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General brief items.

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Multiplet Theory.

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The Intensities of Lines in Multiplets.

I Theory.

H.N. Russell Proc N.A.S. 11, 314, 1925

1. Notation for any spectroscopic term.

	Laudé	Sommerfeld
System. Def. by max. no of components of any term of system	2R	$2j_s+1$
Series " " " " " of any term of series	2K	$2j_a+1$
Component ... No. of components into which any level is divided by E. (of a mult. term)	$2\overline{J}$	$2j+1$

Values

$2R = 1, 2, 3$, for singlet, doublet, triplet systems

$2K = 1, 3, 5, 7$, for S, P, D, F terms, $\therefore K = k - \frac{1}{2}$ where k is ordinary azimuthal quantum number.

$J = j$ (inner quantum number) for systems of even multiplicity

$= j + \frac{1}{2}$ for systems of odd multiplicity.

When $K > R$, $\overline{J}$ ranges by steps of a unit from $(K - R + \frac{1}{2})$ to $(K + R - \frac{1}{2})$, and the "permanent" number of components $2R$ occurs.

If $K < R$, $\overline{J}$ ranges from $R - K + \frac{1}{2}$ to $R + K - \frac{1}{2}$, and there are $2K$ components ("smaller" multiplicity)

Under ord. conditions, spectral lines corr. to transitions for which $\Delta \overline{J} = 0$ or ± 1

$\Delta R = 0$, or ± 1 for intersystem combinations.

ΔK runs from ± 1 in the simplest spectra, zero in more complex spectra, an occasionally ± 2. (Few faint lines of Ti or Fe+ where $\Delta K = \pm 3$)

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Multiplet involving terms of same system ($\Delta R = 0$), where $K_1 + K_2 = 2K$. Three principal types of structure, illustrated from quintet system.

Ordinary

$\Delta K = 1$ $\quad K > R$

$2K_1 = 5$ $\quad 2K_2 = 7$ (DF)

$2J$	11	9	7	5	3
9	x_4	y_3	z_2		
7		x_2	y_1	z_0	
5			x_0	y_{-1}	z_{-2}
3				x_{-2}	y_{-3}
1					x_{-4}

Rhombord

$\Delta K = 1$ $\quad K < R$

$2K = 3$ $\quad 2K_2 = 5$ (PD)

$2J$	9	7	5	3	1
7	x_3	y_2	z_1		
5		x_1	y_0	z_{-1}	
3			x_{-1}	y_{-2}	z_{-3}

Symmetrical

$\Delta K = 0$

$2K_1 = 2K_2 = 7$ (FF')

$2J$	11	9	7	5	3
11	x_4	y_3			
9	y_3	x_2	y_1		
7		y_1	x_0	y_{-1}	
5			y_{-1}	x_{-2}	y_{-3}
3				y_{-3}	x_{-4}

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"Rhomboid" groups corr. to ~~groups~~ terms of smaller mult.
"Ordinary" multiplets " " " ordinary "
"Symmetrical" " are same in both cases.

Where $K = R$, a special case, for which $J_1 + J_2$ term with smallest value is absent. When $2R$ is even this happens: one term has only $2R-1$ components. When $2R$ is odd, both values of j are zero, and the line is excluded by Laude's "Zusatzregel".

Let intensities of various lines be rep. by x, y, z as above. Subscripts are values of l, defined by

$l = J_1 - K_1 + J_2 - K_2 = J_1 + J_2 - 2K$ (when $K > R$)
$l = J_1 + J_2 - 2R$ (when $R > K$)

2. Qualitative Rules for Intensity

Empirical rules, from observational data.

a. The leading x (one with greatest value of l) is always the strongest line in the multiplet, and the following x's decrease steadily in intensity.
b. The y's are strongest near the middle of the sequence
c. The leading z (if z's present) is the weakest line in the multiplet
d. When $K > R$, the y's average much fainter than the x's, and the z's than the y's (Sommerfeld's rule) These ratios decrease as K/R increases; and y/x is nearly the same, for symmetrical multiplets, as for the adjacent ordinary ones.
e. When $K > R$, the fall of the x's is most conspicuous when $K - R$ is small. When $K - R = 0$ the last x is

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absent, and when K-R=1 it is usually fainter than the adjacent y's. The increase in intensity along the y's is relatively small.

(f) In rhomboid groups the values of y increase rapidly, and the last line is often strong.

(g) In symmetrical groups, when K<R, the later values of x are small, & next to last line is often almost or quite absent. (Meggers)

(h) When ΔK=1 the values of y are substantially equal for lines equidistant from the two ends, but when ΔK=0 the later lines are fainter, especially when K=R

3 Quantitative Rules for Intensity

Sum-rule.

The sum of the intensities of the lines which have a given initial or final level in common is proportional to the statistical weight of this level.

Otherwise: The sum of the intensities in any row or column of corr. values of 2J. (This rule will only determine intensities where R=2 and ΔK=1)

Zero rule. We assume that the intensities are expressible by gen. formulae which satisfy the sum rule algebraically for all values of J, K, R.

Correspondence principle in addition, where K or R great, suffices for almost complete solution.

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To satisfy the sum-rule, sum of each column must be of the form

$$C\,\overline{J}_1\,\Sigma\,\overline{J}_2$$

and that of each row

$$C\,\overline{J}_2\,\Sigma\,\overline{J}_1$$

For every term of permanent or smaller multiplicity

$$\Sigma J_1 = 4RK_1$$

$\therefore$ sum S of intensities for whole multiplet

$$S = 16\,C R^2 K_1 K_2$$
$$= 16\,C R^2 K^2 \quad \text{for symmetrical}$$
$$= 4\,C R^2 (4K^2-1) \quad \text{for ord. or rhomboid}$$

Set $C = 4K^2-1$ in first case, $C = 4K^2$ in second,

then $S = 16R^2K^2(4K^2-1)$ (1)

which suffices for all groups

4 Ordinary Multiplets

Sum-rule gives

$$\begin{aligned} x_l + y_{l+1} + z_{l+2} &= 8RK^2(2K-1)(2K+1+l) \\ x_l + y_{l-1} + z_{l-2} &= 8RK^2(2K+1)(2K-1+l) \end{aligned} \quad (2)$$

whence it follows that

$$y_{l-1} + z_l + z_{l-2} = y_{l+1} + z_{l+2} + z_l + 16RK^2 l \quad (3)$$

The last physically real values of x correspond to

$$l = \pm(2R-1),$$

for y, $l = \pm(2R-2)$

for z, $l = \pm(2R-3)$

from sum rule: $y = 0$ when $l = \pm 2R$,

$z = 0$ when $l = \pm(2R-1)$ or $\pm(2R+1)$

Hence from (3) $y_l + z_{l+1} + z_{l-1} = 4RK^2(4R^2 - l^2)$ (4)

" from (2) $x_l - z_l = 4RK^2(8K^2 + 4Kl - 4R^2 + l^2 - 1)$ (5)

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From the zeo rule

$$z = \psi(l)\{(2R+1)^2 - l^2\}\{(2R-1)^2 - l^2\} \qquad (6)$$

without defining ψ

We now apply the correspondence principle in detail. From Sommerfeld + Heisenberg

$$x : y : z = (1+\cos\theta)^2 : 2(1-\cos^2\theta) : (1-\cos\theta)^2 \qquad (7)$$

where θ is the $\angle$ bet the vectors rep. the L^2 mom^a of the "light electron" and the whole atom.

From Sommerfeld's vector model

$$\cos\theta = \frac{j^2 + j_a^2 - j_s^2}{2jj_a}$$

From Lande's ditto

$$\cos\theta = \frac{J^2 + K^2 - R^2}{2JK} \qquad (8)$$

From S^{ps}, Ornstein + Burger Haiu similar equation to (4).

From Landé we get

$$\begin{aligned} x &= C\{(J+K)^2 - R^2\}^2 \\ y &= 2C\{(J+K)^2 - R^2\}\{R^2 - (J-K)^2\} \\ z &= C\{R^2 - (J-K)^2\}^2 \\ x+y+z &= 16\,C\,J^2K^2 \end{aligned} \qquad (9)$$

C may be determined by setting $x+y+z$ equal to the values given by the sum rule, taking the mean of equations (2), or setting the sum for the whole multiplet equal to (1)

For J we take $\frac{1}{2}(J_1 + J_2)$

from (9) and (2) then

$$C = 2R\{1 - (2Kl + l^2 + 1)/(2K+l)^2\}$$

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Whence

$$x = R(32K^4 + 16K^3l - 16K^2R^2 + 4K^2l^2 - 8K^2 + 2R^4 - R^2l^2 + \tfrac{1}{8}l^4 + 2)$$

$$y = R(4K^2 - R^2 + \tfrac{1}{4}l^2 + 1)(4R^2 - l^2) \qquad (10)$$

$$z = \tfrac{1}{8}R\left\{1 - \frac{l}{2K+l}\right\}(4R^2 - l^2)^2$$

which satisfy (4) and (5) almost exactly.
Laude's vector model suggested

For z, from (6) and (10)

$$z = \tfrac{1}{8}R\left(1 - \frac{l}{2K+l}\right)\{(4R^2 - l^2 - 1)^2 - 4l^2\} \qquad (11)$$

From (4)

$$y = R\{4K^2 - (R^2 + \tfrac{1}{4}l^2 + 1)\}(4R^2 - l^2) + \ldots\ldots$$

In computation
z is best found from (11) x and y from (3) + (4)

Ornstein + Burger give for z's

$$J_{+1} = \frac{i\{j_s(j_s+1) - (k-j)(k-j+1)\}^2}{4j(j+1)}$$

where j is the larger of the two inner quantum numbers, k the smaller of the two azimuth quantum numbers.
In our n^2 this is

$$z = \frac{RK^2\{4R^2 - (l-1)^2\}^2}{2(2K+l)(2K+l+2)}$$

This is zero when $l = (2R+1)$ or $(1-2R)$, but not when $l = (2R-1)$ or $(-1-2R)$. A disadvantage.

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5. Rhomboid Multiplets

When $R > K$ we have (sum-rule)

$$\begin{aligned} x_l + y_{l+1} + z_{l+2} &= 8RK^2(2K-1)(2R+1+l) \\ x_l + y_{l-1} + z_{l-2} &= 8RK^2(2K+1)(2R-1+l) \end{aligned} \qquad (12)$$

Zero rule indicates roots of intensity function when (for x) $l = -2K \pm 1$

(for y) $l = \pm K$

(for z) $l = 2K \pm 1$

Setting

$$\begin{aligned} x_l &= A(l+2K+1)(l+2K-1) \\ y_l &= B(4K^2 - l^2) \\ z_l &= C(l+2K+1)(l-2K-1) \end{aligned}$$

we find ~~that~~ if

$$\begin{aligned} A &= 2KR(R+K) \\ B &= 4KR^2 \\ C &= 2KR(R-K) \end{aligned}$$

the equations (12) are identically satisfied.

$$\begin{aligned} x_l &= u_l + 2KR(R+K)(l+2K+1)(l+2K-1) \\ y_l &= 4KR^2(4K^2 - l^2) - (u_{l-1} + u_{l+1}) \\ z_l &= u_l + 2KR(R-K)(l-2K+1)(l-2K-1) \\ u_l &= \tfrac{1}{8}K\left(1 - \frac{l}{2R+1}\right)\left\{(4K^2 - l^2 - 1)^2 - 4l^2\right\} \end{aligned} \qquad (13)$$

When K neg. comps. with R, These corr. to Hönl's equations.

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From the correspondence principle, when $J = R + \frac{1}{2}l$

$$x = C(4R + 2K + l)^2(2K + l)^2$$
$$y = 2C\{(4R+l)^2 - 4K^2\}(4K^2 - l^2)$$
$$z = C(4R - 2K + l)^2(2K - l)^2$$
$$x + y + z = 64\, CK^2(2R + l)^2$$

Comparing this with mean of (12) this shows

$$C = \frac{RK}{8R+4l} - \frac{R}{8(2R+l)^2}$$

Dropping the second term in the previous expression for legitimate reasons

$$x = \{2RK(R+K) + \tfrac{1}{8}K(2K-l)^2\}(2K+l)^2$$
$$y = \{4KR^2 - \tfrac{1}{4}K(4K^2 - l^2)\}(4K^2 - l^2)$$
$$z = \{2RK(R-K) + \tfrac{1}{8}K(2K+l)^2\}(2K-l)^2$$

6 Symmetrical multiplets

When $K > R$, from the sum rule

$$y_{l-1} + x_l + y_{l+1} = 4RK(4K^2 - 1)(2K + l) \qquad (15)$$

The number of equations is halved, by symmetry. The zero rule gives

$$y_l = \psi(l)(4R^2 - l^2)$$

From the correspondence principle $2y : x = \sin^2\theta : \cos^2\theta$ whence

$$x = C(J^2 + K^2 - R^2)^2$$
$$2y = C\{4K^2R^2 - (J^2 - K^2 - R^2)\}$$
$$x + 2y = 4CJ^2K^2$$

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Here $J = K + \frac{1}{2}l$, whence

$$c = \frac{4R(4K^2-1)}{K(2K+l)}$$

$$y = \tfrac{1}{2}R(4K^2-1)\left\{2 - \frac{(4R^2-l^2)}{4K(2K+l)}\right\}(4R^2-l^2)$$

which will be correct as regards terms of highest degree in R, K, l; terms in lower powers will need correction.

When $R > K$, from the sum rule

$$y_{l-1} + x_l + y_{l+1} = 4RK(4K^2-1)(2R+l) \qquad (16)$$

from the zero rule;

$$y = \psi(l)(4K^2-l^2)$$

from the cor. principle, with $J = R + \frac{1}{2}l$

$$c = \frac{4R(4K^2-1)}{K(2R+l)}$$

$$y = c(4K^2-l^2)(R^2 + \tfrac{1}{2}Rl - \tfrac{1}{4}K^2 + \tfrac{1}{16}l^2)$$

K fixed, $R \to \infty$, giving into approaching those of the Zeemann pattern, gives $c = 4K$ for R great.

To obtain this limiting value set $4K^2$ for $4K^2-1$ whence $c = \frac{8RK}{2R+l}$

$$y_l = 2RK\left(2R - \frac{4K^2-l^2}{4(2R+l)}\right)(4K^2-l^2)$$

Making same correction when $K > R$

$$y_l = 2RK\left(2K - \frac{4R^2-l^2}{4(2K+l)}\right)(4R^2-l^2) \qquad (18)$$

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General solution, from (15), (16), (17), (18)

$$y_l = \tfrac{1}{2}K^2(6K+l)(4K^2-l^2)$$

$$x_l = K^2(8K^3 - 2K + (12K^2-1)l + 6Kl^2 + l^3)$$
$$= K^2(l+2K-1)(l+2K)(l+2K+1)$$

For last line of diagonal, $l = 1-2K$, $x = 0$
This line corresponds to a transition between two levels of inner quantum number zero, excluded by Lande's rule.

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Summary of line intensities

Page	8	Cr	Cd	Ca	Fe	Ni	Co	Cu	Ti	Mn
		0	?00	0000N(Fe)	0000N(Ca)					
		0			000?					
		000?			1?					
		000								
		0								
	-11(6)	00								
	9	00		000	000Ni	0	00Cr	1?Ca	000?Ca	00?
		00Co		2Cu?	2?-	000Fe	1?Cr			00?
		1 Co?		0	00N	00	00-			00N?
		2		000Ti?	00-	-2Nd?	2?-			
		00NdFe		0	00NdCr	5d?-				
		3		1-	00-					
					0N-					
					3?-					
					1N-					
					1Nd?					
					00					
					1?					
					2N-					
	0(6)	0			1N					
	10	1?			2?	1	00		1?	000?
		1			4Nd-		000			00?
		1			1-		0?			1
		2			-1 000		1Cr			
		1Co			00		0			
		2-			00Cr		0			
		1			3					
		1 00Fe			4					
		1			2					
	13(11)	4 13			2					

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from Rowland's Table.

0000	000	00	0	1	2	3	4	5	6	higher
Ca, Fe?	Cr?	Cd?	Cr	Fe?						
	Cr	Cr	Cr							
	Fe?		Cr							

Fe, Ni	Cr	Ni	Co? Cr	-, Fe?	Cr	Ni, -
Ca	Cr, Co	Ca	-, Fe	Ca, Cu?	Fe-?	
Ti, Ca	Fe, -	-, Fe	Fe	Cr		
	Fe, -	Ca	Fe?	-, Ni		
	Co, -		-, Ca	-, Co?		
	Cr, Fe		Fe	-, Fe		
	Ni					
	Fe, -					
	Mn?					
	Fe					
	Mn?					
	Mn?					

Mn	Co	Co	Cr	Cr	Fe	Fe
Co	Fe	Co	Cr	Fe	Fe	Fe
Mn	Cr	Co	Cr	Ti		Cr
Fe	Fe		Co	Cr		
			Cr	Fe		
			Fe	Fe		
			Cr			
			Fe			
			Ti			
			Cr			
			Mn			

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	Cr	Cd	Ca	Fe	Ni	Co	Cu	Li	Mn	Mg	Zr	V	Ba	Al
Page 11	2 00 2 2 2 2 8(6)		0	3 3 1 1 10 3 2 2 3 3 4	3 3 3	1Cr. 2 2 2 0 3		4	1 00 1 0000 3 3					
Page 12	0 3 00 6(3)			20 4 4 20 1 3	5 2	0 000 1 1		5 2 20 Fe 4 3	2 1 2 Co 10 Ni		0 00			
Page 13	2 1 3(2)			2 1 2 8 2 1 2 2 3	3	1 3 4 1 3 00	00	0 2 1 2 Fe. 3 3 6 3	1 2 3 1				00	
Page 14	0 00 000 6(3)	00		3 0 4 3 4 1 4 1	5	0 2 00 1 4 0 3		8 1 9 1 1 Fe. Co.	2 3 1	4				5
Page 15	0 000 4(2)			4 1 1 Goo Cu. 4 2 2 Co 3 3 4 mm. 3 Zi. 1 Co. 1 1	2 2 4 3	00 0 000 000 2 2 Fe. 00		1 3 Fe.		1 5		0 3		4 1

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	0000	000	00	0	1	2	3	4	5	6	Higher
Al	Mn		Cr.	Ca.	Fe	Cr.	Fe	Ti			Fe -10
			Mn.	Co.	Co.	Cr.	Fe.	Fe			
					Cr.	Co.	ni				
					Fe	Cr.	Ni				
					Mn	Co.	Fe				
					Mn.	Co	Fe				
						Cr.	Fe				
						Cr.	Co.				
						Fe.	mn				
						Fe.	Ni				
							Mn.				
	Co		Zr.	Co.	Mn.	Mn.	Cr.	Fe	Ti		Fe - 20
			Cr.	Cr.	Co.	Mn.	Ti.	Fe	Ni		Mn, Ni - 10
				Zr.	Co.	Ti.	Co Fe.	Ti.			Ti, Fe. - 20
					Fe.	Ni					Fe - 20
	Cu	Ba.	Cu.	Mn	Fe.	Co	Co			Ti.	Fe. 8
		Co.		Co.	Cr.	Ni.					
				Ti.	Mn.	Mn					
				Fe.	Ti	Ti.					
				Co.	Ti.	Fe	Ti.				
				Mn.	Fe.	Co.					
				Cr.	Fe.	Ti.					
				Fe.	Fe.	Fe.					
					Fe.						
5	Cr.		Cr	Cr.	Fe.	Co.	Fe.	Fe.		Ni.	Ti. 8
			Cl.	Fe.	Fe.	Mn.	Fe.	Fe.		Al.	Ti. 7
			Co.	Co.	Co.		Co.	Fe.			
				Co.	Ti.		Mn.	Co.			
					Ti.			Mg.			
					Ti.						
					Ti. Fe. Co.						
					Mn.						
4	Fe Cu.		Co.	Cr.	Al.	Fe.	Fe	Fe.		Mg.	
1	Cr.			Co.	Mg.	Ni.	Fe.	Al.			
	Co.		Co	Zr.	Fe.	Fe Co.	Fe Ti.	Al.			
	Co.				Fe.	Ni.	Ni	Fe			
					Ti.	Co	V.	Fe Mn			
					Fe Co	Co Fe	Ti Fe	Ni.			
					Fe						
					Fe						

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Page 16.

Cr. Mo Cd Ca. Fe Ni. Co Cu Ti Mn Ba Mg. Zr. V Ca Al

3
1Zr.
2

1 5 1 2 2 Ti. 1 1 1 1 2

2 0 3 ~~00~~

000 000 00 1 2Fe 00 0 0

00 2 00 5V 00 1 00 2Fe. 1

2 3

6(3)

Page. 17.

1. 1 1Zr.
3
4
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3 2 1 1 0 0 5V 0Co 1 1 3Ni 2

1 3 1 00 00 0

1 0 1 00 3

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9(8)

Page 18

3Co.
000

1 1 2 2 2 5Co 2 5Cu 2 1 2

87e. 3 000 0 3

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0 0 1 2

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Page. 19.

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1 1 1 3 Cr. 1 2 1 3 1 1 3Ti. 1 1 2 1 2

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37e. 2 1 0000 000 0 1 0 1 17e.

1 27e. 1 2 5 3

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	0000	000	00	0	1	2	3	4	5	6	Higher.
	Co	Ti.	Co. Cu. Co. Co. Ti. Ti	Ni. Co. Co.	Fe. Co. Cr. Fe. Fe. Fe. Ti. Fe. Fe. Fe. Ti.	Ti Ni. Zr. Co. Fe. Fe. Fe. Ti. Fe. Ti. Fe. Cr.	Ti Cr. Ni. V.		Fe. Ti: V.		
		Co.	Ti Cr Co. Cr.	Zr. Ti. Fe. Fe Zr Fe. Co Zr. Zr. Be Cr. Co. min.	Cr. Ti. Cr. Ti. Ti Fe Co. Fe. Co. Fe. Fe. Be	Fe. Cr. Fe. V	Fe. Cr. Co. Fe, Ni. V Ti.	V. Cr. Cr.	Fe V. V, Fe.		
		Co. Cr.	Ti. Mn.	Zr. Zr Co Ti.	Fe Fe Fe Zr. Fe.	V Fe Fe Fe Fe. Fe. Fe.	Cr. Co Co Co.	Ti,	Fe. Co. Fe. Cu.		Ni. Fe - 8
	Co Co	Cr.	Cr.	Co. V	Fe. Ti. Zr. Fe. Fe. Mn. Co Fe Fe Co. Fe. Fe. Fe. Co. Fe	Ni. Co Ti. Fe. Ti. Fe Fe Fe.	Co. Fe Fe Cr Fe. Fe. Ti. Ti Cr.		Ti		

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Page 20.

Cr Mo Cd Ca Fe Ni Co Cu Ti Mn Be Mg Zr V Ba Al

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Page 21

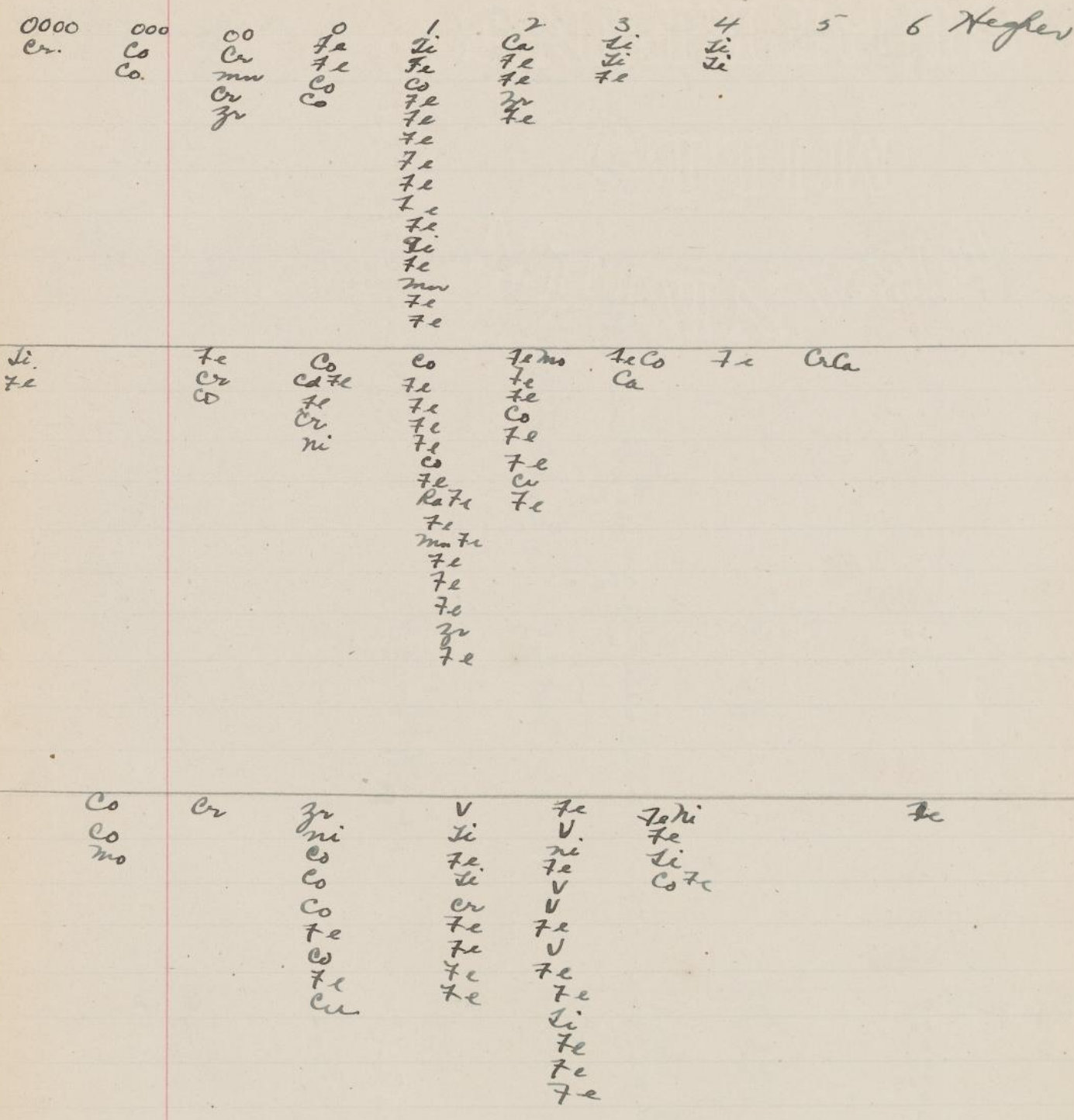
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Page 23

Cr Mn Il Cd Co Fe Ni Co Cu Li Mn Be Mg Zn V Ba Al

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O		Fe Ti Co Mn Zr	Fe Fe Co Mn	Ti Fe	Fe Fe Fe		Ni Ti Ti Co V	Fe Fe Fe	Ti	Fe Mn	Fe-7

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Page 31 Di Cr Mo Il Sm Cd Ca Fe Ni Co Cu Ti Mn Be Mg Zn V Ba Al Sr Ce La

Page 32

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		Fe	Fe Co Zr Co Mn	Ti Mn Zr Mn Fe Fe Fe Zr Ni Co	Co Ti Ti Co Ni La Fe Cr Co Fe Fe Ti Cr Cr	Ti Ti Ti	Fe Ni Ni	Ti Pd	Fe Ni
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			Mn Zr		Fe Fe Fe Ni Ni Ti	Fe Fe Ni Ni Ni	Fe Ni Ni Ni Ni	Cr Fe Fe Ni Ch Pd Ni	Fe		Ni – 7
Pd			Zr	Cr Cr Co	Fe Zr	Cr Cr Fe Co Mn Zr	Cr Fe Fe Fe Co	Fe Co Co	Co		Ni Cr – 8
Pd				Cr Cr Ni Co	Cr Fe Ni	Fe Fe Cr Fe Ni Co	Fe Fe	Fe Co ~~Mn~~ Ti	Fe Co	Mn	Fe – 20 Fe – 15 Fe – 8 Ni – 15

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	Cr	Pd	Cb	Ca	Fe	Ni	Co	Cu	Ti	Mn	Be	Mg	Zr	V	Ba	Ce	Sr	Ag	La
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			Cr Ti	Cr Fe Zr	Fe Fe Fe Fe Fe	Fe Fe Fe Fe Fe Ni Cr Co Mn Mn	Fe FeBr FeCo Ni Ni	Co	Ni	Fe Co	
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	Cr	Pd	~~Ce~~	~~C~~	Fe	Ni	Co	Cu	Ti	Mn	Re	Mg	Zr	V	Ba	Al	Si	Ag	La
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Il	Fe	Pd	Co Mn	Fe Fe Fe Ti	Fe Fe Fe Fe Co Fe Fe Fr Fe Fe Co Fe Ni Ti Mn	Fe Fe Fe Ni Co Ti Fe Zr	Fe Ni Co Co	Co Co	Co	Fe - 7 Fe - 8 Ni - 12 Ni - 7 Ni - 20
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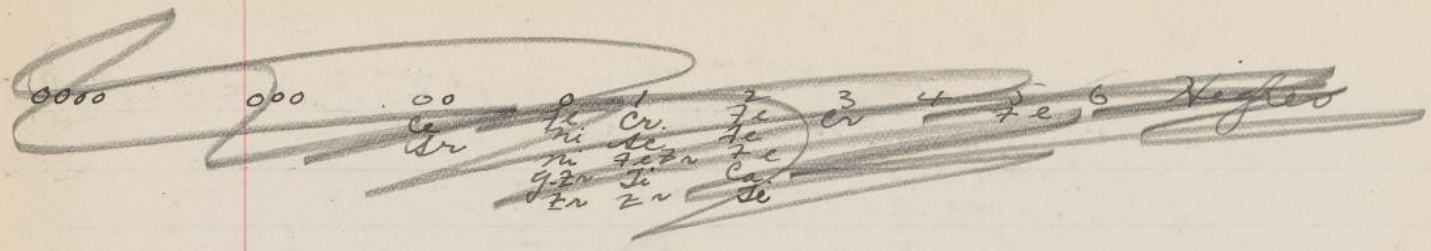
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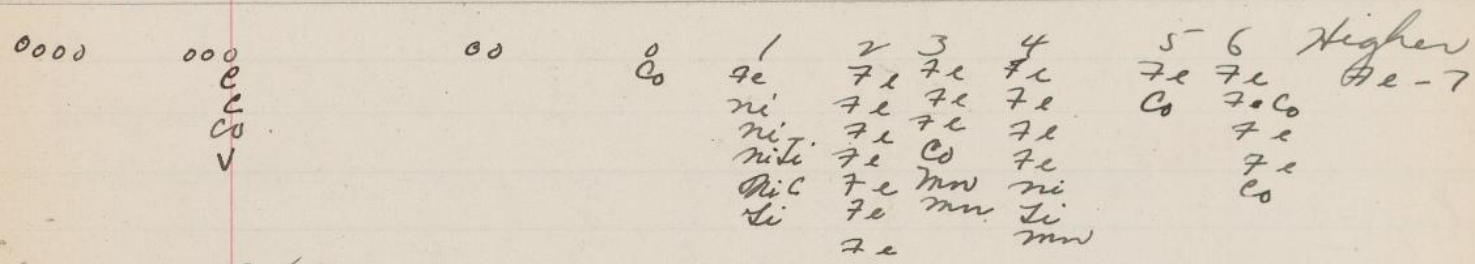
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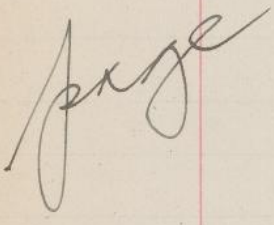
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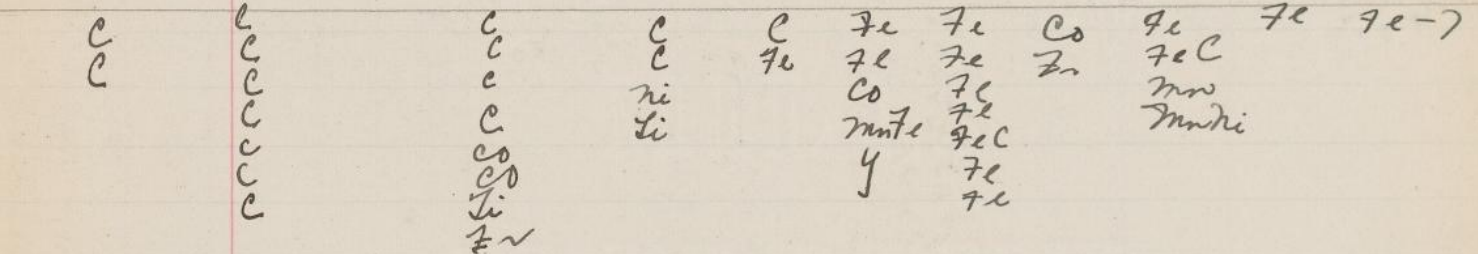
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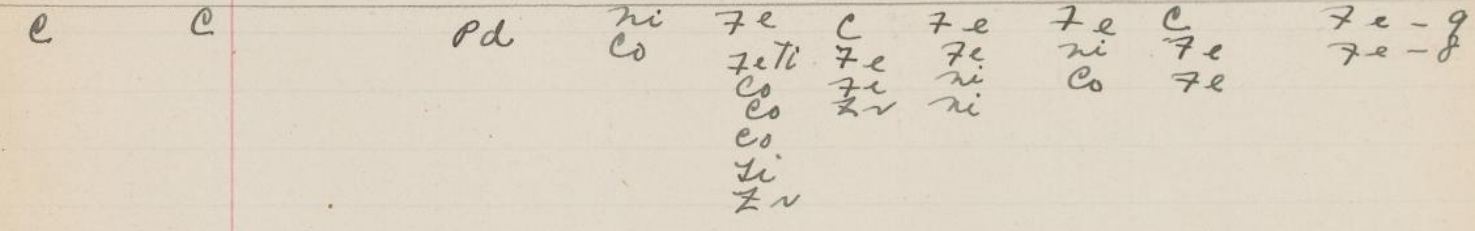
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	Ti V	Co Ti Ti	Ti Mn Mn V	Fe Ni Co V	Fe Co Co Co Ti Zn Mn Mn	Fe Fe Ti	Fe Fe Fe Fe Fe V Fe	Fe Fe Fe Fe	Mn	Fe - 8 Fe - 9 Fe - 8

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	Cr	Pd	Sc	Ce	Fe	Ni	Co	Ca	Ti	Mn	Y	Zr	V	Bi / Pt	La
Page 66	✓ 3				1 1 4 3 3 7 4 40 3 2 2	00	60		0 0 2 4	4 1Pd	3	0	0+		
	3(1)														
Part II			—	000 0	3 6 4Mn 3 4 3 3 3 7 40 4	3 1 1 1	0 2 0Zn 1 1		67e 1 1 1 27e 3 67e	00 0			1+		
Page 4	1 2														
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Page 5	1 1V+ 2 0 1			000 00	30 3 2 1 3 2 3 1 00 3 6 4 8 6 2 3 10	3 3 1 0	1 2	5Mn	4 4 2 1 1 0	1				000	
	4(5)														
Page 6	2 1 49i			00 000 0000 000 000 00 00 00 80 000 0 0 0 0 0 0 1 1 1	0 20 1 3 3 6 Zi 3 4 3 15 5 4 8	1	0 1 00C 1		4 12 7 3	00 000		00 1	2+ 1+	~~Ti~~	27e
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0000	000	00 Ni Co	0 Ti Ti Zr V+	1 Fe Fe Mn Pd	2 Fe Fe Ti	3 Cr Fe e Fe Y	4 Fe Fe Ti Mn	5	6	Higher Fe-7 Fe-40	
	C	Mn	C Co Co Zr Mn	Cr Ni Ni Ni Co Co Ti Ti Ti V+	Cr Co Ti Fe	Fe Fe Fe Fe Fe Ni Ti	Fe Mn Fe Fe		Fe Ti Fe Ti Fe Co	Fe-7 Fe-40	
	C Bi	C Fe	Cr Ni Ti	Cr Cr V+ Cr Fe Fe Ni Ni Ni Co Ti Ti Mn	Cr Fe Fe Fe Co Ti	Fe Fe Fe Fe Fe Ni Ni	Fe Ti Ti	Ca Mn	Fe Fe	Fe-30 Fe-8 Fe-10	
C	C C C C C Mn	C C C C C C C Cr Mn Zr	C Fe Ca Ca	Cr C C Fe Fe Co Ca Zr V+	Cr Fe Fe Fe V+ La Fe	Fe Fe Ti	Cr Ti Fe Fe Ti	Fe	Fe Ti	Fe-20 Fe-15 Ti-12 Ti-7	

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	Cr	~~Rd~~ Il	Sc	C	Fe	Ni	Co	Ca	Ti	Mn	Y	Zr	V	La
Page 7	1	000		00	10	2			2C	0	3		2+	
				00	6	7			1C	1				
				00 00	1				2					
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Page 8	000			000	2C	2			1Fe				3Fe C	
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				00	3V+	6								
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				00	3	~~[illegible]~~								
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	Cr			Ti Fe Fe Fe Ti Fe Cr	Fe C Ni Fe Fe Fe Fe	Fe FeV+ V-FeC Fe Fe Fe	Fe Fe	Fe	Ni	Fe-9

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	Cu	~~Mg~~ Mg	Sc	Fe	Ni	Co	Ca	Ti	Mn	Y	Zr	V	La	Mo	Sm
Page 9	1 1 1 00 1			1 1 5 2 2 3Cr 2 2 2 4 8 1 5 2 6 7	1 4				2 1 1			00 1 1	1Ca 1	0	000
Page 10	1C			3 2 2 3 2ErC 6 2C 6 1 3 3C 2 2 2	6	0		1NiC	00C 87e 00 4 0C			0 0MnC 0C 0			
Page 11	1 0 0			4e 15 3Co 3C 25C 4 4 1		1 0TiC		00rC 0	1 4Cr 1			1C 0 1			
Page 12		10 10		20 8 1C 0 2 2 4 10 3	6			1e 2C 1C	3C 4			0			
Page 13	1	25C		3 2 8C 10Mn 2C 4 3 2 0 10		0 3 8C			2C 0 QC			0 1 0 004	3C		

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	Ln	V	Cr Cr Mo	Cr Cr Cr Co Fe Fe Fe Ni Mn Mn V V La Ca La Ca C Fe Ti Ni C	Fe Fe Fe Fe Fe Fe Mn	Fe Cr	Fe Ni	Fe Fe	Fe	Fe-8 Fe-7
		Mn C Mn	Co Mn C V V Mn C V C V	Fe Fe Fe C Fe C Fe Fe	Fe Fe Fe Cr C Fe C Fe Fe	Fe Fe Fe Fe C	Mn	Fe	Fe Fe Ni	Mn Fe-8
			Cr Cr Co Ti C Ti Cr C Ti V	Cr Fe Co Y Y C V	Fe	Fe Co Fe C	Fe C Fe Fe Y Ca			Fe-15 Fe C-25
			Fe C V	Fe Zr C Ti C	Fe Fe Ti C	Fe Mn C	Fe Mn		Ni	Mg-10 Mg-15 Fe-20 Fe-8 Fe-10
		V +	Co Mn V V	Cr V	Fe Fe C Fe Mn C Mn C	Fe Fe Co La C	Fe	Fe		C-Mg-25 Fe C-8 Fe Mn-10 ~~Fe C-8~~ Fe-10 Co C-8

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	Cr	Mg	~~Ca~~ Ca	Fe	Ni	Co	Ca	Ti	Mn	Y	Zr	V	La	Mo	Si	Nd
Page 14.				4 4C 1C 8 3 20C 3	7 0C 3C	0 00C 4						2 4				
Page 15				3 7 3 3 2 6		1 2						1		1		
Page 16	0			4 5 1 8 7 2 2		4 4 27e 2		2				2				
Page 17	3 3		1 0	1 2 2Cr 4 15 7 2Mn 27n 3 4 4 2 7 9 3	2	00 5 3	1	0 2	1 2 0 3 0 0		0 0	0 1 27e 0				
Page 18	4			2 3 8 1 10Cr 5 10 4 33e 5 4 5 4V		0 2 3Ca		0 5Ti2n 1 3	2 0 0			5 3		12	0	

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6000 300 Co Ni Co Fe V Fe Fe Ni Fe Fe Co V Fe-8 Fe-20 Ni-7

Cr V Mn Fe Co Fe Fe Fe Fe-7

Cr Fe Fe Fe Co Fe Co Ti V Fe Fe Co Co Fe-8 Fe-7

Co Mn Ce Ti Mn Zr Zr V V Ce Fe Ca Mn V Fe Fe Cr Fe Mn Fe Mn Fe Fe Ti Ti Mn V Fe Cr Cr Fe Fe Co Mn Fe Fe Co Fe-15 Fe-7 Fe-7

Co Ti Mn Mn Mn Fe Ti Fe Co Mn Fe Fe Co Ca Ti V Cr Fe Fe Fe Fe Ti Fe Zr V Fe-8 FeCr-10 Fe-10 Mn-12

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	Cr	Mg	Sc	Fe	Ni	Co	Ca	Ti	Mn	Y	Zr	V	La	Mo	Ce	al	na
Page 19	2 5 2 0 3 0 3 Hd		2	1 0 4 3 0 1 1 Cr 5- 5- 4 4 5- 3 10 1 2 12	2 2 1	2 1 0		57e 2 1	0 00 0 1 1		1 0 La 0 0 4 Na	0 1	4		1		
Page 20	0 2 3		0	5 4 8 2 2 Co 2 La Mn 8 1 1 0 2 3 2		47e 9 8 07e 17e 2	1000	4 0 1 1	0 0 1 2 0 1 0 0 0 0								
Page 21	3 0 0 0 1 0 0			5 Co 3 3 3 2 3 3 0 3 4 5 4 2 5 5 4 3 3 Cr		3 0 Ce 1 3 0 0 0 3	1	2 4	0 0 1 2 3	2 0			1		1	15	0

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Na	0000	000	00	0 Cr Cr Fe Fe	1 Fe Fe Fe Cr Fe Fe	2 Cr Cr Sc Fe	3 Cr Cr Nd Fe Fe	4 Fe Fe Fe	5 Cr Fe Fe Fe	6	Heights Fe 10 Fe - 12
			Mn Mn Mn	Cr Fe Fe Co Fe Li Mn Mn	Fe Fe Co Co Fe Li Li Mn Mn	Cr Fe Fe Co Fe Ba Fe Fe Co Mn	Cr Fe	Fe Co Fe Li	Fe		Fe - 8 Fe - 8 Co - 8 Ca = 1000
O			Cr Cr	Cr Cr Fe Co Ce Co Co Co Mn Mn Y Ba Na	Cr Co Ca Mn V Ce	Fe Fe Li Mn Y	Cr Fe Fe Fe Fe Fe Fe Fe Cr Co Co Co Mn	Fe Fe Fe Li Y	Fe Co Fe Fe Fe		Al - 15

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	Cr	Ni	~~Ce~~	Fe	~~Ti~~	Co	Ca	Ti	Mn	Y	Zr	V	La	Ac	H	Cu
Page 22	00 3	2Mn 2Fe		3 1- 5 3 4 6 7Ca 1Co 0 1 4 3 1 2 3 3 0 2 3 3 1 2 1-		4Ti 2 0 0 0	700	5Zr 3 2						20		
Page 23	0Co 2 0 00 3 1	2 3Zr 2 2	1	10 0 5 0 1 0 1 0 3 2 2Mn 2 2 3 2 6 2 # 3 0Cr 1 2		0 1 67e 1 0 3Cr 0 4	2		00						5	
Page 24	3 2 1Mn 3Zr 1	1	2Zr	2 4 5 3 3 2 1 2 4		1 0 0 2Cr		4 2Mn 3 2 4	00 2 1 3 0	3 *	0 2Co	0 3Cr	0 ~~3La~~			002

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Bah	0000	000	00	0 Fe Fe Co Co Co	1 Fe Fe Co Fe Fe Fe Fe	2 Ni Mn Ni Fe Fe Fe Co Ti	3 Ca Fe Fe Fe Fe Fe Fe Ti	4 Fe Fe Co Ti	5 Fe Ti Zr	6 Fe	Heights Fe Ca - 7 Ca - 700 al - 20
			Cr Mn	Cr Co Cr Fe Fe Fe Fe Fe Cr Co Co V	Cr Ce Fe Fe Fe Co Co Co	Cr Ni Ni Ni Fe Mn Fe Fe Fe Fe Ca	Cr Ni Zn Fe Fe Fe Co Cr	Co	Fe H	Fe Co Fe	Fe - 10
002			Ti Mn Ba	Co Co Ti Mn Zr V La	Cr Mn Cr Ni Fe Fe Co Ti Mn Mn	Cr Ce Zn Fe Fe Fe Co Cr Ti Mn Ti Ti Mn Zr Co Nd	Cr Cr Zn Fe Fe Y Mn V Cr	Fe Fe Y Ti	Fe		

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	Cr	Mi	Ce	Fe	Ba	Co	Ti	Mn	Y	Zr	V	La	Se	Nd	Cu	Ar	K
Page 25	1 00 1	1	0 37eti	3 2 4 4 00 0 2 2 3 0Ti 1 7 2 3 3	000	5 4	00 4 0	000 000 00 00 00		17e		1	00				
Page 26	0	0 2 1 Ie	0	00 1 3 1 2 2 3 2 0 5 1 5 2 00 4 3 000		0 00 0Cr 0	3 1 4 37e 0 0	0Ti 60 3 4 1					1	1Zr.			
Page 27	0 0 1 0 0			1 5 1 0 2 000 2 4 1Ie 5Zr 2 5Ti 1 2La 2 2 4 7Mn		3 2 3 2La 1	0 3 3 1 4	2 4 5 2 1 1		1 00 000 00		000	2	0 0	000	0	
Page 28	00 0Nd 0 0		Mdlo	1Mn 1 2 3 0 3 3 30 2		2 5	00Zr	67e 4 5 2 1 5Cr 0	00 0	1 1		0					0 00

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K

0000	000 Ba Mn Mn	00 Cr Fe Ti Mn Mn Mn Sc.	0 Fe Fe Ti Ti	1 Cr Cr Ni Fe Zr Fe La	2 Fe Fe Fe Fe	3 Fe Fe Fe Fe	4 Fe Fe Co. Ti	5 Co	6	Higher Fe-7
	4e	Ni Fe Fe Co Mn	Cr Ce Fe Co Co Cr Co. Ti Ti Mn Ti	Ni Ni Ce Fe Fe Fe Ti Mn Ce Nd Zr	Ni Fe Fe Fe Fe	Fe Fe Fe Ti Ti Fe Mn	Fe Ti Mn	Fe Fe		
	Fe Zr La Ce	Zr Zr	Cr Cr Cr Fe Ti Nd Nd Sr	Cr Fe Fe Fe Ce Fe Co. Ti Mn Mn Zr	Fe Fe Fe Fe La Fe Fe Co Co La Mn Mn Sc	Co Co. Ti Ti	Fe Fe Ti Mn	Fe Fe Fe Zr Fe Ti Mn		Fe Mn-7
0 00		Cr Ti Zr Y K	Cr Nd Cr Cr Mn Y V K	Cr Ce Nd Co Fe Mn Fe Mn Zr Zr	Fe Fe Co Mn	Fe Fe Fe Fe 1	Mn	Co Mn Mn Cr	Mn Fe	Fe-30

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	Cr	Ni	Ce	Fe	Ba	Co	Li	Mn	Y	Zr	V	La	Sc	Nd	Cu	Pt	Sr
Page 29	0 V 0		0	2 2 3 2 3 1 2 3 Ti 1 3 0 3 3 Cr 2 5		0 1 47c	37c 1	0 0 2 0 0 6 0 3 1 2		0 0 0	0	0 0 0	0 0	3	0	0	
Page 30	0 0 0	1 0 Fe Cr	0 0 0 0 0	4 2 0 2 3 2 5 3 6 Mn 4 1 1 5 2 4 3 3 1 Ce 2 7 V 4 2 4		2 0	1 3	0 Ti 2 3		0 0	0 0 0	0 0 0 14		0 2 0			8
Page 31	0			8 2 3 3 Na 2 1 2 2 1 5 4 4 3 3 3 2 3 2 1		0 3 3 Mn 0 0 0		3 3 4 0 Ce 4 Y 0		0 Ce 0 0 0	1 3 Ca	1	37 Fe Ti	0			

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Sr

0000	000 La	00 Mn Mn Zr V Sc	0 Ca V Cr Ce Fe Co Mn Zr Zr Cu Pb	1 Fe Fe Fe Co Ti Mn	2 Fe Fe Fe Fe Fe Mn Mn	3 Fe Fe Fe Ti Fe Fe Fe Ti Fe Mn Nd	4 Co Fe	5 Fe	6 Mn	Figles
8	La La	Ce Ce Ce Zr	Cr Cr Zr Ce Ce Co Mn Zr Nd Nd	Ni Fe Fe Ce Ti La Y	Fe Fe Fe Fe Co Mn Ti Nd	Fe Fe Fe Fe Fe Ti Mn	Fe Fe Fe Fe Fe	Fe	Fe Mn	Fe-20 Fe-15 Sr-8
	Co	Co Zr	Cr Fe Co Ce Mn Mn Zr Ce Zr	Fe Fe Fe V La	Fe Fe Fe Fe Fe Fe	Fe Fe Nd Fe Fe Fe Fe Co Co Mn Mn Mn V Ca Sc Fe Ti	Fe Fe Mn Mn Y	Fe		

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	Cr	Ni	Ce	Fe	Ba	Co	Si	Mn	Y	Zr	V	La	Le	Nd	Ca	H	Lng	C
Page 32	0		37eZr	3 2 3 5 2 4 2 5 2 2 3 3		0V 00V 4	00	0 5 Si 00	0	0 00	0 2 0 1 2 2	000		1	4 4	40		
Page 33	44		1 00	2 3 4 5 2 1 4 3Cr 3 5		4+	1 1Cr 000	1 1 1 00 000 1		00	4 3 1 0 00 0	1+		1				
Page 34	2 00 0 000 00 0		00 3 0	3 3 4 4 4 2 0 4 2 3 3 5	2 0		000	1 0		0	000 6 2 37e							
Page 35	2 2		00 0 0	4 6 1Ce 6 0 000 4 4 15 2 4			0mw 000	0 1 0		2		0						0

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				1	2	3	4	5 6		Higher Hdw -40
0000	000 La	Co V Li Zr	Cr Co V Y Zr V V V	Nd	Fe Fe Fe Fe Fe V V V	Fe Fe Fe Fe	Fe Co Ca Ca	Ce Zr Zr Fe Fe Fe		
	Li Mn	Ce Mn Zr V	V V	Ce Fe Fe Li Li Cr Mn Mn Mn Mn La Nd	Fe Fe	Fe Fe Cr Fe	Fe Fe Co V	Fe Cr Fe		
	Cr Li V	Cr Cr Ce	Cr Cr Ce Ba Mn Zr	Mn	Cr Fe Fe Ba V	Ce Fe Fe Fe Fe V Fe	Fe Fe Fe Fe	Fe	V	Fe-10
0	Fe Li	Ce	Ce Ce Fe Li Mn Y Y La	Fe Ce Y	Cr Cr Zr	Fe	Fe Fe Fe Fe		Fe Fe	Fe-15

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	Ci	Ni	Ce	Fe	Ba	Co	Li	Mn	Y	Zr	V	La	Sr	Zn	Al
Page 36	0 La 0 0 1 Ba 0		0 0 0 1	4 2 La 3 1 4 4 4 3 5 5		1 0 5	0	0 0		12i 0 0 1 2			1	0	
Page 37	0 0 0 0 0 2 La, Mn, Ni, Fe 0 0	2	2 0	3 4 2 4 2 3 4 5	0		4Fe 4 27o								2
Page 38	0 Co 0 0		2 Zn	5 Mn 3 5 3 4 Cr 6 2 5		1	0 0 0 1	0		0 1 0	3 0	0 0		0	
Page 39	0 0 0 1 0 0 0 0 0 2 0 0	1		6 3 5 2 4 1 2 4 3 2 0 1 Ni Mn 8 3			1 0 0 6 0			57e 0 0 0		0 8 0 2 4			

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0000	000	00 Cr Cr Ce Ce Mn Zr	0 Cr La Co Ti	Cr Ce Fe Co Zr Ti Zr Sr	2 Fe La Zr	5 Fe Fe	4 Fe Fe Fe Fe	3 Fe Fe Co	8	Higher
		Cr Cr Cr Cr	Cr Ce Ba		Cr, La, Mn, Ni, Fe Ni Ce Fe Fe Ti Fe Al	Fe Fe	Fe Fe Fe Ti Cr Ti	Fe		
	Ti	La.	Cr Co Cr Cr Mn Zr Zr V nd	Co Ti Zr	Co Zr Fe	Fe Fe V	Fe Cr	Fe Mn Fe Fe	Fe	
Zr	Cr	Cr Ti Ti La La	Cr Cr Cr Cr Cr Cr	Cr Ni Fe Fe, Ni, Mn Ti	Cr Fe Fe Fe La	Fe Fe Fe Fe	Fe Fe La	Fe Zr Fe	Fe	Fe-8

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	Cr	Ni	Ce	Fe	Ba	Co	Ti	Mn	Y	Zr	V	La	Sr	Nd	Cel	Ca	Mt
Page 40	6 0 0 0 0 3 0 0			1 3 3 1 3 4 3 2 3 4				0		1 2 0 1	1	5Ce	5+				
Page 41	0 0 3Fe 000	4		3 5 4 3 2 2 4 2 3 2 6		0V	0 0 0 0	0 0 0 4Fe		0 1 0	0 0 1		0			20	1
Page 42	0 0 1	1		8 3 3 1 5 3 2 2Zr 2 3 4 2 4 1			0 0 0 0	2 3 3	5	0 0 0		1					
Page 43	8 0Mn 2 0 0 0			8 8 2 1Cr 2 2 2 2 2 2 2 2 2 3 2 2		0	0 0 0 0 0 0 2Cr 0	2 2		0 0 0		0					

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0000	000	00 Cr	0 Cr Cr Cr Cr Cr Mn Zr	1 Fe Fe Zr Zr V	2 Fe Zr	3 Cr Fe Fe Fe Fe Fe	4 Fe Fe	5 LaCe Ir+	6 Heiden	
Cr Mn		Ti Ti V	Cr Cr Co V Zr Zr Sr	Zr V Nb	Fe Fe Fe Fe	Cr Fe Fe Fe Fe	Ni Fe Fe Mn Fe	Fe	Fe	Ca -20
		Cr Ti Ti Zr	Zr	Cr Ni La	Fe Fe Zr Fe Fe Fe Mn	Fe Fe Fe Fe Mn Mn	Fe Fe	Fe Yp		Fe -8
		Cr Ti Ti Ti Zr	Cr Mn Cr Co Ti Ti Ti Zr La	Fe Cr	Cr Fe Fe Fe Fe Fe Fe Ti Cr Mn Mn	Fe Fe				Cr -8 Fe -8 Fe -8 Fe -10

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	Cr	Ni	Ce	Fe	Ba	Co	Ti	Mn	Y	Zr	V	La	Ca	W	Sc	Sr	H	Mg
Page 44	0 1			3 3 2 6 15 3 1			0 0 1 1 2 0			0 2 2 0	1	0						
Page 45	1 5 0 V	1 1		3 Ti 5 3 1 2	0 0		1 0 0 2 2 1 2 1 1 2 3 2	2 0 V				2	4 4					
Page 46	0 0 a Ti 6 V	1 0 0		5 2 2 3 Sr Ti 4			2 1 2 4 Fe 2 3 2 2 2 4	0		2 Set 1 0		0	3 4	0 0	2+			
Page 47	0 0			6 2 3 4 2			3 1 1 3 1 0	1		0			3 4 mn		3+ 3+.			
Page 48		17r 2		8 2 3 3 2 5			1 Cr 0 Ti			0	0 0	1 0			4+			
Page 49	3 4 3 0 2 4 1 3 5			1 0 2 2 2 1 2 2 0 2 4	0 0		4 2 2 1	0 0		0 0 0 0	0						0 0 2 0	5

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	0 000	000	°Ti	°Cr Ti Zr Zr La	¹Fe Ti Ti V	²Fe Ti Zr Zr	³Fe Fe Fe	4	5	⁶Fe Higher Cr - 7 Fe - 15
			Ba	Cr V Ti Ti Mn V	Cr Ni Ni Fe Ti Ti Ti Ti	Fe Ti Ti Ti Ti Ti Ti Mn La	Fe Ti Fe Ti	Ca Ca	Cr Fe	
			Cr Ni W	Cr V Mn Zr La	Cr Ni Ti Zr	Cr Ti Fe Fe Ti Ti Ti Ti Ti Zr Sc+ Sc+	Fe Sc Ti Cr Ti Ca	Ti Fe Ti Ti Ca	Fe	
				Cr Cr Ti Zr	Ti Ti Ti Mn	Fe Fe	Fe Ti Ti Ca Sc+ Sc+	Fe Ca Mn		Fe
				Ti Zr V V La	Ni Zr Ti Cr La	Ni Fe Fe Ti Ni	Fe	Sc+	Fe	Fe - 8
5	Zr		Ba Mn Sc	Cr Fe Fe V	Cr Fe Fe Ti	Cr Fe Fe Fe Fe Fe Ti Ti	Cr Cr Cr	Cr Cr ~~Ca~~ Fe Ti	Cr Mg	Fe - 20

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	Cr	Ni	Ce	Fe	Ba	Co	Li	Mn	Y	Zr	V	La	Sc	Ca	Sr
Page 50	3 1	0 0	00	0 2 1Zn 2 5- 2			1 2		0Zn	0 1	0		1+	2	00
Page 51	2 1 1 0 0	0 00		4 0 2 6 1Cr 1 2		2	00 0	00 0		1 0 0	0 2Mn 4		3+Fe		
Page 52	2 0 1	0 60		15- 2Co 3 2 1 2		0 0	1 1 0 2 3 1	00 0Ni		00	3 2 1 0 0 2Zn	1	0+		
Page 53	0Zn 0 0 0 1 0 0		0 0 0 1 2	2 1 0 4 3 1			3Cr 1	000		0 00	1 2 2 2 2 00		3+		
Page 54	0 0			8 3 4 1 2 5		00	0 3 1 0 0 0 0 2	2 00		00 00	0 0 0 0 0		3+ .00+	4	
Page 55	0			1 3 1 3 1 2 2Ni 1 1 0 0 6 1 3			0 00 00	2		1 0	1Cr 00 0 0 3	000 0000 000 00	0+	5 4	00Zn

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0000	000	0 Ce Sr	0 Ni Ni Fe Y Zr V	1 Cr Fe Zr Ti Zr Sc+	2 Fe Fe Fe Ti Ca	2 Cr	4	5 Fe	6	Higher
		Ni Ti Mn	Cr Cr Ni Fe Ti Mn Zr V	Cr Cr Fe Cr Fe Zr	Cr Fe Fe Co V Mn	Sc+Fe	Fe V		Fe	
		Ni Mn Zr	Cr Ni Co Ti Mn V Sc+	Cr Fe Ti Ti Ti V Ca	Cr Fe Co Fe Fe Ti V V Zr	Fe Ti V				Fe-15
	Mn	Cr Cr Zr V	Cr Zr Cr Cr Ni Ni Ni Zr	Cr Ni Fe Fe Ti V	Ni Fe V V V V	Fe Ti Cr Sc+	Fe			Fe-10
		Co Ti Mn Zr Zr V Sc+	Cr Cr Ti Ti Ti V V	Fe Ti	Fe Ti Mn	Fe Y Ti Ti Sc+	Ca	Fe		Fe-8
La	La	Fe Ti Ti V Zr La Ca Ce Nd	Cr Fe Ti ~~Y~~ Zr V V Sc+	Fe Fe Fe Fe Fe ~~Y~~ ~~Zr~~ Cr Zr V Cr	Fe Fe Ti	Fe Fe Fe V	Ca	Ca	Fe	

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	Cr	Ni	Ce	Fe	Ba	Co	Ti	Mn	Y	Zr	V	La	Le	Ca	Sc	Ag	In
Page 56	0	2		2 Ti 1 2 6 3 1 2 3 1 Cr			6 2 2 1 2 1 20 gr	27 c 3 1 2 Ti 2 0 2 2		17 c	00 Ti 0 00 1			5 gr 3 2			
Page 57	0 00	1 0 2 Zr 0		1 Zr Ni 0 4 3 Mn 5 4 1		17 m 0	0 Ni 0000 2 1 5 1 1 0	1 1 2 1 0			0 00 00						
Page 58	00 20			00 4 Co 1 1 1 5 3 4 3 0 Cr 1		0	0 00 0 Ni 1 17 c 0	0			0000					3	
Page 59	0 0 Mn 00 0 Zr 3 0 0 0 Mn		0	4 2 6 0 1			00 1 0 5	37 c 1 00 0 2 00	00	0							
Page 60	1 0 0	0 0		4 1 Co 3 3	00	0	3 3 0										00
Page 61	0 2 0 0 1			0 5 1 8 1 2 Co 5 2			2 3 4 6 Co 4 3 2 2	1		0		0000		3			

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0	0	0	0	1	2	3	4	5	6	Higher
0 0 0 0	0 0 0	0 0 Ti V	Cr Mn V	Ni Ni Ni Cr Ti Ti Mn Mn Zr Fe V	Ti Fe Ti Ni Ni Ti Ti Ti Ti Zr Mn Fe Mn Ti Mn Mn Mn Ca	Ni Ni Mn Ca	4	5 Ti Ca Zr	6 Ni	
Ti		Cr V V	Cr Ni Ni Fe Co Ti Ni Ti Mn V	Ni Fe Zr Ni Mn Co Zr Ti Ti Ti Mn Mn Mn	Ni Zr Ti Mn	Fe Mn	Fe Mn	Mn Ti		
Zr		Cr Cr Fe Co Ti ~~Ti~~	Fe Cr Co Ti Ti Ni Ti Mn ~~Ti~~ ~~Ti Ti~~ ~~Ti~~	Fe Fe Fe Fe Ti Ti Fe ~~Ti~~ ~~Ti Ti~~		Fe Fe Cag	Fe Fe	Fe		
	Mn	Cr Ti Mn V	Cr Cr Mn Cr Fe Cr Cr Cr Mn Ce Fe Ti Zr	Fe Ti Mn	Fe Mn	Cr Mn Fe	Fe	Ti	Fe	
		Ba Ti	Cr Cr Ni Ni Co Ti	Cr Fe Co		Fe Fe Ti Ti	Fe			
V			Cr Cr Cr Cr Fe Zr	Cr Cr Fe Fe Mn	Cr Fe Co Fe Ti Ti Ti	Ti Ti Fe	Ti Ti	Fe Fe	60	~~Fe-8~~ ~~Ti-6~~

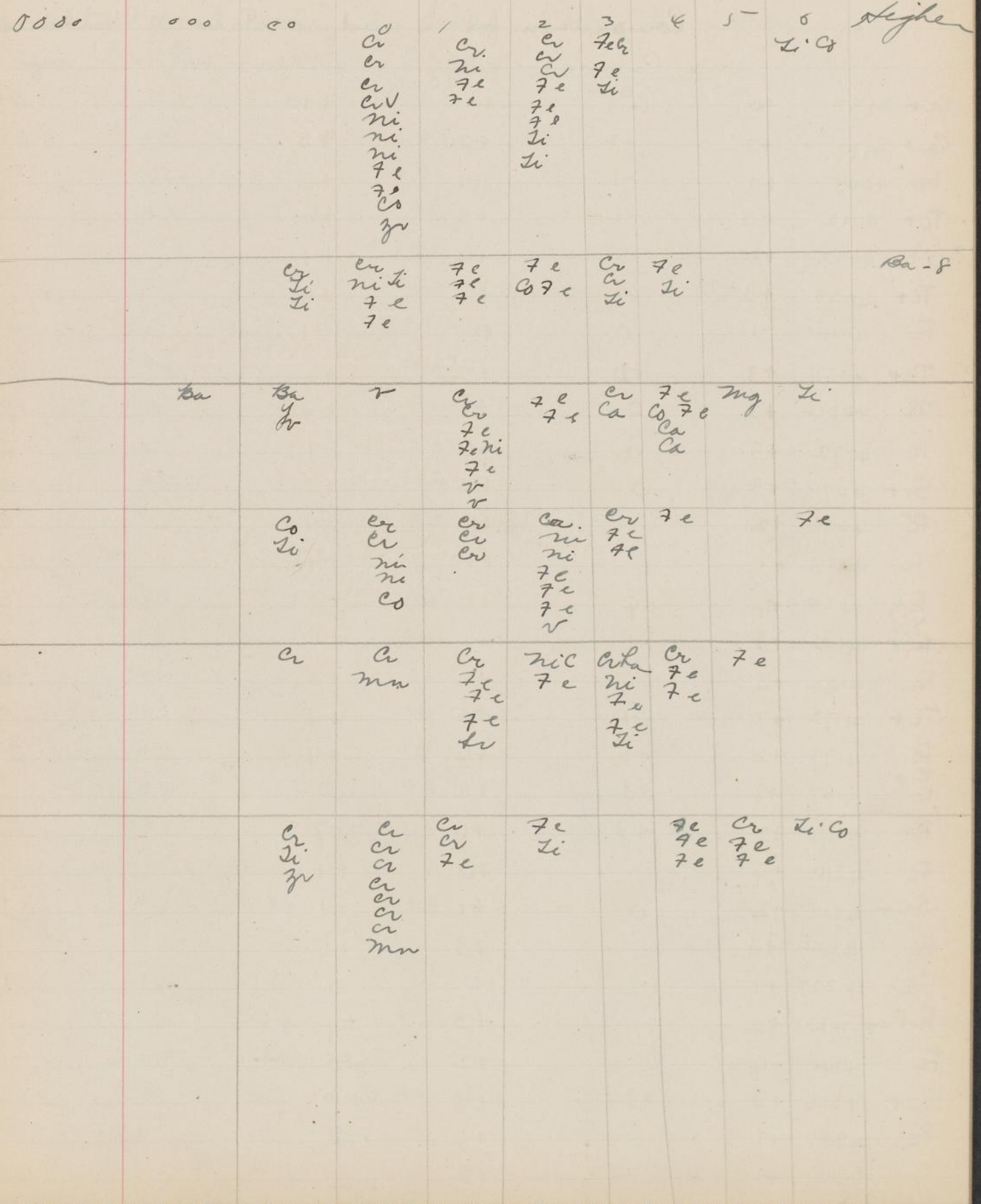
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	Ca	Ni	Ce	Fe	Ba	Co	Li	Mn	Y	Zr	V	La	Lc	Ca	Cr	Mg
Page 62	0 2 8 2 0 1 0 V	1 0 0		0 0 1 3 Cr 2 3 2 2 1			3 2 6 Co 2									
Page 63	3 3 0 0 0	0 Li		4 Cr 2 0 0 1 1 1	8	27 Fe	3 0 0 ,0 4									
Page 64	1 3 1			1 2 1 Ni 4 1 2	0 0 0 0	47 Fe	6			0 0	0 0 1 1			3 4 4		5
Page 65	2 1 0 1 1 3 0	2 0 0 2		4 2 2 3 3 3 6		0 0 0	0 0				2					
Page 66	0 0 3 Lu 4 1	3 2 Ce		2 4 5 3 1 4 3 1			3	0							1	
Page 67	0 1 0 0 0 0 0 0 0 0 0 0			5 4 4 1 2 5 4			2 0 0 0 0	0			0 0					

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Comparison for c and ac Stars of enhancement

		x Carinae / ε Aur.	γ Cyg	δ CMa
Ca+ 3933	+0	−3	+15	+10
Ca+ 3970	+2	+1	+20	+5
Fe 4005	+0	−1	+1	+2
Ti+ 4012	+5	+6	+3	+6
? V+ 4022	+6		+4	+4
Ti+ 4028	+3		+4	+4
Fe 4046	−1	0	0	−1
Ti+ 4054	+3	+2:	+2	+6
Ti 4064	+3	0	+1	+2
Fe 4072	+3	0	−1	−1
Sr+ 4077	+3	0	+3	+3
Fe 4096	+2		+1	+4
Fe 4098	+1		+1	+4
Fe, Y, 4128	+4	+4	+1	+3
Fe, V 4132	+3	−1	+1	+1
Fe 4144	+2		+1	+2
Ti+ 4172	+7	+4	+5	+4
Fe 4177	+2	+5	+4	+4
Fe+ Fe 4187	+2	+3	+2	0
Fe 4191	+2	+3	+1	+7
Fe 4210	+4		+6	+4
Sr+ 4215	+2	0	+1	−1
Fe 4222	+3		+3	+5
Ca 4227	+1	−2	0	0
Fe Fe+ 4233	+4	+4	+3	+9
Fe 4240	+4		+2	+5
Sc+ 4246	+3	+3	+4	+10?
Fe 4250	+1		+1	+8
Fe 4261	+1		+2	−1

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of neutral and ionized lines. From Bk p. 100 on

χ Sgr	K Pav	l Car	δ Cep
+3			+2
+3	+15		+1
−1	0		+1
	+2		+2
			+2
			+2
−2	0		0
+2	+2		+2?
−2	0		+5
−2	0		+3
+2	+2		+3
0			+3
0	+5		+4
	+5		+4
0	+1		+1
0	+3		+6
+2	+2		+5
	+2		+3
	+2		
0	+4	+4	+3
−1	+2	0	0
	+6	+4	+3
	+5	~~+2~~	/
	+1	+2	+4
	+1	+2	0
		−2	0

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		χ Car.	ε Ouw	ϑ Cyg	δ CMa
Fe	4272	0		0	0
CrTi+	4290	+2	0	+3	0
Fe+	4296	+5		+5	+9
Sc+, Ti+, Ti	4314	+2	+3	+5	+9
Sc+, Ti+	4321	+3	+4	+1	+8
Fe	4326	+5	0	−1	+9
Ti+	4330	−1	+2	+1	+8
Ti+	4337	+6	+6	+3	+3
Cr, Ti+	4344	+2		+2	+4
Ca	4355	+1		+1	+7
Cr, Y+	4359	+4		+1	+3
Fe+Ti+	4368	+6	−1	+1	+2
Fe Sc+ Y+	4374	+4	+2	+1	+3
V	4379	+2		+2	+2
Fe	4383	+2	+2	~~+1~~	0
Fe+	4385	+3		+1	
Ti+	4395	+4	+2	+2	+3
Ti+ Y+ Sc+	4399	+5	+1	+3	+3
Fe, V	4405	+3	+4	−1	+1
Sc+	4415	+3	+2	+5	+2
Y+	4422	+4	+3	+1	+5
Ti+	4444	+8	+2	+3	+2
Ti+	4450	+4	+2	+2	+8
Ca	4455	+3	−4	0	0
Mg+	4481	0	0	0	0
Fe+	4489	+5	+1	0	+3
Ti+	4501	+4	+5	+1	+4
Ti+	4534	+3	0	+1	+7
Fe+ Ba+	4554	+2	+1?	+2	+7

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x Sgr	κ Pav	ℓ Car	δ Cep
	0	+1	+1
0	+2	0	+3
	+3		
+3	+8	+2	+5
	+5	+3	+3
−1	−1	+1	−1
	+1		−1
−	+3	+8	
		+5	
		0	
+2	+2	+3	
+3	+2	+3	+4
+1	+2	+3	+1
		+4	
0	+1	+2	+1
		+3	
+2	+1	+1	+3
+3	+1	+3	
	+6	+1	
+2	+4	0	+4
		+5	
+1	+1	+5	+4
	−1	+4	−3
0	0	+2	0
	+2	+4	+4
	+6	+4	
	+3	+2	
	+1	+2	

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Mean enhancements for individual stars

x Car.	Fe	0, −1, +3, +2, +1, +2, +2, +2, +2, +4, +3 +4 +1 +1, 0, +5 +2 +2	
	Fe+	+4 +2 +4 +5 +6 +3 +5	+4
	Ti	+3	+3
	Ti+	+5 +3 +3 +7 +2 +2 +3 −1 +6 +6 +4 +5 +8 +4 +4 +3	+4
	Ca	+1 +1 +3	+2
	Ca+	+0 +2	+1
	Sc	−	−
	Sc+	+3 +2 +4 +5	+4
	Sr		−
	Sr+	+2	+2
ζ Aur	Fe	−1 +0 +0 −1 +3 +3 +4 +0 +2 +4	+1
	Fe+	+4 +5 +4 −1 +1	+3
	Ti	0	0
	Ti+	+6 +2 +4 +0 +3 +4 +2 +6 −1 +2 +1 +2 +2 +5 +0	+3
	Ca	−2 −4	−3
	Ca+	−3 +1	+1
	Sc+	+3 +2 +4 +1	+2
	Sr+	0	0
γ Cyg	Fe	+1 +0 −1 +1 +1 +1 +1 +4 +2 +1 +6 +3 +3 +2 +1 +2 +0 −1	+1
	Fe+	+1 +4 +3 +5 +1, 0, +1	+2
	Ti	+1	+1
	Ti+	+3 +4 +2 +5 +3 +1 +1 +3 +2 +1 +2 +2 +3 +1 +1 +1	+2
	Ca	0 +1 +0	0
	Ca+	+15 +20	+16
	Sc+	+4 +1 +1 +3	+2
	Sr+	+1	+1

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δ CMa.

Fe	+2 −1 −1 +4 +4 +2 +4 +0 +7 +4 +5 +5 +8 −1 +0 +9 +0	+3
Fe+	+3 +4 +9 +9 +2 +3 +7	+5
Ti	+2	+2
Ti+	+6 +4 +6 +4 +0 +9 +8 +8 +3 +4 +2 +3 +3 +2 +8 +4 +7	+5
Ca	0 +9 +0	+2
Ca+	+10 +5	+8
Sc+	+10 +9 +3 +3	+6
Sr+	−1	−1

Summary

	α Car.	ε Aur	γ Cyg	δ CMa	Mean
(Fe+)−(Fe)	+2	+2	+1	+2	+2
(Ti+)−(Ti)	+1	+3	+1	+3	+2
(Ca+)−(Ca)	−1	+4	+16	+6	+6
Sc+	+4	+2	+2	+6	+4
Sr+	+2	0	+1	−1	0

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ac stars

X Sgr	Fe −1 −2 −2 +0 +0 +2 −1 +0	0
	Fe+ 0 +2 +3	+2
	Ti −2	−2
	Ti+ +2 +0 +0 +3 +2 +1	+1
	Ca −1	−1
	Ca+ +3 +3	+3
	Sc+ +1 +3 +3	+2
	Sr+ 0	
K Pav	Fe 0 +0 +0 +1 +2 +2 +2 +5 +1 +0 −1 +1	+1
	Fe+ +5 +2 +6 +3 +2 +2	+3
	Ti 0	0
	Ti+ +2 +2 +3 +2 +8 +5 +1 +3 +1 +1 +6 +3	+3
	Ca +2 −1	0
	Ca+ +15	+15
	Sc+ +1 +2 +8 +1	+3
	Sr+	+4
l Car	Fe +2 −2 +1 +1 +2	+1
	Fe+ +4 +3 +3 +4	+4
	Ti −	—
	Ti+ 0 +2 + 3 +8 +5 +1 +5 +4 +2	+3
	Ca 0 +0 +4	+1
	Ca+ −	—
	Sc+ +2 + 3 +2 +3	+2
	Sr+ +4	+4

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δ Cep

Fe	+1 +0 +3 +3 +1 +5 +3 +0 +0 +1 −1 +1	+2
Fe+	+4 +5 +3 +4 +4	+4
Ti	+5	+5
Ti+	+2 +2 +2 +6 +3 +5 +3 +3 +4	+3
Ca	0 −3	−1
Ca+	+2 +1	+1
Sc+	+4 +1 +5	+3
Sr+	+3	+3

Summary

	χ Sgr	κ Par	l Car	δ Cep	Mean
(Fe+)−(Fe)	+2	+2	+3	+2	+2
(Ti+)−(Ti)	+3	+3	+3?	+2	+3
(Ca+)−(Ca)	+4	+5	?	~~+0~~	+7
Sc+	+3	+3	+2	~~+3~~	+3
Sr+	+2	+4	+4	+3	+3

Comparison

	c	ac
Fe	+2 −	+2 +
Ti	+2	+3 −
Ca	+6	+7
(Sc)	+4	+3
(Sr)	+0	+3

· Excess of Fe+, Ti+, Ca+, over Fe, Ti, Ca, scarcely alters – decreases if anything – with increasing log P_e or decreasing pressure.

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Milne. Emission of high speed atoms
MNRAS 76, 459, 1926.

Residual intensity $F_\nu = \frac{8\nu^2 \tau m q}{c} \cdot \frac{v_1}{v_2}$

$$v_\infty^2 = V_\infty^2 \left[\frac{I_1 - I_0}{I_0} - \frac{V^2}{V_\infty^2} \right]$$

$$= V_\infty^2 \left[\frac{I_1}{I_0} - 1 - \frac{V^2}{V_\infty^2} \right]$$

P. 466. V_∞ is of the order of a few hundred km/sec for all stars.

Sun:- $V_\infty = 615$ km/sec
Capella $V_\infty = 350$ km/sec

$$\left(V_\infty \propto T e^{\frac{11}{5}} \mu^{-\frac{1}{5}} (1-\beta)^{-\frac{3}{8}} M^{\frac{3}{20}} \right)$$

or $V_\infty \propto M^{\frac{3}{20}}$ for very large masses
$\propto M^{-\frac{3}{5}}$ " " small masses

Points to be observationally analyzed.

1. v_∞ to be compiled for various stars from measured data.
   a. Assume V_∞ const.
   b. Vary V_∞ with M.

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2. Examine effect on line symmetry
   General spectrum drift
3. Nova.
   a. are absn. lines sharp to violet?
   b. do they ultimately become sharp on both sides before they fade?
   c. calculate V_∞ for pre nova state; hence v_∞ from known brightening

4. Quantitative estimate of how much stuff is accelerated?

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100

Meridian Photometer: Inspected Variables

Date	B. p.	Design.	R.A.	Dec.	Magn.	J.A.	Read
April 12, 1894	65	189	H.P. 1468	1900 $7^h\ 41^m.1$	$-6°\ 23'$	59	541, 865, 966	$14^m\ 3$

1. Computation of v_∞.

Assume $V_\infty = 500$ km/sec

$$v_\infty = V_\infty \sqrt{\frac{I_1}{I_0} - 1 - \frac{V^2}{V_\infty^2}}$$

$$= 500 \sqrt{\frac{I_1}{I_0} - 1 - \frac{V^2}{500^2}}$$

Data

Star	Line	dM	w	dl	W
α Lyrae	Hβ				
	Hγ				
	Hδ				
	Hε				
	K				
	Hζ				
	Hη				
α Bootis	Hγ	.54		.39	
	Hδ	.74		.49	
	4227	1.34		.71	
α Aquilae	Hβ	.71		.48	40
	Hγ	.81		.53	45
	Hδ	.71		.48	28
	Hε	1.50		.75	32
	K	.79		.52	18
	Hζ				
	Hη				
α Cygni	Hβ	.33		.26	10
	Hγ	.63		.44	9
	Hδ	.63		.44	7
	Hε	.70		.48	6
	K Hζ	.54		.39	3

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		dM	w	dl	W
δ Cas	Hβ	1.49		.75	31
	Hγ	1.46		.74	27
	Hδ	1.54		.76	21
	Hε	2.15		.86	12
	K	1.48		.74	12?
	Hζ	-			
	Hη	-			
α Cas	H	2.50		.90	12?
	K	2.47		.90	12?
α Aur	H	1.62		.78	12
	K	1.67		.79	12
δ CMa	H	>2.25		.87	12?
	K	>2.25		.87	12?
β Ori	Hβ	.22		.18	
	Hγ	.45		.34	
	Hδ	.43		.33	
	Hε	.45		.34	
	K	.17			
	Hζ	.43		.33	
ε Ori	Hβ	.23		.14	
	Hγ	.40		.31	
	Hδ	.37		.29	
	Hε	.32		.26	
	Hζ	.33		.26	
α CMa	Hβ	1.02		.61	31
	Hγ	1.38		.72	27
	Hδ	1.45		.74	41
	Hε	1.47		.74	29
	K	.18		.15	
	Hζ	1.48		.74	
	Hη				

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Computations, for H and K., of V_∞

Star		W	$d\lambda$	$\frac{cd\lambda}{\lambda} = v$	$\frac{V^2}{500^2}$	$dl + H\left(dl - 1 - \frac{V^2}{500^2}\right) N$				$500\sqrt{}$
α Lyr	H									
	K									
α Aql	K	18	9	665	1.69 ×	.52	.48			
α Cyg	K	.3	1.5	112	.22	.39	.61	0.44	.7	350
δ Cas	K	12	6	450	.90	.74	.26	2.1	1.4	700
α Cas	H	12	6	450	.90	.90	.10	7.1	2.6	1300
	K	12	6	450	.90	.90	.10	7.1	2.6	1300
α Aur	H	12	6	450	.90	.78	.22	2.6	1.6	800
	K	12	6	450	.90	.79	.21	2.9	1.7	850
β Ori	K	2	1	75	.015	.17	.83	0.185	0.4	200
α CMa	K	2	1	75	.015	.15	.85	0.180	0.4	200

For H Lines

α Lyr	Hβ						
	Hγ						
	Hδ						
	Hε						
	H8						
	H9						
α Aql	Hβ	40	20	1500	300	9	
	Hγ	45	22	1650	33	11	
	Hδ	30	15	1050	2	4	
	Hε	32	16	1100	2.2	6	
	H8						
α CMa	Hβ	31	35	1050		4	
	Hγ	27	45	1375		7	
	Hδ	41	20	1500		9	
	Hε	29	15	1050		4	
	H8						

No possible values

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1. ~~The effect of radiation pressure~~

The effect of radiation pressure upon an atom in the high level chromosphere of a stellar atmosphere has been discussed by Milne ( ) in a recent paper. The results of the acquisition of an appreciable outward velocity by an ~~absorb~~ atom are examined, and Milne concludes that considerable velocities of expulsion may be produced in consequence of the ~~as a result of~~ increased intensity of incident radiation as the atom moves into the violet wing of its own absorption line.

(2)

The ability of an atom to escape from a star is ~~not~~ described by the term

$$\frac{I_1 - I_0}{I_0} - \frac{V^2}{V_\infty^2}$$

$\frac{I_1 - I_0}{I_0}$ maybe written $\frac{1}{r} - 1$, where r is the residual intensity at the line center.

This quantity ..... depends.

1. Estimates made, references
2. Other likely results
3. possible disabilities

$\frac{1}{r} - 1$ measures the .....

Nothing Nothing Nothing N

$\frac{V^2}{V_\infty^2}$ $\frac{1.5 \times 10^{11}}{4 \times 10^3}$ =

km = 1000 meters

81
69
71
74
295
74

5×10^{8} cm
4×10^{3}
1.5×10^{8} cm
$= 1.5 \times 10^{5}$

W	dλ	$\frac{c\,d\lambda}{\lambda_0} = V$	$\frac{V^2}{500^2}$	dl	$dl - 1 - \frac{V^2}{500^2}$	√	500√	375
ε Ori 16	5	375	.56	.74	1.36 − 1 − .56			1.81
α Lyr				.24 .81			14 | 100	7.1 − 1.8 = 5.3
α Aql			.006					
α Aur 1	.5	37.5	~~.56~~	.59	1.7 − 1 − .006 = 0.694	.85	less than V_∞	2.30
α Aur 12	6	450	.81	.22	4.5 − 1.81 − = 2.7	1.6	800 ✓	1450
α Boo 4	2	150	.09	.59	1.7 − 1 − .09 =			
					~~1.7 − 1 − .09~~ =			
					3.4 − 1 − .09 = 2.3	1.5	750	
					9 − .81 = 8.81	2.96	1480 ~~1500~~	

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~~In the second part of the~~

~~Abb~~

The application of the ejection theory to the phenomenon of novae provides an ~~opportunity~~ for the application of ~~numerical~~ observational data. The pre-max spectrum immediately of a nova presents a strong similarity to that of a c star, and the line depths are probably of the same order. Unpublished ..... on the spectra of certain c stars indicate a depth of the order of .... for the stronger lines, such as those of iron and ionized strontium. Having regard to the probable great narrowness of these lines, the ejection effect could probably come into play for such atoms.

A displaced absorption line for a nova should, on Milne's assumption, be sharp to the violet edge, and fade off gradually to the red. The probable limiting velocities cannot be estimated in the absence of precise data on width and residual intensity, ~~but velocities in excess of the probable~~ but they might well attain values of eight hundred km/sec. It should be noted that the absorption lines of a nova do not in general show displacements of this order; the emission lines are displaced ~~with~~ corresponding velocities of several thousand km/sec, but presumably an atom that got into the violet wing of the emission line would be retarded while ~~and~~ those in the red wing would be accelerated. Such line structure ....?

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For lines of considerable width and small central contrast there is no real solution for

$$v_\infty^2 = V_\infty^2 \left[\frac{I_e}{I_0} - 1 - \frac{v^2}{V_\infty^2} \right]$$

since $\frac{I_e}{I_0}$ is not much greater than 1,

and $\frac{v^2}{V_\infty^2}$ may exceed 1 considerably, running up to 10 and higher for wide line stars. Velocities as great as are represented by wings 20 Å wide are greater than the velocity of gravitational escape. This makes it appear that the wings (as early suspected) are not velocity effects.

No probable value of gravity at the stars surface will remedy the defect.

For Milne's upper limit (narrow line) the contrast 0.25 gives

$$v_\infty^2 = 3V_\infty^2$$

or .90 gives

$$v_\infty^2 \doteqdot V_\infty^2$$ no escape possible.

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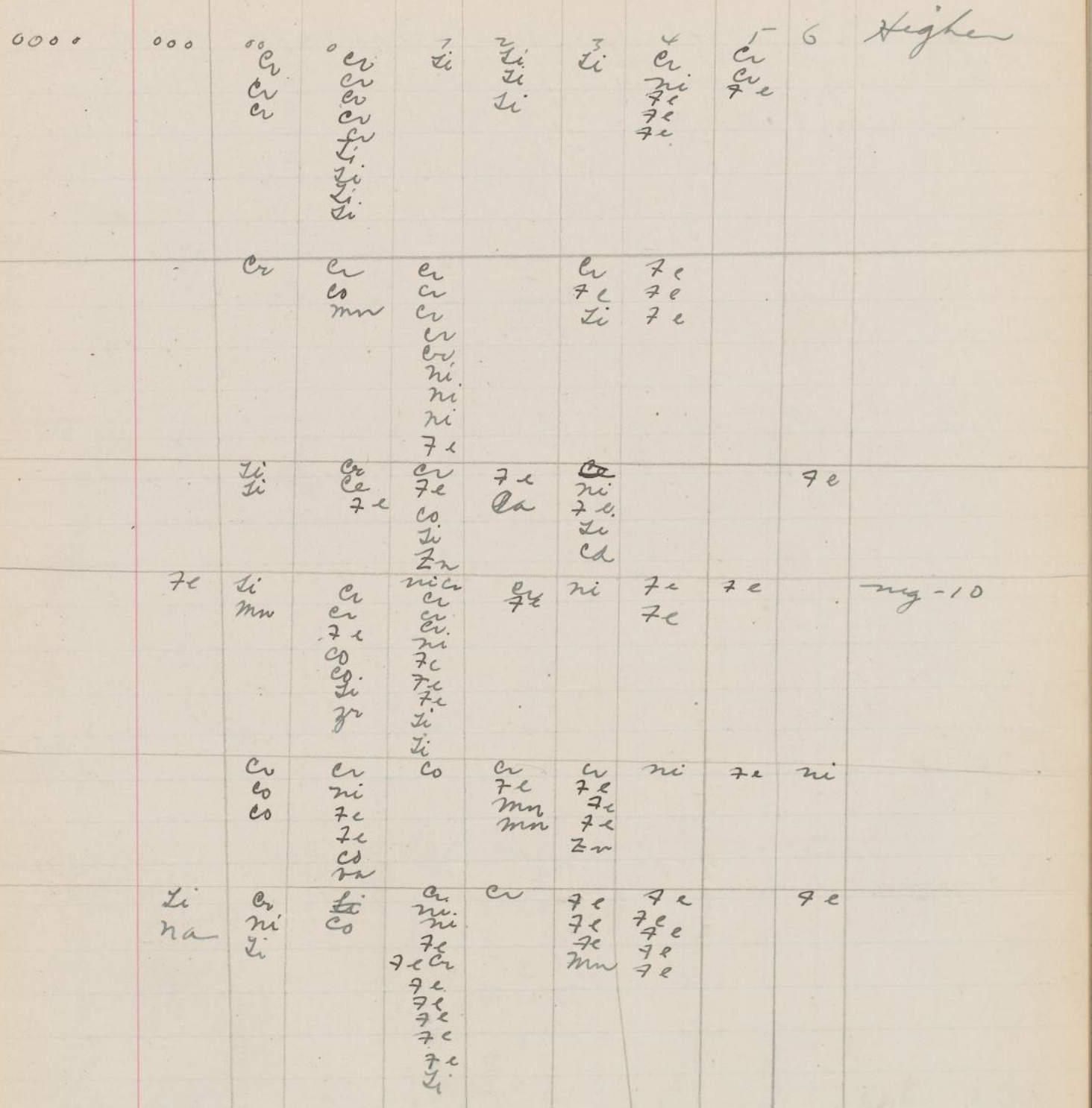
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	Cr	Ni	Ce	Fe	Ba	Co	Li	Mn	Y	Zr	V	La	Sc	Ca	Sr	Cl	Zn	Mg	Va
Page 68	0500000000047500	4		4445			2210000002												
Page 69	1113101001	11		14434		0	3	0											
Page 70	10	3	0	6032		1	1000003							2		3	1		
Page 71	201110	Cr 13		2145100140		00	0001	00		0								10	
Page 72	2300	064		5330203			100000	22									3		0
Page 73	1200	1100		4 Cr 44136134441		0	000001	3											000

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Higher



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	Cr	Mg	Ce	Fe	Ba	Co	Li	Mn	Na	Zr	V	La	Sc	Ca	Cd	H	
Page 74	2 00 000 00	2 3 1 3 1		2 000 2 2 4 00 1		000 0 2	1 2 4Mi 00 00 00	7 3 5 3 4	00								
Page 75	2 00 00Li 1 000	0 3 2Fe 2		0 2 1 3 3 1 1 2 1		1 0	2Cr 000 1 0 00	6			000			00			
Page 76	2	00 2Fe 3 3		0 3 3		1	00 0000 1 000 00	5	3		000 00 00						
Page 77	00 00			1 2 1Mi 3 3 1 3 1 1 1		2	0000 3 0000	0000						0 1V			
Page 78	0	3 1 2 3Cr 2 0		1 2 0 4 2 0 5 4 2		1	1 0 1				0 1					30	
Page 79	00 0	2Cr		4 2 3 3 2 2 3 3 2 6 8 1 1 5		000	000 000 2 0 2Ka 0	000			1			3			2½ earth 1½
Page 80	000 2	1 2 0 000		0 2 3 3 2 2 1 2 1 6 10			2 000				0 1Li						

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0000 Fe	000 Cr Co	00 Cr Cr Fe Co Ti Ti Co Ti Na Cr Ti Ca	0 Co	Ni Ni Fe Ti	2 Cr Ni Fe Fe Fe Cr Ti	3 Ni Ni Mn Mn	4 Fe Ti Ni Mn	5 Mn	6	Higher Mn-1
	Cr Ti V	Ni Fe Co Ti	Cr Fe Fe Fe Fe Co Ti	Cr Ni Fe Ni Fe Fe Ti Cr	Ni Fe Fe				Mn	
Ti	Ti La	Ni Ti Ti Ti La Cr	Fe	Co Ti	Cr Ni Fe	Ni Ni Fe Fe Zr		Mn		
Ti Ti Mn		Cr	Ca	Fe Fe Ni Fe Fe Fe Fe CaV	Fe Co	Fe Fe Fe Ti				
			Cr Ni Fe Fe Ti Zr V	Ni Ni Fe Co Ti Ti V	Ni Ni Fe Fe Fe	Ni Ni Cr	Fe Fe	Fe		H-30
	Co Ti Ti Mn	Cr	Cr Ti	Fe Fe V	Ni Cr Fe Fe Fe Fe Ti Ti La Yt earth Y	Fe Fe Fe Ca	Fe	Fe	Fe	Fe-8
	Cr Ni Ti		Ni Fe V	Ni Fe Fe V Ti	Cr Ni Fe Fe Fe Fe Ti	Fe			Fe	Fe-10

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	Cr	Ni	Ce	Fe	Co	Ti	Mn	Na	Zn	V	La	Ba	Sr	Pt
Page 81	12	1 00 2 3 1 0 2		00 3 00 1 2 2 2 0 2 4 3 3 1 3 2 1 2		0 000						4		
Page 82	2 1	0 00 0 1 4		1 5 8 2 4 3 3 1 3 1 00 1 3 00 4 3		00 000 0 47 00 00 4	00						000	
Page 83	00 000	2 1 1 2 4 0 0 0 1	#	3 3 3 1 2 0 2 La 0 3 0 5 2 0 4 5 2 4 3		00 3 0 3 La 0 3 100	0							0000
Page 84	Zi 000	3 1 00 0 1 2 00		0 4 3 0 0 3 2 1 0		0 2 2 2 3 1 3 2								

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Higher

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	Cr	Ni	Ce	Fe	Co	Li	Mn	Na	Zr	Y	La	Ba	Ca	Cl	Y
Page 85	0	2 0 0 0 1 3e07e 0 2 1		3 3 4 4 3 6 4 1 0 0 1 0 Ni 60 3	00	2 3 0 0 0 0 0 0 0 0							2		
Page 86	0 0 0 0 0 0 1	1 4 3 2 3		3 2 3 5 3 2 5 3 3 4 4	000	0 6 3 0 0 0 0 0 0 0 0 0									
Page 87	0 0 0 0	0 0 0 0 1 2 1		5 3 1 3 0 4		0 0 0 0 0								0 0 0 0	1
Page 88	0 0 0 0 0 0 0	2 0 1		4 4 2 5 0 2 3 3 2 0	000	0 0 0 0 0	60								0
Page 89	0 0 0 0	2 0 0 1 3 2 3		3 1 2 4 0 3 4 4 3 4 3 1 2	000	3 0 0									
Page 90		1 2		3 4 3 3 5 5 1		0 2	0 0	0 0							

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0000	000	00	0	1	2	3	4	5	6 Higher
		Ni Ni Fe Fe Co Ti Ti Ti Ti	Cr Ni Fe Ni Ti Ti	Ni Ni Fe Fe Fe	Ni Ni Ti Ca	Ni Ni Fe Fe Fe Fe Ti	Fe Fe Fe		Fe
Cr Ti	Cr Co Ti Ti	Ti Ti Ti Ti	Cr Ti Ti	Cr Ni	Ni Fe Fe	Ni Ni Fe Fe Fe Fe Fe Ti	Ni Fe Fe Fe	Fe Fe	
Cr Ti Ca			Ni Ni Ni Ni Fe Fe Ti	Ni Ni Fe Y	Ni	Fe Fe	Fe	Fe	
Ti	Cr Cr Co	Cr Cr Mn	Ni Fe Ti Ti Y	Ni	Ni Fe Fe Fe Co	Fe Fe	Fe Fe	Fe	
	Co	Cr Cr Ni Fe	Ti Ti	Ni Fe Fe	Ni Ni Fe Fe	Ni Ni Fe Fe Fe Fe Fe Ti	Fe Fe Fe Fe		
	Mn		Ti	Ni Fe Fe	Ni Fe Ti Co	Fe Fe	Fe	Fe	

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	Cu	Ni	Ce	Fe	Co	Li	Mn	Na	Zr	V	La	Ba	Ca	Cd	Mg	Y	Sr
Page 91	37c 00 000	1 1		2 5 3 4 0 6 0 1 2 1 Mn Cu 000 1 4 5 4	000 00	2 2 2 2 2 000				000			3		15 20 30.		
Page 92	0 00 5 5 1/2 5 00 00 0 00 000 0 00 1/2 000	00 Mn 0		2 1 3 2 4 3 2 00 3 3 3 0 1 0 2		000 00 3 0 60 Cu 6000 0 60 Cu H	00			0						0	
Page 93	000 1 00 00 2 0	00		3 Cu 5 4 7 1 2 1 1 00 2 3 0 2 3	2 Cu 000 000	2 000 000 000 0000	0										00
Page 94	4 00 00 00 9 4 000	2 Cu 0		4 0 6 8 4 000 3 2 Cu 3 1 5	0000 00 000 00	000 3 00							0 20 Lines				
Page 95	000 3 000 Li 2 1 4 2 0 0	0		6 00 Fe 2 0 0 0 5 3	00	00 Co 1 0											

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0000	000 Cr Fe Co Ti Y	00 Cr Co	0 Fe Fe	1 Ni Ni Fe Fe Ni Cr Fe	2 Fe Fe Ti Ti Ti Ti	3 Cr Fe Fe Ca	4 Fe Fe Fe Fe	5 Fe Fe	6 Fe	7 Higher mg -15 mg -20 mg -30
Ti	Cr Cr Ti	Cr Cr Cr Cr Ti Fe Ni Mn Fe Ti Ti Cr Ti Mn	Cr Cr Cr Ni Fe Fe Ti Ti V Y	Cr Fe Fe	Fe Fe Fe Fe Fe	Fe Fe Fe Fe Fe Ti	Fe	Cr Cr Ti Cr		
Ti	Cr Co Co Ti Ti Ti	Cr Cr Ni Fe Ti	Cr Fe Mn	Cr Fe Fe Fe Fe	Cr Fe Fe Fe Co Ca Ti	Fe Cr Fe Fe	Fe	Fe		Fe - 7
Co	Cr Fe Co Ti	Cr Cr Cr Ni Co Co Ti	Cr Fe Ti Ca	Cr Fe	Ni Fe Cr	Fe Fe Ca Cr Ca Ca Ca Ca	Cr Fe Fe	Fe	Fe	Fe - 8
	Cr Cr Ti	Fe Ti Co Ti Co	Cr Cr Ni Fe Fe Fe Ti	Cr Ti	Cr Cr Fe	Cr Fe	Cr	Fe	Fe	

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	Cr	Ni	Fe	Ce	Co	Zr	Mn	Ca	V	Y
Page 96	07c 2 3 00		1 4 0 2 3 7 1 8 2 2 2 4 6 7		000 0 00 00 17c 000 1 00 00	4	000 01			
Page 97	00 5 4 00 4	1	2 0 1 36 1Co 5 3 6 6 3 2Cr		1 0 1 0 00 1Zr	00	00 00	4		
Page 98	00 000	00 000	0 3 2 6 1 0Cr 00 3 2 1 5 1 3		0000 000		2 1 1			
Page 99	6 00 4	1	3 2 5 6 2 4 5 V 0 6			000 1	0 00 000 0		00	0
Page 100	00	2 000	6 2 5 1 1 1 4 6		00	2	1			

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0000	000 Co Co Mn	00 Co Co Co	0 Cr Fe Cr Fe Co	1 Fe Fe Co Fe Co Mn	2 Cr Fe Fe Fe	3 Cr Fe	4 Fe Fe Ti	5	6 Fe	Higher Fe-7 Fe-8 Fe-7	
		Cr Cr Co Ti Mn Mn	Fe Co Co	Ni Fe Fe Co Co Co Ti	Fe Fe Cr	Fe Cr Fe Fe	Cr Cr Mn	Cr Fe	Fe Fe		
Co	Cr Ni Co	Cr Mn Fe	Fe Fe Cr	Fe Fe Fe Mn Mn	Fe Fe Mn	Fe Fe Fe		Fe	Fe	Fe-7	
	~~Co~~ Ti	Cr Mn Mn V	Cr Fe Mn Mn Y	~~Fe~~ ~~Fe~~ Ni Ni Ti	Fe Fe	Fe	Cr Fe	Fe Fe V	Fe Fe		
	Ni	Cr Co		Fe Fe Fe Mn	Ni Fe Ti		Fe	Fe	Fe Fe		

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	Cr	Ni	Fe	Ce	Co	Li	Mn	Ca	V	Sr	La	Y	Mg
Page 101	000	1	2 4 3 3 0 3 1 1		00	000	000 0			00			
Page 102	00	5- 00	3 1 3 0 1 1 Ti 1 1 3 1 0		1	00 00 00 0			0000				
Page 103		1	5- 5 1 5 000 0 1			0 2 2 2	1 00	4			0000 0	0	
Page 104			0 0 2 2 00 600 0 2 2 1			000 606 00	0 0 0 0						8
Page 105		0	0 3 2 2 2 V 1 3 0 2				000					000	
Page 106		1 1	2 3 3 2 6 6 0 4 0 7 0		~~00~~	00		4					
Page 107		0 0 0 0	1 Ni 1 1 6 1 4 2 6			000 0006		C. 3 4 4 3 3					

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0000	000 Cr Ti Mn	00 Co	0 Fe Mn	Ni Fe Fe	Fe	3 Fe Fe Fe	4 Fe	5	6 Higher
V		Cr Ni Ti Ti Ti	Fe Fe Ti	Fe Fe Fe Fe Ti Fe Fe Fe Co		Fe Fe Fe		Ni	
Fe La			Si Y	Ni Fe Fe	Ti Ti Ti		Ca	Fe Fe Fe	
	Fe Ti Ti	Fe Ti Mn Mn	Fe Fe	Fe	Fe Fe Fe Fe				Mg - 8
	Mn Y		Ni Fe Fe	Fe V Fe	Fe Fe Fe Fe	Fe			
		Co	Fe Fe	Ni Ni	Fe Fe	Fe Fe	Fe Ca	Fe Fe	Fe - 7
	Ti Ti		Ni Ni Ni Ni Fe	Fe Ni Fe Fe Fe	Fe	Ca Ca Ca	Fe Ca Ca	Fe Cu	

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	Cr	Ni	Fe	Ce	Co	Li	Mn	Ca	V	Sc	Si	Y	Na	La	Cu	Mg
Page 108	00	00 1F 0	10 4V 3 1 0 1 3 2						00	1+						
Page 109	00 0	0 1Cr	0Ni 1 0 1 1 2 1 4 0 4 2			0 00 00 0 17Y			000	0+ 0+	1 1	2Sc+				
Page 110		0	3			2 3			0	1+ 0 1+	3		5 6			
Page 111	0 0 0	2 5	2 3 0 1Cr 4 1 3 1 1 5 3 2 0			0 000			1 1 D		3 1 3			0	00	6
Page 112		57Zi	4 4			00 0 2V	1									
Page 113	1	2 5 2	2 2 4 5 0 2 1 1 6			000 0										
Page 114	00	Zi 8 2 3 2 1 0 0 4 0 4	4 1 2 0 1 3 3			0 0Cr					3				3	

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0 0 0 0 | 0 0 0 | 0 0 | 0 | 1 | 2 | 3 | 4 | 5 – 8 Higher

0 0 0 0 | 0 0 0 | Cr Ni V | Ni Ni Fe Fe | Ni? Fe Fe Fe Fe Sc+ | Fe | Fe Fe | Fe V |

| V | Cr Ti Ti | Cr Ni Fe+Ni Fe Fe Ti Ti Sc+ Sc+ | Ni Cr Fe Fe Fe Fe Fe Ti Ti Y Si Si | Fe Fe Sc+ Y | | Fe Fe |

| | | Ni Fe Sc | Sc+ Sc+ | Ti | Fe Fe Si | | Fe Ha | Na |

| Co | Cr | Cr Cr Fe Fe Fe Co V Ha | Fe Cr Fe Fe Fe V V Si | Ni Fe Fe | Fe Fe Fe Si Si | Fe | Ni Fe | Mg |

| | Ti | Ti | Mn | Ti V | | Fe Fe | Ni? Fe | Ti |

| Ti | | Fe | Cr Fe Fe Fe Ti Fe | Ni Ni Fe Fe Fe | Fe | Fe | Ni Fe | Fe |

| | Cr Ti Cr Cr | Cr Cr Fe Ti Ti Cr | Cr Cr Fe Fe | Cr Cr Fe | Cr Fe Fe Si Cr | Cr Cr Fe | | |

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	Ca	Ni	Fe	Ce	Co	Ti	Mn	Ca	V	Zn	Ba	Na	Si	N
Page 115		04	2 4 1 0 5 4 0 1 0			000 0				0				
Page 116		1 1	5 0 1 3				00							
Page 117		3	3 1 2 5 6			3		8 2			5			
Page 118		4	4 0 0									20		
Page 119			0 4 1			1								
Page 120			4 3 2 2 6			0 0								
Page 121			5 1			00							6	
Page 122			4 4 3 4			1 2								0000 0060
Page 123		1 0	5 6 5 2 6			1 0								
Page 124		1 1	1 4 6 4 7 4				6 6 6				000			
Page 125		0 1	3 1 5 5 2 1		000	00 27 2				6 0				
Page 126			6 2 4	2 2 3 6 4 1					9	0				
Page 127	00		0 1 1	3 8 3 7 B w 3 4			1		1 0	1 0 0 0		2		

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.0000	000	00	0	1	2	3	4	5	6 Kayser
	Ti		Ni Fe Fe Fe Fe Fe. Ti Fe	Fe Fe	Fe		Ni Fe Fe	Fe	
			Fe	Ni. Ni Fe		Fe		Fe	
				Fe	Fe Ca	Ni Fe Ti		Fe Fe Ba	Ca - 8
		Fe					Ni Fe		Na V
			Fe	Fe Ti			Fe		
			Ti Ti		Fe Fe	Fe	Fe	Fe	
		Ti		Fe				Fe	Ti
Zn				Ti	Ti	Fe	Fe Fe Fe		
			Ni Ti	Ni Ti	Fe			Fe Fe	Fe Fe
	Ba			Ni Ni Fe			Fe Fe Fe	Fe Mn Mn Mn	Fe - 7
	Co	Ti	Fe V V	Fe Fe Fe	Fe Ti Fe	Fe		Fe Fe	Fe - 7
			V	Fe Fe	Fe Fe Ni	Fe	Fe Ni	Fe Ni	Ca - 9
		Cr V	Ni Ni V	V Ni Ni Ti	Na	Fe Fe Fe	Fe		Ca - 10 Fe - 8 Fe - 7 Fe Ba - 7

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	Cr	Ni	Fe	Co	Ti	Mn	Ca	V	La	Ba	Na	Zn	Sr
Page 128		2 3 5 2 4	5 1 3 6 7 2 5 5 5 1 4 9	00			4 1 5 0 3 5 6 7	000 0			3		
Page 129		1 1 0 67	6 5 6 0 0 0 1 3 3 8 5 0		000 2			000 000 8 7 2 000 00 000					
Page 130			5 3 0 3	2	3 1			000 000 00					
Page 131		4 0	4 0 3 7 5 1 2 7 6 4	2				000 0000					
Page 132	1 17 ±	2 2 0 0 0 0 2 1	2 6 7 2 4 4 6 1 0 1 4 7		000 000	000						1	
Page 133		0 000	8 2 1 5 7 4 7 5 1 2	00 000 0		000	8 6 2						000
Page 134		1	3			000	5 5 6						
Page 135		0	8 2 4 1 2		67		4						

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0000	000	CO	→	1	2	3	4	5	6	Heights
V		Co	U	Fe Fe	Ni Ni	Ni Fe Ca Na	Fe Ca	Ni Fe Fe Fe Ca	Ni Fe Ni Ca	Fe - 9 Ca - 15 Ca - 7
	Ti V V V	Fe Fe V	Ni Fe	Ni Ni Fe Fe	Ti	Fe Fe		Fe Fe	Ni Fe Fe Fe	Fe - 8 V Fe - 8
V	V	V	Fe	Mn	Co	Fe Fe Mn		Fe		
√	V		Ni	Fe Fe	Fe Co	Fe	Ni Fe Fe Fe	Fe	Fe	Fe - 7
	Ti Ti Mn	Ni	Ni Ni Fe	Cr Cr Fe Ni Fe Fe Mn	Ni Ni Ni Fe Fe		Fe Fe Fe		Fe Fe	Fe - 7 Fe - 7
	Ni Mn Cr	Co	Ni Fe Fe Co Co	Fe Fe	Fe Ca		Fe ~~Fe~~	Fe Fe	Ca	Fe - 8 Fe - 7 Fe - 7 ~~Fe~~ Ca - 8
	Mn			Ni		Fe		Ca Ca	Ca	
			Ni	~~Fe~~ Fe	Fe Fe Fe		Fe Ca		2 Fe	Fe - 8

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	Cr	Ni	Fe	Co	Li	Mn	Ca	V	La	Ba	K
Page 136	1	1 00 00	0 5 3 00 6 4 0 0 2 3 0 1		0 1 00		1				40
Page 137	000 00	0 5									
Page 138		4 2	0 2 1 3 1	0	1						
Page 139			1 0 0 1 3 2 2 3 3 3	0							
Page 140	0 1 1				000						
Page 141	0000	4			0000						

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0 0 0 0	0 0 0	0 0 ni ni Fe Ti	0 Fe Fe Cr	Cr ni Ti Ca	2 Fe	3	4 Fe	5 Fe	6 Fe	Higher H. 40
	Cr	Cr Fe	ni Fe		Fe	Fe		ni Fe		
			Fe Co	Fe Fe Ti	ni Fe	Fe	ni	Ca		
			Fe Fe Co	Fe Fe	Fe Fe	Fe Fe Fe Fe				
	Ti		Cr	Cr Cr			ni			
Ti Cr										

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Strongest unblended lines in Sun

	Int.	Line	Series	Russell ⁊		IP	E.P.
Fe	20	3859.055	$1^5D - 1^5D'$	3859.91		(8.15)	0.0
Fe+	4	4584.018	$2^4F - 1^4D'$	4583.84		? 13	2.82
Ti	4	3998.790	$1^3F - 2^3F'$	3998.65		6.5	0.0
Ti+	6	4572.158	$1^2H - 1^2G'$ (1.57)	4572.98		?? 12.5	1.57
	12						
	10						
	3	3234.635	$1^4F - 1^4F'$	3234.52	ult.		0.0
	7	3239.170		3239.03			0.0
Sc	2	4023.834	$1^2D - 5^2D'$	4023.69	ult.	5.4:	0.0
Sc+	5	3589.773	$^3D_2 - {}^3D'$			?12.5	0.0
	4	3630.776	$^3D_2 - {}^3F_3$				
Y	0	3593.040	$^2D_2 - {}^2P_1$			5?	0.0
Y+	3	3710.431	$^3D_3 - {}^3F_4$			?12	0.0
	4	4425.608	$1^3P - 2^3D$				1.88
Ca	20	4226.904	$1S - 1P$			6.09	0.0
Ca+	700	3968.625	$1^2S - 1^2P$			11.82	0.0
Sr	1	4607 3905	$1S - 1P$			5.67	0.0
Sr+	5	4215	$1^2S - 1^2P$			10.98	0.0
Mg	30	5183.791	$1^3P - 1^3S$			7.61	2.67
Mg+	–	–	$2^2D - 3^2F$			14.97	8.83
Mn	7		$1b^5S - 1b^6P$	4030.76		7.41	0.0
Mn+	6	3442.118	$^5P_3 - {}^5D_4$			13	
La	4						
La+	0	3337.630	$1^3D - 1^3P'$	3337.50			
V	42	4594.297	$1^4F - 1^4G'$	4594.10		?10.5	0.0
V+	5	3125.399	$^5F_1 - {}^5G'_2$			?12.5	

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2n c stars

	Sun	ΔP	C stars
Fe + stronger			
Ti + stronger			
Sc + stronger			
V + stronger			
Ca + stronger			
Sr + stronger			
Mg stronger			
Mn stronger			
V + stronger			

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				I.P.	R.P.
Zr	~~8~~	~~3803.533~~	not certainly seen	6?	0.0
Zr+	2	3496.348	$1^4F - 1^4G'$ 3496.17	?	0.0
Cr	48	4254.505		6.72	0.0
Cr+	4	3125.109	$^4D_3 - {}^4F_4$	12.5	

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Not stronger #

Cu stronger

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Changes in strengths of unblended lines from Baxandall

Wavelength	Sun	α Boo	α Ari	α Tau	α Ori
4247 Sc+	..	4	4	3	6
4250 Fe	..	3	3	2	4
4251 Fe	..	5	6	7	6
4252 Cr	1	3	3	3	5
4254 Cr	..	6	8	9	10
4274.9 Cr	..	6	6	8	9
4295 Sc+	..	..	..	..	4
4296.9 Fe+	..	4	3	3	2
4331 Ti+	1	3	3	..	3
4337 Fe	..	5	6	6	6
4339 Cr	3	5	4	5	5
4359 Cr	2	4	4	4	4
4376 Fe	3	5	5	6	7
4379. V	1	4	4	4	5
4394 Ti+	2	4	4	–	2
4398 Y+	1	3	2	3	5
4400 Sc+	1	4	4	5	5
4416 Fe+	1	3	3	3	3
4417 Ti+	1	3	3	3	3
4446 Fe	1	3	2	2	4
4482 Fe	3	5	–	–	8
4501 Ti+	..	4	5	5	6
4555 Ba+	..	4	4	4	6
4571 Mg	3	5	4	..	6
4616 Cr	..	3	3	..	6
4623 Ti	..	3	3	..	5

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Black Pen entries on 18th T° scale
Red " " " ~~Scores~~ T° scale
Brill

Stellar Spectra (MNRAS)

Change in Pe Sum to α Boo	α Boo to α Ari	α Ari to α Tau	α Tau to α Ori	Sum to α Ari	Sum to α Tau	Sum to α Ori	α Boo to α Tau	α Boo to α Ori	α Ori to α Ori
—	0.5 1.0	g 1.2	l 1.8	—	—	—	g 2.2	l 4.0	l 3.0 1.2
—		1.2	V.V2	—	—	—			3.7
	0.4 1.4	1.5							
	l 1.5	l 1.5	l 2.0	—	—	—	l 3.0	l 5.0	l 3.5
—	0.4 1.5	l 1.5	l 2.0	—	—	—	l 3.0	l 5.0	l 3.5
—	l 1.6	2.0	g 2.0	—	—	—	l 3.6	l 5.6	g 4.0
l 3.0*	0.4 1.0	—	—	l 4.0	—	l 7.0	~~2.~~	2.0?	2.5
		1.2 0.8	1.9 0.4 0.6						~~2.5~~ 2.5
l 2.4	0.4 1.4	1.4 1.2	0.6 1.4	l 3.8	l 5.2	l 6.6	1.6 2.9	4.7	2.3
	0.4 1.2	V.~~V~~	1.4	V.V					
	1.2	1.4							
l 3.0*	0.4 1.0	—	—	l 4.0	—	6.0	1.6 3.6	l 3.0	l ~~2~~.5
	0.4 1.2	l 1.3	2.0	l 3.5	l 7.0	l 9.0	l 3.0	l 5.0	l 3.5
l 3.2	0.4 1.6	1.0 2.0	0.6 2.0	l 4.8	l 6.8	l 8.8	3.6	5.6	4.0
l 3.2	0.4 1.6	1.0 2.0	0.6 2.0	l 4.8	l 6.8	l 8.8	3.6	5.6	4.0
l 3.5	g 0.9	0.8 1.2	l 1.7	l 4.4	l 6.6	l 8.3	g 2.1	g 3.8	l 2.9
l 2.9	—	—	—	—	—	l 6.6	—	l 3.7	~~l 6.~~
—	l 1.6	1.0 2.0	l 2.0	—	—	—	l 3.6	l 5.6	l 4.0.
	0.5 1.2	0.8 1.2							
l 2.9	g 1.2	—	—	l 4.1	—	l 6.3	—	l 3.5	l 2.5
	0.4 1.5							l 4	l 2.5
—	0.4 1.5	—	—	—	—	—	—	l 4	l 2.5
l 2.4 (1.5)	1.3	1.6	1.6			6.0	3.4	5.3	3.2

for P_{eo} = 10^{-9} atm.

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On the assumption of the following values for T we have

Sun to α Boo	α Boo to α Ari	α Ari to α Tau	α Tau to α Ori
1.5(1)	1.3(14)	1.6(10)	1.6(5)

Change in Pe and weight

SA p 197

Bill

Adopting ~~Seare's~~ effective temperatures,

G0 = 5460 Sun
K0 = 4240 α Bootis
K5 = 3600 α Tauri ? [4000]
M1 = 3380 α Orionis

α Boo to α Ari	α Ari to α Tau	α Tau to α Ori
0.4 (13)	1.0 (8)	0.6 (5) →

Absolute mag.		log brightness (excl. T term)		
α Boo	1.2	$\frac{\alpha\ Boo}{\alpha\ Ari} = 0.2$	$\frac{\alpha\ Boo}{\alpha\ Tau} = 0.3$	$\frac{\alpha\ Boo}{\alpha\ Ori} = 2.0$
α Tau	0.50			
α Ori	−3.8	$\frac{\alpha\ Ari}{\alpha\ Tau} = 0.1$	$\frac{\alpha\ Ari}{\alpha\ Ori} = 1.8$	$\frac{\alpha\ Tau}{\alpha\ Ori} = 2.1$
α Ari	0.7			

Ratios	log in Pe				
$\frac{\alpha\ Boo}{\alpha\ Ari}$	0.4	$\frac{\alpha\ Boo}{\alpha\ Tau}$	1.4	$\frac{\alpha\ Boo}{\alpha\ Ori}$	2.0
$\frac{\alpha\ Ari}{\alpha\ Tau}$	1.0	$\frac{\alpha\ Ari}{\alpha\ Ori}$	1.6	$\frac{\alpha\ Tau}{\alpha\ Ori}$	0.6

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Comparison

	α Boo / α Ari	α Boo / α Tau	α Boo / α Ori	α Ari / α Tau	α Ari / α Ori	α Tau / α Ori
Ratio in log P_e	0.4	1.4	2.0.	1.0	1.6	0.6
Ratio in log M	0.2	0.3	2.0	0.1	1.8	2.1

In all cases α Tauri is effectively and consistently much too bright, giving values of P_e too small.

Or it might be put into agreement by altering the temperature of α Tauri to 4000° (K2)

Agreement fairly satisfactory.

	Coblentz	Sampson	Seares	[Brill]
α Boo	4000	4200	3860 K0	4240
[α Ari]	3800	3800	3560	3700
α Tau	3500	3400	3270 K5	3600
α Ori	3000	3400	3080 M1	3380

Temperatures in order.

4240
4200
4000
3860
3800
3600
3560
3500
3400
3380
3270
3080 3000

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α Boo, α Ari, α Tau, α Ori

4000	4200	3860
3800	3800	3560
3500	3400	3270
3000	3400	3080

The Hwig is quite uniform, and, for equality of strength, the differences are the same for all.

General discussion, various T° scales

	Cobl.	Samp.	Seares	Sum
4247 Sc+				
4250 Fe				
4251 Fe				
4252 Cr	0.4, 1.8, -	1.4, 1.3 -	0.9, 1.0, -	
4254 Cr	-	-	-	
4275 Cr	0.4, -, -	1.4, -, -	0.9, -, -	4.0, 2.7, 2.7
4295 Sc+				
4297 Fe+				
4331 Ti+	, -, 1.8	, -, 0	, -, 0.8	

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