	2	1824,2639	1
2018	Urs. Maj.	χ 63	1966	40.8	+48 20	XV.*a*	—	1	1653	1
2025	Leo	β 94	2383	44.0	+15 8	IX.*b*	178	8	454, 469, 472, 963	4,2,1
2028	Virgo	β 5	2489	45.5	+ 2 20	XIII.*a*	—	1	1773	1
2036	Urs. Maj.	γ 64	1475	48.6	+54 15	VIII.*b*	32	5	474, 510,1133,2518	4,2,1
2057	Virgo	ο 9	2583	12 0.1	+ 9 18	*XIV.a*	104	1	1696	1
2056	Draco	—	461	0.2	+77 28	XV.*a*	185	2	1713,1849	1
2063	Corvus	ε 2	*3487*	5.0	−22 3	XV.*a*	185	1	2507	4,1
2070	Draco	—	412	7.5	+78 10	X.*a*, *b*	77,180	3	1713,1849,1896	1
2077	Urs. Maj.	δ 69	1363	10.5	+57 35	IX.*b*	32,177	4	425,1839,2526,2707	4,3,1
2078	Corvus	γ 4	3424	10.7	−16 59	VI.*a*	33	4	1030,1778,2440,2550	4,3,1
2088	Virgo	η 15	2926	14.8	− 0 6	VIII.*a*	—	1	2480	1
2120	Corvus	δ 7	3482	24.7	−15 57	VII.*b*	48	4	1066,1779,2622,3713	4,3,2,1
2124	Draco	4	*700*	25.7	+69 45	XVIII.*a*	—	9	1767,1900,4646,4656	2,1
2128	Corvus	η 8	3489	26.9	−15 38	*XI.*	30,81	2	2622,3713	2,1
2134	Corvus	β 9	3401	29.1	−22 50	*XIV.a*	103	3	1054,1064,2549	4,1
2135	Draco	κ 5	703	29.2	+70 20	V.*b* *L.*	171	29	1282,4746,4772,4778	2,1
2141	Draco	6	705	30.5	+70 34	*XIV.a*	—	9	1282,1900,4514,4646	1
2155	Virgo	γ 29	2601	36.6	− 0 54	XI.*ab*	183	4	1072,1742,1963,2565	4,2,1
2164	Can. Ven.	—	1817	40.5	+46 0	XXI.	139	1	1892	1
2167	Com. Ber.	27	2533	41.6	+17 8	XVI.*a*	32	1	1760	1
2191	Urs. Maj.	ε 77	1627	49.6	+56 30	VIII.*P.*	66	12	417, 426, 487,2537	4,2,1
2193	Virgo	δ 43	*2669*	50.6	+ 3 57	XVIII.*a*	—	4	881, 914,1805,2600	1
2195	Can. Ven.	12	*2580*	51.4	+38 52	VIII.*P.*	69	4	1046,2514,6516,6544	4,2,1
2201	Com. Ber.	36	*2682*	54.0	+17 57	XVII.*a*	32	2	1874,1879	1
2207	Urs. Maj.	78	*1408*	56.5	+56 55	XI.*a*, *b*	183	3	2744,2760,2826	1
2208	Virgo	ε 47	2529	57.2	+11 30	XV.*a*	185	2	1036,2645	4,1

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2232	Com. Ber.	43	2193	13 7.3	+28 22	XIV.*a*	—	1	1870	1
2249	Hydra	γ 46	3554	13.5	−22 39	*XIV.a*	104,101	2	1085,2508	4,1
2263	Virgo	α 67	3672	19.9	−10 38	III.*b*	18	19	431, 457, 502, 506	4,3,2,1
2264	Urs. Maj.	ζ 79	1598	19.9	+55 27	VIII.*a*	56	10	427, 441, 968,1652	4,3,2,1
2267	Urs. Maj.	g 80	1603	21.2	+55 30	IX.*b*	178	8	968,1652,2287,2291	4,2,1
2294	Virgo	ζ 79	*3076*	29.6	− 0 5	IX.*b*	177	4	1294,6615,6624,6667	3,1
2298	Urs. Maj.	81	*1667*	30.3	+55 52	VIII.*P.*	71	2	5213,5231	2
2338	Urs. Maj.	η 85	*2027*	43.6	+49 49	IV.*b*	—	5	482, 566,1118,1908	4,2
2343	Boötes	υ 5	2564	44.6	+16 17	XVI.*a*	—	3	1620,1811,1846	1
2356	Draco	i 10	963	48.5	+65 13	XVIII.*a*	—	2	1893,2535	1
2360	Boötes	η 8	2725	49.9	+18 54	XIV.*a*	93	3	1047,1065,1970	4,1
2378	Hydra	π 49	10095	14 0.7	−26 12	XV.*a*	—	1	2551	1
2381	Draco	α 11	*978*	1.7	+64 51	VII.*a*	43,44	6	2073,2573,2587,2651	3,2,1
2400	Boötes	α 16	2777	11.1	+19 44	XV.*a*	—	14	87, 401, 475,1184	4,3,2,1
2426	Boötes	θ 23	1804	21.8	+52 19	XIII.*a*	—	1	1875	1
2433	Boötes	ρ 25	*2628*	27.6	+30 49	XV.*a*	—	2	1312,6945	1
2437	Urs. Min.	5	527	27.7	+76 8	*XV.a*	—	2	1353,6972	1
2436	Boötes	γ 27	2565	28.0	+38 45	XI.*ab*	182	5	1059,2544,2566,6546	4,2,1
2442	Boötes	σ 28	2536	30.3	+30 11	*XI.a, b*	30	2	1312,6945	1
2457	Virgo	μ 107	3936	37.8	− 5 13	XII.*a*	—	1	1300	1
2467	Boötes	ε 36	2417	40.6	+27 30	XV.*C.*	150	9	969,1123,1130,1161	4,2,1
2468	Virgo	109	2862	41.2	+ 2 19	VIII.*b*	32	5	994,1967,2623,6681	2,1
2479	Libra	8	3965	45.2	−15 35	XII.*a*	31	2	2630,3714	2,1
2481	Boötes	—	2593	45.2	+38 13	XI.*a, b*	20,182	3	2510,2741,6946	1
2480	Libra	α 9	3966	45.4	−15 37	IX.*ab*	177	5	1079,1297,2630,3710	4,2,1
2488	Boötes	—	2580	46.6	+37 40	XV.*a*	—	2	2510,2741	1
2500	Urs. Min.	β 7	595	51.0	+74 34	XVI.*a*	32	5	501, 844, 985,2552	4,2,1
2506	Libra	δ 19	*3938*	55.6	− 8 7	VII.*a*	—	7	1692,1880,2580,2748	2
2510	Urs. Maj.	—	878	56.0	+66 20	XIX.*a*	—	5	1313,1338,1347,1427	1
—	Libra	—	3946	57.1	− 7 27	VIII.*a*	54	2	1692,2580	2
2515	Boötes	β 42	2840	58.2	+40 47	*XIV.a*	104,101	2	1305,1306	1
2514	Scorpius	γ 20	11834	58.3	−24 53	XVIII*a.*	—	1	1298	1
2541	Boötes	δ 49	2561	15 11.5	+33 42	XV*a.*	184	2	1092,2028	4,1
2539	Libra	β 27	*3935*	11.6	− 9 1	VI.*b*	—	4	2640,2692,6803,6828	4,3,2,1
2555	Urs. Min.	11	678	17.2	+72 11	XV.*a*	—	2	1276,2567	1
2566	Urs. Min.	γ 13	679	20.9	+72 11	IX.*b*	178	5	1276,1316,2017,2572	3,1
2563	Serpens	τ^1 9	2858	21.1	+15 47	XVII.*a*	65	2	1871,1905	1
2569	Draco	ι 12	1654	22.7	+59 19	XV.*a*	2,185	1	1855	4,1
2572	Corona	β 3	2670	23.7	+29 27	XI.*P*	79,182	5	1308,1761,1850,6847	2,1
2586	Libra	37	4171	28.7	− 9 43	XV.*a*	—	1	2761	1
2587	Libra	—	4010	29.0	− 8 51	*IV.a, b*	—	3	1667,2561,2821	1
2589	Libra	γ 38	4237	29.9	−14 27	XV.*a*	184	1	1320	1
2594	Corona	α 5	2512	30.4	+27 3	VIII.*ab*	51	6	535,1037,1135,1968	4,2,1
2595	Scorpius	*39*	10464	30.9	−27 48	XV.*a*	—	1	1326	1
2601	Scorpius	ο *40*	11837	32.6	−29 27	IV.*a, b*	20	1	1886	1
2625	Corona	γ 8	2722	38.5	+26 36	VIII.*ab*	51	6	1330,6633,6693,6706	2,1
2627	Serpens	α 24	3088	39.3	+ 6 44	XV.*a*	185	5	559,1087,1101,2563	4,2,1
2632	Serpens	β 28	2911	41.6	+15 44	IX.*b*	73,178	4	1332,6730,6737,6770	2,1
2636	Serpens	κ 35	3074	44.2	+18 27	XVI.*a*	—	1	1335	1
2638	Serpens	μ 32	*4052*	44.4	− 3 8	VII.*a*	41	7	1337,1806,2771,2822	1

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2645	Serpens	ε 37	3069	15 45.8	+ 4 46	VIII.*a*	59	7	1350,2007,2118,2624	1
2662	Scorpius	ρ 5	11714	50.7	−28 55	IV.*b*	23	1	1901	1
2666	Serpens	γ 41	2849	51.8	+16 0	XIII.*a*	32,91	3	2033,2636,6908	1
2671	Scorpius	π 6	11228	52.8	−25 49	III.*b*	—	5	488, 970,1960,6782	2,1
2673	Corona	ε 13	2558	53.5	+27 10	XV.*a*	—	1	1999	1
2674	Scorpius	δ 7	4068	54.4	−22 20	III.*P.*	25	3	563,6750,6800	4,2
2688	Scorpius	ξ 51	*4237*	58.9	−11 6	XIII.*a*	—	1	2646	1
2690	Scorpius	β 8	4307	59.6	−19 32	III.*b*	19	5	1283,2641,2702,6735	3,2,1
2696	Draco	θ 13	1608	16 0.1	+58 50	XIII.*a*	—	1	2037	1
2698	Scorpius	ω¹ 9	4405	1.0	−20 24	III.*b*	—	4	1906,2702,6735,6779	3,2,1
2700	Scorpius	ω² 10	4408	1.6	−20 36	XIV.*a*	—	2	6735,6779	1
2713	Hercules	φ 11	2376	5.6	+45 12	VII.*a*	45	5	2632,2765,2910,6738	2,1
2726	Ophiuch.	δ 1	3903	9.1	− 3 26	XVII.*a*	127	4	1277,1295,6911,6912	1
2736	Ophiuch.	ε 2	4086	13.0	− 4 27	XV.*a*	184	1	1881	1
2738	Scorpius	σ 20	11485	15.1	−25 21	II.*a, b*	10	2	2766,2804	1
2745	Hercules	τ 22	2169	16.7	+46 33	V.*a*	—	3	1309,1876,6772	1
2747	Hercules	γ 20	3086	17.5	+19 23	XI.*a, b*	182	4	1973,2780,2805,2811	1
2764	Scorpius	α 21	11359	23.2	−26 13	XVII.*C.*	155	9	560,1104,1185,1216	4,2,1
2772	Hercules	g 30	2714	25.3	+42 6	*XIX.a*	129	2	1902,2607	1
2773	Ophiuch.	λ 10	3118	25.9	+ 2 13	VIII.*a*	57	2	1303,2625	1
2774	Hercules	β 27	2934	26.0	+21 42	XV.*a*	32,184	2	2681,2693	3,1
2783	Scorpius	τ 23	*11015*	29.7	−28 0	II.*a, b*	2	1	2816	1
2787	Hercules	σ 35	2724	30.9	+42 39	VII.*b*	52,43,53	5	2613,2618,2634,3855	3,2,1
2788	Ophiuch.	ζ 13	4350	31.7	−10 22	II.*b*	2,7	4	2726,2798,3743,6849	3,2,1
2802	Hercules	42	2531	36.1	+49 7	XVIII.*a*	32	3	2626,6910,6917	2,1
2807	Hercules	ζ 40	2884	37.5	+31 47	XIV.*a*	94	2	2823,2864	1
2810	Hercules	η 44	3029	39.5	+39 7	XV.*a*	119,120	3	3798,3850,3871	1
2838	Ophiuch.	κ 27	3298	53.0	+ 9 32	XV.*a*	185	2	1331,2045	1
2851	Urs. Min.	ε 22	498	56.2	+82 12	*XIV.a*	105	2	1358,1372	1
2844	Hercules	ε 58	2947	56.5	+31 4	VII.*a*	42	6	1887,6158,6196,6205	2,1
2849	Hercules	*32*	3179	58.6	+14 14	XVIII.*a*	65	1	1327	1
2852	Hercules	*33*	3292	59.1	+13 44	VII.*a, b*	20	1	1327	1
2868	Ophiuch.	η 35	4467	17 4.6	−15 36	VIII.*a*	—	5	565, 567,2002,2024	4,2,1
2878	Draco	ζ 22	1170	8.5	+65 50	V.*a*	10	2	1355,2635	1
2879	Hercules	α 64	3207	10.1	+14 30	*XIX.a*	—	7	459,1261,1274,1281	4,2,1
2880	Hercules	δ 65	*3221*	11.0	+24 57	VIII.*b*	2	6	1856,2608,2614,2708	3,2,1
2885	Hercules	π 67	2844	11.5	+36 55	*XV.a*	—	2	1317,2781	1
2890	Hercules	u 68	2864	13.6	+33 13	*IV.a, b*	—	1	1964	1
2893	Hercules	e 69	2864	14.2	+37 24	VIII.*a*	58	2	1317,2781	1
2899	Ophiuch.	θ 42	13292	15.8	−24 54	*IV.a, b*	—	1	1894	1
2914	Hercules	ρ 75	2878	20.2	+37 14	VII.*b*	—	1	2000	1
2920	Ophiuch.	—	3368	21.5	+ 7 41	XII.*C.*	158	2	2799,6913	1
2937	Draco	β 23	2065	28.1	+52 23	XIV.*a*	—	1	2959	1
2944	Ophiuch.	α 55	3252	30.3	+12 38	X.*b*	180	6	1124,1157,1969,6682	4,2,1
2947	Serpens	ξ 55	4621	31.8	−15 20	X.*a, b*	180	3	1978,2906,2932	1
2959	Hercules	ι 85	2349	36.6	+46 3	IV.*b*	—	2	1386,1995	1
2962	Ophiuch.	β 60	3489	38.5	+ 4 36	XV.*a*	185	1	1378	1
2976	Hercules	μ 86	2888	42.6	+27 48	*XIV.a*	102	2	1363,2006	1
2979	Ophiuch.	γ 62	3403	42.9	+ 2 44	VII.*b*	—	4	2029,2082,2643,6806	2,1
3003	Draco	ξ 32	2033	51.8	+56 55	XV.*a*	114?,185	1	2588	1

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3005	Ophiuch.	ν 64	4632	17 53.5	− 9 45	XV.*a*	—	2	1961,2911	1
3007	Hercules	ξ 92	3156	53.8	+29 15	XV.*a*	185	4	1390,1409,2921,2946	1
3009	Draco	γ 33	2282	54.3	+51 31	XVI.*a*	—	7	575, 578,1981,2960	4,2,1
3010	Hercules	ν 94	3093	54.7	+30 11	XI.*ac*	183	4	1382,1390,2946,2994	1
3017	Ophiuch.	67	3458	55.7	+ 2 56	V.*c*	—	4	1333,2052,2918,3861	1
3023	Ophiuch.	68	3560	56.7	+ 1 19	VII.*b*	20	1	2762	1
3037	Ophiuch.	70	3482	18 0.4	+ 2 32	XV.*a*	112,184	1	2800	1
3045	Ophiuch.	72	3564	2.6	+ 9 33	IX.*a*, *b*	177	2	2034,2832	1
3047	Hercules	b 99	3128	3.2	+30 33	XIII.*a*	20	1	1396	1
3048	Hercules	o 103	2925	3.6	+28 45	VII.*b*	—	6	734,1359,2943,3012	2,1
3051	Hercules	102	3674	4.4	+20 48	IV.*a*	10	1	2746	1
3053	Hercules	101	3675	4.6	+20 1	IX.*a*, *b*	178	1	2746	1
3071	Draco	40	570	7.5	+79 59	XII.*a*	87	3	1405,1851,2568	1
3062	Sagittar.	μ 13	4908	7.8	−21 5	VI.*c*	—	2	2888,2903	1
3065	Hercules	A 104	3199	8.2	+31 22	XVII.*a*	—	2	2026,3088	1
3069	Sagittar.	15	5054	9.3	−20 46	*VI.c*	38	1	2903	1
3084	Sagittar.	δ 19	14834	14.6	−29 52	XV.*a*	185	3	2853,2885,2913	1
3090	Serpens	η 58	4599	16.1	− 2 56	XV.*a*	184	1	2030	1
3107	Hercules	109	3411	19.4	+21 43	XV.*a*	—	2	1361,1413	1
3120	Draco	φ 43	889	22.2	+71 17	VII.*P.*	43,44	7	2609,2637,6087,6169	2,1
3122	Draco	χ 44	839	22.8	+72 42	XIII.*a*	—	2	1416,6087	1
3136	Draco	d 45	2113	30.9	+56 58	XIII.*c*	—	1	2620	1
3147	Lyra	α 3	3238	33.6	+38 41	VII.*a*	40	7	476, 547, 570, 654	4,3,2,1
3157	Sagittar.	φ 27	13170	39.4	−27 6	VI.*a*	—	3	2818,2860,6865	2,1
3171	Hercules	110	3926	41.4	+20 27	XII.*a*	2	1	2001	1
3191	Lyra	8	3227	46.1	+32 42	IV.*a*, *b*	—	4	740,1477,6905,6914	1
3192	Lyra	ν 9	3228	46.2	+32 26	IX.	65	4	682, 740,1477,3096	1
3193	Lyra	β 10	3223	46.3	+33 15	*C*, *L.*	166	17	290, 672, 682,3768	2,1
3199	Sagittar.	σ 34	13595	49.1	−26 25	IV.*b*	—	5	652,1988,2776,2856	4,2,1
3207	Lyra	δ^1 11	3307	50.2	+36 51	IV.*b*	—	1	810	1
3210	Lyra	δ^2 12	3319	51.0	+36 47	XIX.*a*	—	1	810	1
3224	Lyra	R 13	3117	52.3	+43 49	*XIX.a*	—	2	1459,3018	1
—	Lyra	—	3017	53.0	+44 5	VIII.*a*, *b*	20	2	1459,3018	1
3225	Lyra	—	3267	53.3	+32 47	XIV.*a*	—	1	287	1
3232	Lyra	γ 14	3286	55.2	+32 33	VII.*a*	41,42,46	5	1399,2738,3202,5840	2,1
—	Lyra	—	3132	56.1	+43 35	VIII.*a*, *b*	20,22	2	1459,3118	1
3252	Sagittar.	o 39	5237	58.7	−21 53	XV.*a*	—	2	2861,2884	1
3259	Aquila	ζ 17	3899	19 0.8	+13 43	VII.*b*	47	6	1299,2694,2796,5879	3,2,1
3260	Aquila	λ 16	4876	0.9	− 5 2	VII.*b*	42,51	8	1888,2801,2908,2933	2,1
3270	Sagittar.	π 41	5275	3.8	−21 11	*XI.ac*	—	3	1296,2837,2854	1
3291	Lyra	η 20	3490	10.4	+38 58	*IV.b*	—	1	1369	1
3307	Draco	δ 57	1129	12.5	+67 29	XV.*a*	119,120	1	1374	1
3316	Cygnus	κ 1	2216	14.8	+53 11	XV.*a*	—	2	2137,2155	1
3319	Sagittar.	ρ 44	5322	15.9	−18 2	X.*a*, *b*	180	2	2777,2806	1
3321	Sagittar.	υ 46	5283	16.0	−16 8	*C*, *L.*	167	5	5011,5030,5050,6831	2
3328	Draco	τ 60	857	17.5	+73 10	XV.*a*	185	1	1364	1
3342	Cygnus	2	3584	20.2	+29 26	IV.*a*, *b*	11	1	735	1
3343	Aquila	δ 30	3879	20.5	+ 2 55	XI.*a*, *b*	182	2	1417,2790	1
3357	Vulpec.	6	3759	24.6	+24 28	XVII.*a*	—	1	791	1
3361	Cygnus	7	2434	25.0	+52 7	VII.*a*	30	1	2835	1

H. P.	Constellation.	B. Fl.	D.M.	R. A. 1900. h. m.	Dec. 1900. ° ′	Group.	Remark.	No. of Pls.	Plate Number.	No. of Dispersions.
3362	Cygnus	β 6	3410	19 26.7	+27 45	XV.*C.*	145	3	1379,1393,1449	1
3365	Cygnus	ι 10	2605	27.2	+51 31	IX.*a, b*	74,178	2	2815,2835	1
3393	Cygnus	θ 13	*3062*	33.7	+50 0	XII.*a*	—	3	1391,1406,2919	1
3407	Cygnus	—	2949	37.7	+45 17	*XI.*	30,81	2	2173,2316	2,1
3418	Aquila	γ 50	4043	41.5	+10 22	*XV.a*	—	2	1302,2964	1
3419	Cygnus	δ 18	3234	41.9	+44 53	VII.*b*	50,42	6	2173,2316,2703,2712	4,2,1
3420	Cygnus	17	3587	42.6	+33 30	XII.*a*	—	2	6354,6387	2
3421	Sagitta	δ 7	4240	42.9	+18 17	*XVII.C.*	148	5	815,1348,1997,2894	1
3424	Sagitta	ζ 8	4254	44.5	+18 53	VIII.*b*	60	6	815,1348,1997,2836	1
3429	Aquila	α 53	4236	45.9	+ 8 36	X.*b*	180	13	171, 172, 237, 561	4,3,2,1
3434	Cygnus	χ	3593	46.7	+32 40	XX.*P.*	135	6	2774,2789,6135,6318	2,1
3436	Aquila	η 55	4337	47.4	+ 0 45	XIV.*ac*	—	9	677, 687, 691, 748	1
3445	Aquila	58	*3871*	49.6	+ 0 1	VII.*a*	22,30	3	1445,1446,1451	1
3447	Draco	ε 63	*1070*	48.5	+70 1	XV.*a*	184	2	3003,3079	1
3450	Aquila	β 60	4357	50.4	+ 6 10	XV.*a*	184	2	478,2046	4,1
3460	Cygnus	η 21	3798	52.6	+34 49	XV.*a*	—	1	2899	1
3466	Sagitta	γ 12	4229	54.3	+19 13	XVI.*a*	—	2	2912,3019	1
3498	Draco	e 64	1405	20 0.4	+64 32	XVII.*a*	—	1	3089	1
3514	Aquila	θ 65	3911	6.2	− 1 7	VII.*a*	43	2	2019,6014	2,1
3515	Vulpec.	18	3815	6.4	+26 37	VIII.*b*	—	5	3001,5887,6078,6165	2,1
3519	Vulpec.	19	3825	7.6	+26 31	XV.*a*	2,117,185	3	3001,6165,6915	2,1
3520	Vulpec.	20	3828	7.8	+26 11	VI.*b*	23	3	3001,5887,6915	2,1
—	Cygnus	—	*3821*	8.4	+38 3	XXII.	141	1	846	1
3527	Cygnus	30	2881	10.2	+46 31	IX.*b*	23,177	5	1383,1384,2036,2039	1
3528	Cygnus	o^1 31	2882	10.5	+46 26	XV.*C.*	146	6	1376,1383,1384,2036	1
3530	Vulpec.	—	4165	11.0	+25 17	IV.*b*	—	1	5887	2
3537	Capricor.	α^1 5	5683	12.1	−12 50	XIV.*a*	20	1	794	1
3541	Cygnus	o^2 32	3059	12.3	+47 24	*XIV.a*	110	6	1376,1383,1384,2036	1
3538	Capricor.	α^2 6	5685	12.5	−12 52	XV.*a*	—	1	794	1
—	Cygnus	—	*3987*	13.3	+37 7	XXII.	142	1	1473	1
3547	Cygnus	P 34	3871	14.1	+37 43	*L.*	165	9	700, 741,1433,4881	2,1
3550	Cygnus	36	3998	14.8	+36 41	VIII.*a*	—	2	1433,5168	1
3551	Cygnus	35	3967	14.8	+34 40	*XII.c*	89	1	5132	1
3552	Capricor.	ν 8	5642	15.1	−13 4	VII.*b*	23	1	794	1
3554	Capricor.	β 9	5629	15.4	−15 5	XIV.*C.*	151	3	2043,2053,2093	1
—	Cygnus	—	4010	15.8	+38 25	XXII.	143	1	1473	1
3564	Cygnus	γ 37	4159	18.6	+39 56	XIII.*c*	—	6	505, 615, 634,2018	4,2,1
3583	Cygnus	41	*4057*	25.3	+30 2	*XII.ac*	—	1	1397	1
3592	Delphin.	ε 2	4321	28.4	+10 58	V.*a*	10	2	2817,2845	1
3600	Delphin.	ζ 4	4353	30.6	+14 20	VIII.*b*	54,60	3	1336,2050,2846	1
3605	Delphin.	β 6	4369	32.8	+14 15	XII.*a*	83	4	1336,2050,2846,6041	2,1
3622	Delphin.	—	4220	34.4	+15 29	IV.*b*	—	2	2855,6174	2,1
3624	Delphin.	α 9	4222	35.0	+15 33	*VI.b*	—	6	2077,2855,2915,5880	2,1
3631	Cygnus	α 50	3541	38.0	+44 56	VIII.*c*	—	10	477, 655,1486,1507	4,3,2,1
3635	Delphin.	δ 11	4403	38.8	+14 43	IX.*a, b*	20,178	1	2077	1
3645	Delphin.	γ 12	4255	42.0	+15 46	*XIV.a*	106,107	4	3053,3091,6909,6920	1
3648	Cygnus	ε 53	4018	42.1	+33 36	XV.*a*	184	4	1434,1463,5920,6079	4,2,1
3647	Aquarius	ε 2	*5506*	42.3	− 9 52	VIII.*a*	—	6	2129,2778,2791,6200	2,1
3649	Aquarius	3	5378	42.4	− 5 23	XVIII.*a*	34	1	3066	1
3654	Cygnus	T	*4028*	43.2	+34 1	XV.*a*	—	4	1434,1463,2953,6079	2,1

H. P.	Constellation.	B. Fl.		D.M.	R. A. 1900.		Dec. 1900.		Group.	Remark.	No. of Pls.	Plate Number.	No. of Disper-sions.
					h.	m.	°	′					
3656	Cepheus	η	3	2050	20	43.2	+61	26	XV.*a*	184	1	1387	1
3708	Cygnus	—		4325		59.2	+38	16	XV.*a*	—	1	2742	1
3716	Cygnus	ξ	62	3800	21	1.3	+43	32	XVI.*a*	—	1	3848	1
3717	Cygnus		61	4343		2.1	+38	13	XVI.*a*	124	3	2742,2858,2866	1
—	T Cephei	—		*1291*		8.2	+68	5	XX.*P.*	136	2	2775,2784	1
3732	Cygnus	ζ	64	4348		8.7	+29	49	XV.*a*	185	1	1394	1
3736	Cepheus	—		2334		9.3	+59	34	III.*a, b*	20	2	3022,6932	1
3739	Equuleus	α	8	4635		10.8	+ 4	50	XIII.*C.*	153	5	1414,2785,2792,2802	1
3741	Cygnus	τ	65	4240		10.8	+37	36	*XI.a, b*	—	3	1388,2868,2902	1
3747	Cygnus	υ	66	4371		13.8	+34	28	IV.*b, L.*	169	25	3026,3120,3298,4332	2,1
3750	Cygnus	A	68	3877		14.8	+43	31	I.*b*	—	7	6916,6941,6970,6975	1
3757	Cepheus	α	5	*2111*		16.2	+62	10	X.*b*	180	4	624, 653,2004,5894	4,2,1
3779	Capricor.	ζ	34	15388		20.9	−22	51	*XIV.P.*	111	4	2828,2934,3075,7017	2,1
3780	Capricor.		35	6020		21.5	−21	37	*XIV.a*	101	2	2828,3075	1
3792	Pegasus		2	4325		25.5	+23	12	XVII.*a*	—	1	780	1
3795	Aquarius	β	22	5770		26.3	− 6	1	XIV.*a*	—	3	1354,1643,6930	1
3798	Cepheus	β	8	*1173*		27.4	+70	7	III.*a*	—	3	1407,2366,2747	3,1
3807	Cygnus	ρ	73	*3865*		30.2	+45	9	XV.*a*	118	2	2057,2865	1
—	Cygnus	—		3877		32.3	+44	56	*XIX.a*	130	2	1592,2865	1
—	Cygnus	—		3889		33.6	+44	14	IX.	—	1	1592	1
3818	Capricor.	γ	40	6340		34.6	−17	7	*XI. C.*	160	3	2044,2833,3044	1
3821	Cepheus	—		*2617*		35.8	+57	2	I.*b*	5	2	2920,3031	1
—	Cepheus	—		*2623*		37.3	+57	8	—	176	1	3031	1
3836	Pegasus	ε	8	4891		39.2	+ 9	25	XV.*a*	2,116,185	7	1556,2069,2072,2088	4,2,1
—	Cepheus	—		2314		39.7	+58	48	XV.*a*	122	3	1439,1478,1525	1
3843	Pegasus	κ	10	*4463*		40.2	+25	11	XII.*a*	—	1	1630	1
3845	Cepheus	μ		2316		40.4	+58	20	XVII.*a*	126	5	1439,1478,1525,3005	1
—	Pegasus	—		*4471*		41.4	+25	6	V.*a, b*	31	1	1630	1
3848	Capricor.	δ	49	5943		41.5	−16	35	X.*a, b*	181	1	2838	1
—	Pegasus	—		*4473*		41.8	+25	6	XV.*a*	—	1	1630	1
3896	Aquarius		32	4242		59.7	− 1	24	IX.*a, b*	178	3	1328,3069,5971	2,1
3899	Aquarius	α	34	*4246*	22	0.7	− 0	49	XIV.*ac*	—	3	1328,3069,5971	2,1
3907	Pegasus	ι	24	4533		2.3	+24	51	XII.*a*	—	1	1418	1
—	Pegasus	—		*4540*		3.7	+25	3	XI.*a, b*	182	1	1418	1
3913	Pegasus	θ	26	4961		5.2	+ 5	42	VIII.*a*	60	4	2879,2935,3025,3039	1
3923	Cepheus	ζ	21	2475		7.4	+57	43	XV.*a*	2,185	3	673, 696,1341	1
3926	Cepheus	—		2727		8.2	+56	21	XIII.*a*	—	3	1467,2797,2808	1
3942	Cepheus	ε	23	2741		11.3	+56	33	X.*a, b*	181	3	1467,2797,2808	1
—	Cepheus	—		2746		12.8	+56	43	*XIV.a*	105	2	1467,2808	1
3950	Aquarius	γ	48	*5741*		16.5	− 1	53	VII.*a*	—	5	2881,2939,6192,6198	2,1
3960	Aquarius	π	52	4872		20.2	+ 0	53	*L.*	164	12	1426,1662,1680,2900	2,1
3962	Lacerta		4	3715		20.4	+48	58	*VI.c*	37	3	2424,2433,6015	2,1
3970	Aquarius	ζ	55	4365		23.7	− 0	32	XII.*a*	32	2	2054,2940	1
3981	Cepheus	δ	27	2548		25.4	+57	54	XIV.*ac*	98	2	1435,1447	1
3987	Lacerta		7	3875		27.1	+49	46	VIII.*b*	—	7	1398,1401,2917,2950	2,1
3994	Aquarius	η	62	4384		30.2	− 0	38	*VI.b*	—	4	2882,3076,6277,6390	2,1
4002	Cepheus		31	*1049*		33.2	+73	7	*XI.*	81	2	835, 839	1
4001	Lacerta		9	*3770*		33.2	+51	1	X.*a, b*	179	2	2466,2472	1
4007	Pisc. Aus.	ε	18	16010		35.1	−27	34	*VI.ab*	—	3	2971,3013,6001	2,1
4013	Pegasus	ζ	42	4797		36.4	+10	19	VI.*ab*	2	6	1349,2016,2071,2307	2,1

H. P.	Constellation.	B. Fl.	D.M.	R. A. 1900.	Dec. 1900.	Group.	Remark.	No. of Pls.	Plate Number.	No. of Dispersions.
				h. m.	° ′					
4015	Pegasus	ο 43	4436	22 37.0	+28 48	VIII.*a*	62	1	1646	1
4020	Pegasus	η 44	4741	38.3	+29 42	XIV.*a*	97	1	1646	1
4024	Pegasus	ξ 46	4875	41.6	+11 40	XII.*a*	—	1	1370	1
4026	Pegasus	λ 47	*4709*	41.7	+23 3	XV.*a*	—	2	2103,2117	1
4031	Aquarius	τ 71	6354	44.3	−14 7	XVI.*a*	—	2	786, 828	1
4034	Pegasus	μ 48	*4615*	45.2	+24 5	XV.*a*	184	1	1362	1
4037	Cepheus	ι 32	1814	46.1	+65 41	XV.*a*	119	1	1392	1
4040	Aquarius	λ 73	5968	47.4	− 8 7	XVII.*a*	2	3	776,1411,3070	1
4047	Aquarius	δ 76	6173	49.3	−16 21	IX.*a*, *b*	32,177	2	2965,3067	1
4057	Pisc. Aus.	α 24	19370	52.1	−30 9	IX.*ab*	177	6	663,1542,1546,2027	4,2,1
4073	Androm.	ο 1	4664	57.3	+41 47	V.*C.*	156	7	2481,2901,2916,2930	2,1
4076	Androm.	2	*4665*	58.0	+42 13	IX.*a*, *b*	178	6	2481,2901,2916,5956	2,1
—	Cassiop.	—	2629	58.3	+59 18	IV.*a*, *b*	20	1	1668	1
4078	Pegasus	β 53	4480	58.9	+27 32	XVIII.*a*	2	3	769,1552,2228	4,3,1
4080	Pegasus	α 54	4926	59.8	+14 40	VIII.*b*	32,64	6	629,1366,1502,6030	4,2
4086	Cassiop.	1	2545	23 2.4	+58 53	II.*a*, *b*	10	1	1668	1
—	Cassiop.	—	*2546*	3.0	+59 13	IV.*a*, *b*	—	1	1668	1
4093	Aquarius	c^2 88	6368	4.1	−21 43	XV.*a*	—	1	1365	1
4099	Cassiop.	2	2552	5.4	+58 47	IX.*a*, *b*	177	1	1668	1
4104	Androm.	7	3964	8.0	+48 51	XI.*a*, *b*	182	1	2923	1
4114	Pisces	γ 6	4648	12.0	+ 2 44	XV.*a*	32,184	1	1635	1
4120	Androm.	8	3991	13.1	+48 28	XVIII.*a*	65	1	2923	1
4139	Aquarius	b^1 98	6587	17.7	−20 39	XV.*a*	—	1	1598	1
4145	Aquarius	b^2 99	6420	20.8	−21 12	XVI.*a*	—	1	1598	1
4153	Cassiop.	—	2748	25.4	+57 59	IV.*b*	—	4	861,3857,3873,6906	2,1
4174	Androm.	λ 16	4283	32.6	+45 56	XV.*a*	112,184	1	1636	1
4182	Cepheus	γ 35	*928*	35.2	+77 4	XV.*a*	185	1	840	1
4198	Pisces	19	4709	41.3	+ 2 56	XXI.	137	4	1591,2122,2208,2210	1
4217	Pegasus	φ 81	5231	47.4	+18 34	XVIII.*a*	—	1	3007	1
4224	Cassiop.	ρ 7	3111	49.4	+56 57	XIII.*c*	—	2	2396,6992	1
—	Cassiop.	—	3115	50.5	+56 53	II.*P.*	14	2	2396,6992	1
4234	Cassiop.	R	4202	53.4	+50 50	XX.*a*	133	2	2206,2207	1
4238	Pisces	ω 28	5227	54.2	+ 6 18	XII.*a*	—	1	1415	1
4247	Pisces	30	6345	56.8	− 6 35	XVIII.*a*	—	1	3071	1

Table XIII., as stated on page 106, gives for each star in Table XII., whose spectrum was examined on more than four plates, the number taken from the Harvard Photometry, and the numbers designating the additional plates. When a star does not occur in that catalogue, it is readily identified by referring to Table XII.

According to Flamsteed the stars H. P. 155, 2595, 2601, 2849, and 2852 are in the constellations Ursæ Minor, Libra, Libra, Ophiuchus, and Ophiuchus respectively.

TABLE XIII.

ADDITIONAL PLATE NUMBERS.

Star.	Plate Number.	Star.	Plate Number.	Star.	Plate Number.
5	2097,2102,5094,5104,6201	936	1800,3016,3052,3104,4016,	*1823*	5526
9	5101,5170,6206,6271		4035,6106,6156	1923	5484
94	5192,6045,6124,6272	979	6508,6565	1949	1944,2359,2523,5497,6491,
142	2227,2294,4350,4376,5125,	978	5147		6629
	5189	1023	1688	1951	6523,6562
185	1373,2217,3081,5108,5232,	1024	1688	1965	6749
	5241,6031,6303	1026	1688	2025	6427,6459,6492,6532
213	2446,5145,5151	1029	6381	2036	5514
324	5166,5217,5254,6261,6498,	*1045*	6434,6616	2124	5202,5290,5271,5400,5491
	6509	1068	6084	2135	4791,4808,4821,4877,4891,
333	5184,6203	1091	1493,1504,1675,2201,6395,		4908,4927,4971,4988,5009,
336	6182,6231		6423,6566		5021,5038,5043,5047,5271,
356	6402	1100	2280,2302,2303,2349,2411,		5290,5342,5400,5422,5466,
361	6402		3250,3274,3282,3289,4396		5539,5548,5592,5600,5603
370	1419,1420,1432,1441,1452,	1104	6314,6401,6444,6457,6473,	2141	4656,5202,5271,5290,5400
	1480,1522,1572,1614,2123,		6628	2191	2849,3742,4836,4841,6475,
	2839,2852	1160	3105		6514,6569,6623
445	7020,7037	1201	6382,6424,6584	2263	516, 523, 550,1205,2611,
482	5248,6193	*1220*	4306,4347,4379,4461,4479,		2705,2710,2717,2721,2729,
489	2218		4512		3709,3719,6460,6493,6570
496	783, 784, 966, 973, 974,	1249	6400,6437,6474	*2264*	1748,2285,2287,2291,3712,
	1049,1050,1051,1060,1061,	1256	755,4307,4397,4454,4470,		6000
	1069		4506,4531	2267	4594,6000,6631,6668
516	4505,5161,5239,5381,5385,	1275	1708,1728,1775,3074,6092,	2338	6515
	5430,5464,5496,6118,6321,		6302	2381	6191,6213
	6405,6520	1295	3195,3206	2400	1200,1201,1241,1248,1259,
541	2257,5207,5257,6208	1311	834		1810,2650,6494,6563,6886
550	6408,6461,6564	1325	6488	2436	6621
551	6081,6194	1350	2596,4568,5421,6308,6425	2467	1273,1998,6625,6773,6798
554	6397,6408,6564	1399	6489,6513	2468	6785
555	5257,6254	*1423*	5285	2480	3714
578	4394,4453,4478	1442	5399,6309	2500	6842
665	6273	1459	5289,6256	2506	2794,6778,6789
797	1535,1584,1600,1673,1698,	—	3121,5129,5133	2510	1568
	2187,5258,6034,6195,6306	—	2534,5129,5133	2566	2680
862	6204,6217	1588	6468,6522,6679	2572	6859
877	2416,4564	1636	6295	2594	6622,6801
879	2527,6495,6500,6511,6524	1645	5427,6147,6619,6680	2625	6731,6732
—	6511,6524	1676	6641	2627	6642
896	6495,6500	1698	2597,5431	2638	2831,6804,6848
932	1440,2229,2237,2241,2343,	1797	500, 515,1110,1268,2528,	2645	2749,2788,2927
	4194,5256,6076,6190		5465,6359,6385,6390	2671	6818

Star.	Plate Number.	Star.	Plate Number.	Star.	Plate Number.
2690	6779	3260	3043,3060,5981,6861	3739	2803
2713	6872	3321	6918	3747	4345,4366,4924,4933,4992,
2764	1275,1278,2642,2772,2825	3419	2725,2727		5001,5007,5018,5027,5031,
2787	6741	3421	2928		5040,5045,5051,5058,5060,
2844	6805,6860	3424	2894,2928		5077,5080,5100,5103,5144,
2868	6829	3429	584, 655,1485,1946,1974,		5150
2879	3797,3897,4587		1983,2292,5995,6049	3750	6991,6993,6994
2880	6126,6226	3434	6354,6387	3836	6028,6166,6931
2944	6739,6776	3436	1430,1445,1446,1451,1471	3845	3080
3009	6751,6802,6843	3515	6915	3950	6228
3048	3027,5886	3527	2144	3960	4979,5023,5042,5046,5053,
3120	6197,6227,6259	3528	2039,2144		5067,5164,5187
3147	790,1494,2810	3541	2039,2144	3987	5972,6063,6088
3193	3772,3777,3786,3793,3796,	3547	4923,5006,5022,5032,5168	4013	5722,5988
	3839,3872,4862,4928,4932,	3564	2678,5889	4057	2941,5982
	4950,4964,4970	3624	6041,6174	4073	5956,6053,6074
3199	5858	3631	1511,1533,1984,4837,5929,	4076	6053,6074
3232	6059		6042	4080	6141,6167
3259	6108,6844	3647	6021,6889		

SUPPLEMENTARY NOTES.

1. Since the recent discovery of helium, the principal lines of that element have been identified by Vogel with lines in the spectra of stars of the Orion type. (Astrophysical Journal, Vol. II., page 333.) Table XIV. contains a comparison of the lines of helium with those already found in this investigation in the first six groups of stars of the Orion type, and in five of the principal stars of the same type but having bright lines in their spectra. The first and second columns give the wave length and intensity of helium lines as published by Runge and Paschen. (Astrophysical Journal, Vol. III., page 4.) All the helium lines are included whose wave lengths are between 3540 and 5050, and whose intensity is one or more, and also four of less intensity with which Orion lines appear to coincide. The series to which each line belongs is indicated by letters in the third column. The principal series of helium, the two subordinate series, and the three corresponding series of parhelium, are indicated by the letters a, b, c, d, e, and f, respectively. The fourth, sixth, and seventh columns are, with the exceptions mentioned below, copied from the second, fourth, and sixth columns respectively of Table IV. of this volume. The lines 3546, 3613, and 5045 have been subsequently determined by interpolation, although two of them, 3613 and 5045,

TABLE XIV.

HELIUM AND ORION LINES.

Helium.			Orion Lines.								
λ	Int.	Ser.	λ	I.	II.	III.	IV.	V.	VI.	Div. *c*.	γ φ π β P
3554.59	1	b	3546	.	.	.	3	.	.		
3587.43	2	b	3584	.	6	.	6	.	.		
3613.78	3	d	3613	.	3	.	3	.	.		
3634.39	2	b	3634	.	6	.	6	.	0		
3652.12	1	c	. . . .	.	0	.	0	.	0		
3705.15	3	b	3705	.	.	.	.	.	.		
3733.00	1	c	. . . .	.	.	.	.	.	.		
3785.03	<1	e	3784.6	p	1	1	1	0	0	. .	
3805.90	<1	e	3805.1	0	1	2	3	0	0	. . .	
3819.75	4	b	3819.2	p	10	13	13	6	3	. . . . .	. . . : :
3867.61	2	c	3867.6	p	1	1	2	1	1	. . .	.
3871.95	<1	e	3872.4	0	0	1	2	1	1	. .	
3878.33	<1	f	3876.4	0	0	1	1	0	0		
3888.78	10	a	3889	.	.	.	.	.	.		: :
3926.68	1	e	3927.1	0	1	1	4	2	0	. . .	. . . .
3964.88	4	d	3964.6	0	2	3	4	0	0	. . .	. .
4009.42	1	e	4009.5	w	2	6	7	3	1	. . . .	. . . . .
4026.34	5	b	4026.4	p	10	12	12	6	5	. . . . .	. . . : :
4120.97	3	c	4120.5	w	3	7	4	2	2	. . . . .	. . . : :
4143.92	2	e	4144.0	w	3	7	8	4	2	. . . . .	. . . : .
4169.13	1	f	4169.2	0	0	1	2	0	0	. .	
4388.10	3	e	4387.8	w	3	7	8	4	1	. . . .	. . . : .
4437.72	1	f	4437.9	0	0	1	2	0	0	. . .	
4471.65	6	b	4471.8	p	10	11	12	5	4	. . . . .	. . . : :
4713.25	3	c	4712.8	p	2	2	2	1	1	. . .	. . . : :
4922.10	4	e	4925.7	p	4	6	6	3	1	. . . .	: : :
5015.73	6	d	5023	.	1	1	1	.	1	. . . .	: : :
5047.82	2	f	5045	.	1	?	1	.	.		:

had been previously recorded as faint lines. The wave lengths of the helium lines 3705.15 and 3888.78, the former always and the latter generally inseparable from the lines of hydrogen, have not been independently determined. The lines of helium present in Group I., Division *b*, are given in the fifth column. As no numerical estimates were made of the intensities of lines in Division *b*, the letter p has been used to indicate that a line is present with approximately the same intensity as in Group II., Division *a*, w to denote that it is weaker, and a zero that it is absent. The material for this column is that given in the first vertical row of the fifth column of Table IV., as modified by statements in regard to the comparative intensity of these lines found in the descriptions of Groups I. and II., pages 15 and 16 of this volume. The presence of helium lines in the first five stars of Table XI., γ Cassiopeiæ, ϕ Persei, π Aquarii, β Lyræ, and P Cygni, is indicated by dots in the last column of the table. When the lines are accompanied by bright bands, a colon is substituted for a dot. In γ Cassiopeiæ fine bright bands are suspected, lying centrally upon the dark Orion lines 4026.4, 4387.8, and 4144.0, and possibly on 4471.8 and 4009.5.

From this table it appears that, with the exception of 3652.12, which is not very intense and occurs in a part of the spectrum photographed with difficulty, and of 3733.00, which is concealed by the hydrogen line Hλ, all the lines of helium and parhelium having intensity 1 or greater, are represented in Orion type stars.

In the case of the Orion lines 3546, 3584, 3876.4, 4925.7, 5023, and 5045, the agreement is doubtful. With the exception, however, of 3876.4, the wave lengths of these lines could not be obtained with accuracy, since they lie near the limits of the photographic spectrum where no standard lines of reference are to be found. Hence it appears probable that they may be lines of helium, notwithstanding the discordance.

It further appears that all the series of both helium and parhelium are represented, and that nearly all the lines of the first subordinate series of both helium and parhelium, as well as some lines of other series, reach a maximum intensity in Group IV., are very strong in Group III., and fall off more rapidly from this maximum toward the first type stars (Group VII.) than toward the beginning of the series. This fact, when the more precise behavior of the spectrum of helium under varying conditions of temperature and pressure has been investigated, may furnish a clue to the physical condition of the atmospheres of these stars. The coincidence, at the same point in the series of stellar spectra, of the disappearance of these helium lines with the earliest appearance of solar lines, is in this connection a fact of much interest.

An important exception to the above mentioned rule for the maxima of lines of the two first subordinate series is found in line 3705.15. The presence of this line in combination with Hξ, λ 3704.0, is inferred from the unusually great intensity of the latter line, which is the last line of hydrogen appearing in photographs of stars of the first four groups. In the first three groups the intensity of Hξ is decidedly greater than that of Hν and Hμ; in the fourth, it exceeds the first of these lines only, while in the fifth and sixth it falls below both. Since it is the rule that at the close of the hydrogen spectrum each successive line of shorter wave length diminishes in intensity, it is inferred that the helium line 3705.15 is here combined with Hξ, 3704.0; that it is strong in the first three groups, declines in the fourth, and is absent in the later groups of the series.

The distribution of helium lines in stars of Division *b* is essentially the same as in those of Division *a*, except that the prominent line of the principal series of parhelium, 3964.88, the only line of this series commonly included in the photographic spectra, is generally absent in stars of Division *b*. It was, however, found in stars of Group III. of this Division. As is the case with stellar lines in general, the fainter lines of helium may become invisible in Division *b*, owing to the haziness of the spectra.

In Division *c* the relative intensity of the helium lines to one another does not differ appreciably from that found in Division *a*, except in the case of line 3805.90, where it is greater in Division *c*. The helium lines as a whole, however, are more clear and conspicuous in Division *c*, and are far more persistent. They commonly remain present in from one to three groups beyond that in which they disappear in Division *a*. This may be seen from the seventh column of Table XIV., and from the added statement that the lines 4471.65 and 3819.75 are present in Group VIII., Division *c*. This greater persistence of the lines of helium, in connection with the greater intensity of calcium lines and the marked narrowness of the lines of hydrogen characterizing Division *c*, may some day furnish a clue to the difference of physical conditions in stars of Divisions *a* and *c*. It will further be seen that most of the stronger lines of both helium and parhelium were present in all five of the stars having bright lines in their spectra, though the lines of the second subordinate series of parhelium in the region having wave length shorter than 4860 were, perhaps owing to faintness, not seen in any of the five. The only line of the principal series of parhelium lying in the same region, 3964.88, was not seen in the first three stars, and the only line of the principal series of helium found in the entire photographic spectrum 3888.78 was undetermined in the first three, owing, as in the case of the normal stars, to its coincidence with Hζ.

The aspect of these two lines of the principal spectra of helium and parhelium in β Lyræ and P Cygni is singular, and worthy of consideration. In β Lyræ, at the time of second maximum, when the two component spectra are most widely separated, a strong line, recorded as the "displaced Hζ," is seen lying far to the violet of the true Hζ of hydrogen, being widely separated from it even under the dispersion of a single prism. (See page 103.) Though there is little doubt that this line belongs to the component of β Lyræ, whose lines at this period lie toward the violet, yet the wide separation observed could not be chiefly due to the separation of the component spectra, since this was only made visible by twice the dispersion, no other lines beside Hζ appearing double in plates taken with a single prism. Nor could the separation be perceptibly increased by the difference in wave length

0.23 ten-millionths of a millimeter between the hydrogen and helium lines, much greater differences being altogether imperceptible with one prism. It therefore appears probable that the displacement of the helium line is real. This opinion is confirmed by the fact that an apparent displacement of Hζ was recorded in P Cygni, although in that star the spectral lines do not become double. In P Cygni, as in β Lyræ, the line Hζ is accompanied by a strong bright band, and it can hardly be doubted that the marked reversal is in part, and the observed displacement wholly, due to the helium line in question. The wave length of the other line, 3964.88, appeared to be so much diminished that its identification was doubted. This line, though having greater intensity than in the normal stars of Orion type, is not reversed in either β Lyræ or P Cygni. A marked decrease in the intensity of this line during the change of phase of β Lyræ from principal to secondary minimum is, however, recorded in a previous study of this star. The line 3888.78 is in both P Cygni and β Lyræ accompanied by a very conspicuous bright band. This however, in P Cygni at least, is probably due in part to a bright band accompanying Hζ, with which the helium line is combined.

It will further be seen from the table that in β Lyræ and P Cygni most of the helium lines are accompanied by bright bands. These are for the most part quite conspicuous, and constitute with those of hydrogen the majority of bright bands present in these stars. These bands in P Cygni lie on the side of greater wave length of the dark lines, while in β Lyræ their position varies with the phases of the star. In P Cygni no reversal has been detected in the lines of the first subordinate series of parhelium having wave length shorter than 4860.

In γ Cassiopeiæ the reversal is not marked except in lines having wave length greater than 4860. A partial reversal is however, as previously stated, suspected in the lines 4026.34, 4388.10, 4143.92, and perhaps also in 4471.65 and 4009.42. These lines under the dispersion of four prisms appear very wide and hazy, and indistinctly double. This appearance, if confirmed, would indicate the presence of fine central bright lines similar to the central bright bands on the lines of hydrogen, but of less width and intensity. The reversal clearly seen in the helium lines 5015.73 and 5047.82 in γ Cassiopeiæ, and the well known reversal of D_3, render such additional reversals probable.

The stars ϕ Persei and π Aquarii, owing to their faintness, could not be photographed under sufficient dispersion to render visible such fine bright central bands, but the line 4922.10 appeared with a bright border in the first of these stars.

2. As regards the line 4144.0 mentioned in the text as possibly common to the Orion and solar systems of stellar lines, it may here be said that, since the line

found in Orion type stars is without doubt identical with the helium line 4143.92, it is evidently not solar, but is at some point in the series, perhaps in Group VII., replaced by the lines of the solar band within which it falls.

3. In connection with stars of the Orion type having bright lines it may be added that all the stars in Table XI. have been found by Campbell to have Hα bright, and that in his opinion this line is bright in all stars having the line Hβ bright. (Astrophysical Journal, II. 177.) It is also a matter of interest that as the bright Hα was found to have greater intensity than Hβ, the intensity of the bright lines in the spectrum of hydrogen in these stars diminishes in each successive line of shorter wave length. The contrast between this relation found in stars of the Orion type, where hydrogen emission lines occur, and that found in long period variables of Type III., like *o* Ceti, where the maximum intensity lies in the bright Hδ declining in either direction, is interesting in connection with the discovery made by Professor J. J. Thomson, that when hydrogen is negatively electrified Hα is brighter than Hβ, while when it is positively electrified the relative intensities are reversed. (Proc. Roy. Soc., Vol. LVIII. No. 350.)

The star η Tauri, which in this classification has been taken as the typical star of Group V., Division *a*, by Campbell's discovery that Hα is bright, is removed to the class of stars in Table XI. of Orion type having bright lines.

4. In connection with Remark 166, page 102, on β Lyræ, it is interesting to note that the spectrum of this star at the time when the dark lines become widely double has been resolved by Lockyer into two component spectra, one of which resembles that of β Orionis, the other that of γ Orionis. This result agrees nearly with that independently arrived at here (see Remark 166), that one of the component spectra is of Group VII., Division *c*, approaching Group VI., Division *c*, the other of Group IV. In the present classification β Orionis is of Group VI., Division *c*, and γ Orionis of Group IV., Division *a*. (Monthly Notices, Vol. LV. p. 250.)

5. The double reversals observed in the hydrogen lines of γ Cassiopeiæ, ϕ Persei, (see Remarks 162, 163,) and other stars of the Orion type having bright lines, and the hazily triple character of the dark lines when the emission bands are faint, are facts of interest in connection with Jewell's discovery of complex reversals in lines of the solar spectrum, and his theory in regard to them. (See Astrophysical Journal, Vol. III. p. 89.) The dark borders found on the edge of greater wave length of the bright bands of P Cygni in photographs where the dispersion used was not sufficient to obliterate them by loss of contrast, and the similar border sometimes seen on the line Hβ of β Lyræ, and perhaps also the anomalous lines accompany-

ing Hδ and Hε in υ Sagittarii, are phenomena of the same order. (See Remarks 165, 166, 167.) The temporary disappearance of a line 3719.801 in the solar spectrum observed by Jewell may further be mentioned in connection with similar phenomena described in the remarks on various Orion type stars having bright lines. The occasional obliteration of the line Hγ in one of the components of the double spectrum of β Lyræ, and the total absence of Hβ in one photograph of υ Sagittarii, are instances in question. The indistinctness or invisibility of one or other component of certain of the triple lines of hydrogen in 11 Monocerotis and κ Draconis (see Remarks 170, 171), and the absence in γ Cassiopeiæ and φ Persei of the component of shortest wave length of the line Hκ (see Remarks 162, 163), while all the neighboring lines of hydrogen are triple, are further facts of which the explanation is as yet not clear, but which must have an important bearing on questions of molecular physics.

6. The star ζ Cephei should be inserted on page 90 in Group XV., Division *a*, with the Remarks 2 and 185.

7. A recent photograph of ν Hydræ, H. P. 1893, classified in the Tables as of Group XVII., shows it to be a star of Group XV., Division *a*, resembling α Cassiopeiæ. See Remark 125, page 98.

END OF VOLUME XXVIII., PART I.