INTENSITY MEASUREMENTS IN THE SPECTRUM OF NICKEL AND COBALT

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Abstract

Quantitative intensity measurements have been carried out in the Ni I and Ni II, and the Co I spectrum. The spectrographic outfit for the intensity measurements consisted of a stigmatic concave grating mounting used with step weakeners, and a Hilger E 1 used with the method of slit width variation. The *summation rules* have been tested both for *multiplets* and *supermultiplets*, also the intensity ratio for singlets and triplets, doublets and quartets. Serious divergencies have been found everywhere. In the Ni II spectrum an extension of the summation rules to supermultiplets gives better results in several cases. Intensity tables are given of the lines measured.

QUANTITATIVE intensity measurements have been carried out in the nickel I and II and the cobalt I spectrum. In the Ni I spectrum the analysis of Becher and Sommer[1] has been utilized; later on also the very extensive analysis by Russell, obtained through the courtesy of Professor Harrison.[2] For Ni II the analysis has been given by Shenstone;[3] for Co I by Catalan and Bechert.[4]

In the Co II spectrum no intensity measurements have been carried out, the classified multiplets[5] being situated in the far ultraviolet where intensity measurements meet with special difficulties.

Although the material used was the purest Ni and Co that could be obtained, the Ni contained some Fe, and the Co some Fe and Ni as impurities.

The Experimental Methods

In the first measurements for the Ni I spectrum an image of the light source through step-reducers was formed on the slit of a stigmatic concave grating-mounting; the line intensities was determined by the usual method.[6] For the subsequent investigation a Hilger E 1 quartz-spectrograph was used. The density curves were obtained by the method of variable slit width.[7]

Frequently the photometer curves of two or more lines lying close together coalesced. In such cases it is necessary to change the photometer curve accurately point for point into the intensity curve of the complex of

[1] K. Bechert and L. A. Sommer, Ann. d. Physik **77**, 351 (1925) and **77**, 537 (1925).
[2] Afterwards published, Phys. Rev. **34**, 821 (1929).
[3] A. G. Shenstone, Phys. Rev. **30**, 255 (1927).
[4] Catalan and Bechert, Zeits. f. Physik **32**, 336 (1925).
[5] Meggers and Walters. Scientific Papers of the Bureau of Standards No. 551.
[6] L. S. Ornstein, Intensity of Multiple Spectrallines, Proc. Phys. Soc. **37**, 334 (1925).
[7] L. S. Ornstein, Proc. Phys. Soc. **37**, 337 (1925).

lines. The same thing is done for a neighbouring isolated line. It may be assumed that the shape of the intensity curve for all these lines is the same[8] and that therefore the intensity curve of the complex can be analysed into a few separate curves of this shape.

The First Measurements

The Ni I quintet $z^5G^0 - e^5F$ was photographed with the above mentioned concave grating in second order. The results will be found in Table I, and for 0.95 amp. also in an intensity scheme (Table II).

Table I. *Intensities of the lines of the $z^5G^\circ - e^5F$ multiplet of Ni I.*

Line λ	Intensity 1.4 amp.	Intensity 0.95 amp.	Line λ	Intensity 1.4 amp.	Intensity 0.95 amp.
4900.97	1	~1	4714.416	100	100
4874.803	1.1	~1	4686.209	11	11
4814.59	0.95	~1	4648.656	40	44
4786.541	38	41	4604.990	27	25
4756.529	26	29	4600.364	10	9.5
4715.757	22	24.5	4592.532	17	16

Table II. *Intensity scheme for the $z^5G^\circ - e^5F$ multiplet of Ni I.*

Statistical Weight		z^5G^0 5	7	9	11	13	Sum	Quotient
	3	9.5					9.5	3.2
	5	11	16				27	5.4
e^5F	7	~1	24.5	25			50.5	7.2
	9		~1	29	44		74	8.2
	11			~1	41	100	142	12.9
Sum		21.5	41.5	55	85	100		
Quotient		4.3	5.9	6.1	7.7	7.7		

According to the summation rule the quotients in Table II ought to be equal. The divergencies are serious, as will be seen. Self-reversal cannot be the cause of this divergency for it would diminish the contrasts, whereas the divergencies lie in the opposite direction.

Although in the case under consideration the summation rule does not determine the intensity of each line separately, it gives the ratio of the extreme diagonal terms; this ought to be 27:91 i.e. 29.7:100. As this is a sensitive test, the intensity ratio between these two lines has been measured several times. (Table III).

Table III.

Current	Int. proportion
2.4	10. 9:100
1.4	10.15:100
1.4	9.9 :100
0.95	9.3 :100
0.95	9.6 :100

[8] L. S. Ornstein and M. Minnaert, Zeits. f. Physik **43**, 404 (1927).

As blending with impurity lines is out of question, the experimental ratio 9.6:100 differs from the theoretical 29.7:100.

In order to get more facts the measurements have been continued with the Hilger E 1 in the ultraviolet. Here fairly large regions could be photographed at once and with a sufficient dispersion.

The current used was the smallest possible (about 0.45 amp.) A preliminary examination with 0.80 and 0.45 amp. showed that difference between the intensities found for these currents is comparatively small.

A few intensity measurements have also been carried out in an arc with a pressure of 50 and 28 cm of air. These also did not show any appreciable difference for the intensity. Therefore the definitive measurements for Ni I and CO I have been carried out with a current of 0.45 amp. in air.

In the Ni II investigation a Leyden jar was charged by the secondary tension of an induction coil. The spark discharge of the jar took place via a self-induction between two small bars of nickel. Variations of the conditions of discharge could not be used here. Only, to get a current of small density, a Leyden jar of the smallest possible capacity was chosen.

The Definitive Measurement

In each of the three spectra mentioned a region has been chosen in which a number of multiplets, suitable for intensity measurements was situated. The region was situated for Ni I between 2900 and 3800A, for Ni II between 2450 and 3770A for Co I between 2500 and 4500A.

Besides the multiplets the intensities of all the lines appearing in the photographs have been measured. In the tables the intensities found by analysis of the photograms have been marked (1) when the analysis was certain, (2) when it was less certain and (3) when the analysis was very doubtful. Intensities marked (4) are inexact, owing to the slight density and the great influence of the irregularities which the photometer curve shows in the unexposed plate for that case. The tables are the least complete on the side of the largest wave-lengths where the dispersion was so small that several lines had to be omitted. The experimental facts have been used for testing: (1) the multiplet summation rules; (2) the supermultiplet summation rules; and (3) the intensity ratio for singlets and triplets, doublets and quartets. Generally the theoretical expectations are not fulfilled. For this reason we have limited our measurements to the spectral regions given below. Perhaps our material will be of some help in developing the intensity rules for the complicated spectra.

The Ni I Spectrum

Besides the quintet $z^5G^0-e^5F$ already mentioned 13 multiplets have been examined.

The intensities in horizontal and vertical direction have been formed and the quotients of intensity sums and statistical weights have been calculated in the same way as has been done for $z^5G^0-e^5F$, the results are collected in Table IV.

TABLE IV. *Intensity quotients in multiplets of Ni I.*

No.	Multiplet Designation	Quotients									
1	$a^3D-y^3D^0$	35	28	17			36	29	16		
2	$a^3F-y^3D^0$	11.7	6.2	5.8			9.1	3.9	3.8		
3	$a^3D-y^3F^0$	34	18	7.4			25	25	23		
4	$a^3F-y^3F^0$	10	7.5	3.2			2.4	7.0	7.8		
5	$a^3F-z^3G^0$	3.2	6.5	4.2			2.6	8.5	6.1		
6	$a^3P-v^3D^0$	0.4	0.4	0.4			0.8	0.8	0.7		
7	$a^3D-z^3G^0$	4.5	1.7				6.2	2.3			
8	$a^3D-z^3F^0$	31	22	10			30	28	24		
9	$a^3D-z^3D^0$	23	[25]	18			[37]	29	10		
10	$a^3F-z^3D^0$	22	21.6	10.3			23.3	10.1	6.6		
11	$a^3F-z^3F^0$	21	12.1	5.9			12	17.6	6.7		
12	$a^3D-z^3P^0$	70	51	33			49	28	14		
13	$a^3F-z^3P^0$		4.3	2.4			3.1	1.4			
14	$z^5G^0-e^5F$	3.2	5.4	7.2	8.2	12.9	4.3	5.9	6.1	7.7	7.7

The quotients [25] and [37] have been deduced from sums containing a line, ordered doubly, so that they are too high by an unknown amount.

Only the multiplet 6 is in accordance with expectation (and multiplet 3 in one direction). In the case of all other multiplets the summation rules do not apply. In the case of the incomplete multiplets, e.g. $2^5G^0-e^5G$ it also appears from the intensities of the lines present that the summation rule will not hold.

Supermultiplets. If singlet, triplet and singlet-triplet intercombinations are taken together, no satisfactory results are reached (Table V).

TABLE V. *Supermultiplet sums and quotients of intensity.*

Statistical weight	a^3D 3	5	7	a^1D 5	Sum	Quotient
y^3D^0 3	61	43		39	143	48
5	47	55	40	20	162	32
7		48	71	43	162	23
y^1D^0 5	8.7	23		72	103.7	21
Sum	116.7	169	111	174		
Quotient	39	34	16	35		

In the same way the quotients in Table VI are found.

TABLE VI.

Combinations	Quotients							
$a^3D, a^1D-z^3D^0, z^1D^0$	24	[35]	28	22	[38]	32	11	42
$a^3D, a^1D-y^3F^0, y^1F^0$	34	25	7	15	25	25	28	25
$a^3D, a^1D-z^3F^0, z^1F^0$	36	33	10	33	30	39	31	46

Again, when either the multiplets or all the lines, coming from the same term, are taken together the summation rules do not apply, e.g. for y^5D^0: (Table VII).

TABLE VII.

Statistical weight	a^3F 5	7	9	a^3D 3	5	7	a^1D 5	Sums	Quotient
3	35			61	43		39	178	59
y^3D^0 5	5.2	26		47	55	40	20	193.2	39
7	5.2	1.3	34		48	71	43	202.5	29

Now we add up in Tables VIII and IX the spectral lines originating from the same level.

TABLE VIII.

	a^3F 5	7	9
z^1G^0		31	
z^3G^0	13	59.3	54.8
z^5G^0	1.6	11.8	22.2
z^1F^0	30	51	32
z^3F^0	60.4	123.3	60
z^5F^0	41.4	46.5	57.9
y^1F^0	1.7	5.0	4.7
y^3F^0	12	49.2	70
z^1D^0	1	54	
z^3D^0	116.3	71	59
z^5D^0		0.65	2.1
y^1D^0	10.5	4.2	
y^3D^0	45.4	27.3	34
z^1P^0	3.8		
z^3P^0	15.5	9.5	
Sum	352.6	543.8	396.7
Quotient	71	78	44

TABLE IX.

	a^3D 3	5	7
z^1G^0			42
z^3G^0		31	15.8
z^5G^0	1.7	20.7	23
z^1F^0		55	50
z^3F^0	91	139	168
z^5F^0	36	93.3	114.4
y^1F^0			31
y^3F^0	74	125	164
z^1D^0	2.4	13	2.8
z^3D^0	[110]	145	71.4
z^5D^0	0.8	3.7	[28]
y^1D^0	8.7	23	
y^3D^0	108	146	111
z^1P^0	17	40	
z^3P^0	146.6	140	100
	596.1	974.7	918.4
	199	195	131

Here the divergencies are smaller than for the separate multiplets. Still it is not very likely that the few multiplets still wanting will be able to equalize the quotients.

According to Mack[9] the multiplets arranged in Table X belong together. Equal quotients are not obtained in this way either. Especially the first column shows a great divergence.

Finally we shall consider the ratio between the sums of the intensities for the corresponding singlet-triplet multiplets. When intercombinations are absent a ratio of 1:3 can be expected.[10] The values found for our case are shown in Table XI; the last column contains the ratios after dividing the intensities by the fourth power of the frequency. There is a fairly great difference between the experimental and the theoretical ratios. However, fairly strong intercombinations are present in all 5 cases.

Table XII contains the intensities for all the lines in the spectral region investigated; an (arbitrary) intensity of 100 has been awarded to the line 3524.543.

[9] J. E. Mack, Phys. Rev. **34**, 17 (1929).

[10] L. S. Ornstein and H. C. Burger, Zeits. f. Physik **40**, 403 (1926).

TABLE X.

Statistical weight		a^3D 7	a^3D 5	a^3D 3	a^1D 5	Sum	Quotient
z^3F^0	9	93				93	10
	7	66	86		78	230	33
	5	[9]	53	91	[27]	180	36
z^3D^0	7	66	64		65	195	28
	5	5.4	80	41	50	176.4	35
	3		1	69	3	73	24
z^3P^0	5	100	54	9.6	4	167.6	34
	3		86	67	9.5	162.5	54
	1			70		70	70
z^1F^0	7	50	55		124	229	33
z^1D^0	5	2.8	13	2.4	93	111.2	22
z^1P^0	3		40	17	106	163	54
Sum		392.2	532	367	559.5		
Quotient		56	106	122	112		

TABLE XI.

Combinations	Ratio	
$a^1D-y^1D^0$ and $a^3D-y^3D^0$	1:5.1	1:5.1
$a^1D-y^1F^0$ and $a^3D-y^3F^0$	1:4.8	1:4.5
$a^1D-z^1F^0$ and $a^3D-z^3F^0$	1:3.1	1:2.6
$a^1D-z^1D^0$ and $a^3D-z^3D^0$	1:3.5	1:3.2
$a^1D-z^1P^0$ and $a^3D-z^3P^0$	1:3.6	1:4.4

TABLE XII. *Intensities of Ni I lines.* Intensities marked (1) are certain, (2) less certain, (3) doubtful, (4) inexact because of small intensity and the influence of irregularities inthe plate.

λ (Kayser)[1]	λ(I.A.)	Int.	λ (Kayser)	λ(I.A.)	Int.	λ(Kayser)	λ(I.A.)	Int.
2798.78	2798.651	23	3012.11	3012.007	72	3165.64	3165.513	0.8
2802.40	2802.28	3.1	3018.09	3017.96	0.3 (4)	3170.86	3170.73	0.3
2803.25	2803.15	1.4	3019.28	3019.150	42	3176.44	3176.30	0.4
2805.20	2805.081	4.7	3029.36	3029.30	0.6	3181.89	3181.75	3
2814.48	2814.37	0.5	3031.98	3031.869	28	3183.14	3183.05	0.8 (3)
2821.42	2821.296	31	3038.04	3037.940	55	3183.40	3183.26	1.9 (3)
2834.66	2834.550	4.2	3045.15	3045.012	26	3184.50	3184.372	11
2839.05	2838.97	1.3	3048.98		0.4	3191.97	3191.89	0.2
2849.93	2849.84	0.5	3050.92	3050.828	67	3195.67	3195.577	5.2
2865.61	2865.508	8.7	3054.42	3054.317	53	3197.22	3197.121	17
2868.85	2868.76	0.9	3057.76	3057.647	61	3199.44	3199.36	0.2
2905.85	2905.76	0.5	3064.75	3064.626	48	3200.50	3200.433	2.8
2907.58	2907.462	10.5	3066.59	3066.46	0.4	3202.21	3202.149	1.7
2914.12	2914.013	5.0	3080.91	3080.758	47	3207.05	3206.963	0.2
2916.95	2916.85	0.2 (4)	3097.27	3097.120	39	3210.00	3209.910	0.9
2917.60	2917.53	0.2 (4)	3099.25	3099.117	31	3213.53	3213.435	0.5
2931.03	2930.93	0.3 (4)	3101.67	3101.563	72 (1)	3214.17	3214.064	3.7
2932.74	2932.63	0.3 (4)	3101.99	3101.881	76 (1)	3216.93	3216.823	1.3
2944.06	2943.922	40	3105.60	3105.466	35	3217.93	3217.828	5.8
2958.39	2958.29	0.7	3107.83	3107.717	1.3	3219.92	3219.810	0.4
2969.30	2969.20	1.2	3114.26	3114.128	40	3221.41	3221.28	1.9 (1)
2973.84	2973.73	0.4	3116.84	3116.700	0.2 (4)	3221.81	3221.661	32
2981.80	2981.652	43	3129.42	3129.310	5.2	3223.66	3223.542	0.7
2983.56	2983.42	3.1	3132.68		0.3 (4)	3225.19	3225.030	39
2984.28	2984.129	34	3134.22	3134.106	74	3227.11	3226.992	8.4
	2991.103	1.7	3145.23	3145.117	0.4 (1)	3233.06	3232.945	46
2992.71	2992.597	42	3145.82	3145.707	9.5 (1)	3234.00	3233.88	0.7
2994.58	2994.458	42	3151.33	3151.29	0.15	3234.78	3234.658	31
3002.58	3002.492	71	3154.68	3154.58	0.5	3235.86	3235.764	1.0
3003.70	3003.628	55	3159.65	3159.524	0.7	3243.20	3243.064	50
3010.96		0.3	3164.30	3164.17	0.3	3245.47	3245.35	0.2

[1] H. Kayser. Handbuch der Spektroskopie.

TABLE XII (*continued*)

λ(Kayser)	λ(I.A.)	Int.
3248.56	3248.44	15
3249.55	3249.440	3.8
3250.90	3250.749	20
3264.56	3264.44	0.1 (4)
3268.21	3268.09	0.3
3269.08	3268.96	0.08 (4)
3271.25	3271.118	13
3273.62	3273.50	0.15 (2)
3276.66		0.15
3277.35	3277.23	0.15
3282.03	3281.876	0.5
3282.81	3282.701	9.3
3284.56	3284.432	0.4
3287.08	3286.953	9.0
3293.83	3293.674	0.4
3296.42	3296.264	0.15
3305.10	3304.951	0.7
3307.16	3307.014	0.2
3309.56	3309.44	0.2
3310.35	3310.206	1.9
3312.49	3312.319	2.8
3313.15	3312.992	0.7
3315.82	3315.668	55
3320.42	3320.259	54
3322.50	3322.316	43
3326.80	3326.673	0.4
3327.52	3327.402	0.6
3328.85	3328.720	1.0
3332.31	3332.19	0.5
3335.72	3335.59	0.06
3337.15	3337.015	0.4
3338.90	3338.763	0.1 (2)
3339.20	3339.049	0.4 (2)
3359.30	3359.104	1.4
3361.75	3361.557	53
3362.97	3362.808	2.4
3363.76	3363.612	0.6
3364.75	3364.590	1.1
3365.92	3365.771	48 (1)
3366.32	3366.169	51 (1)
3366.95	3366.808	4.5 (1)
3368.05	3367.892	5.4
3369.71	3369.576	59
3372.19	3371.995	50
3374.42	3374.228	33 (1)
3374.82	3374.637	11 (1)
3375.70	3375.560	0.5
3376.46	3376.330	0.8
3380.71	3380.577	106 (3)
3381.01	3380.885	13 (3)
3387.54	3387.467	0.3
3391.20	3391.051	48
3393.10	3392.993	66
3396.31	3396.174	0.6
3397.37	3397.28	0.1
3401.31	3401.164	1.9
3403.58	3403.427	2.2
3409.74	3409.579	12
3413.66	3413.478	55 (1)
3414.12	3413.943	34 (1)
3414.91	3414.771	93 (1)
3420.88	3420.742	1.0
3421.49	3421.339	2.3
3422.47	3422.334	0.7
3423.00	3422.870	1.3
3423.87	3423.713	69
3433.74	3433.565	66
3435.63	3435.495	0.5
3437.45	3437.283	53
3442.17	3442.017	0.9
3442.67	3442.540	0.4
3443.14	3443.00	0.2 (4)
3444.36	3444.247	0.8
3446.40	3446.263	80
3453.02	3452.891	59
3458.60	3458.467	91
3461.80	3461.660	78
3464.25	3464.12	0.3 (4)
3467.61	3467.505	23
3469.65	3469.484	30
3472.71	3472.545	64
3476.80	3476.66	0.4
3478.00	3477.876	0.2 (4)
3478.42	3478.302	0.4
3479.36	3479.263	0.5
3480.30	3480.170	0.4
3483.98	3483.776	66
3486.09	3485.892	14
3488.43	3488.293	0.4
3493.11	3492.965	86
3496.47	3496.352	0.8
3501.02	3500.852	58
3502.73	3502.604	4.9
3507.85	3507.695	6.5
3510.52	3510.340	70
3512.08	3511.94	0.4
3514.10	3513.947	22
3515.21	3515.057	86
3516.33	3516.220	3.5
3518.80	3518.635	2.3
3519.97	3519.776	51
3523.23	3523.075	4.6 (2)
3523.61	3523.445	11 (2)
3524.68	3524.543	100
3526.67	3526.53	1.0
3528.13	3527.988	13
3529.02	3528.890	0.6 (1)
3529.76	3529.625	0.5 (1)
3530.73	3530.588	0.9
3537.35	3537.243	0.3 (4)
3537.72	3537.634	0.4 (2)
3542.14	3542.00	0.3 (4)
3545.30	3545.16	0.3 (4)
3548.32	3548.189	41
3551.71	3551.563	5.3
3553.64	3553.483	1.7
3560.05	3559.925	0.4
3561.90	3561.752	8.2
3566.51	3566.373	93
3572.02	3571.871	63
3576.08	3575.94	0.4
3577.36	3577.23	0.4
3588.07	3587.928	12
3597.86	3597.699	67
3599.66	3599.530	0.3
3602.41	3602.278	17
3607.00	3606.853	0.4
3609.48	3609.312	19
3610.61	3610.45	54
3612.90	3612.732	50
3619.52	3619.391	124
3624.89	3624.733	14
3630.01	3629.891	0.3
3635.10	3634.943	3.0
3641.75	3641.632	0.3
3642.52	3642.383	0.2 (4)
3662.10	3661.938	1.7
3664.27	3664.089	13
3666.16		0.2 (4)
3668.36	3668.200	0.4 (1)
3669.40	3669.233	6.6
3670.60	3670.424	9.5
3674.30	3674.105	27
3688.59	3688.413	9.4
3694.07	3693.933	2.8
3697.05	3696.904	0.25
3713.84	3713.696	0.2 (4)
3715.65	3715.498	0.2 (4)
3722.64	3722.484	9.6
3724.95	3724.815	0.25
3729.06	3728.919	0.2 (4)
3730.90	3730.745	0.5
3736.98	3736.811	20
3739.40	3739.229	5.2
3739.94	3739.787	1.5
3744.72	3744.560	0.5
3749.19	3749.042	2.1
3762.76	3762.62	0.3
3769.60		0.15 (4)
3772.67	3772.518	0.7
3775.75	3775.562	50
3778.20	3778.048	0.9
3783.72	3783.521	51
3792.48	3792.325	1.1
3793.79	3793.599	2.5
3807.35	3807.135	65
3811.46	3811.32	0.08 (4)
3831.89	3831.685	9.5
3833.00	3832.865	0.65
3844.40	3844.27	0.2 (3)
3844.71	3844.58	0.15 (3)
3858.51	3858.284	78
3863.21	3863.08	0.3
3889.84	3889.673	0.9
3909.10	3908.93	0.3
3912.47	3912.31	0.2 (2)
3913.14	3912.975	0.15 (2)
3942.00	3941.86	0.1
3944.29	3944.10	0.4
3954.70	3954.53	0.1
3962.25	3962.10	0.1
3970.65	3970.49	0.35
3972.32	3972.157	1.4
3973.71	3973.547	4
3974.82	3974.681	0.35
3984.29	3984.17	0.2
3994.15	3993.97	0.1
4006.30	4006.14	0.01
4010.14	4009.99	0.007 (4)
4017.67	4017.56	0.15
4019.20	4019.055	0.06
4025.60	4025.44	0.1
4057.45	4057.30	0.1
4064.55	4064.380	0.05
4069.39	4069.24	0.015 (4)
4073.08	4072.93	0.01 (4)
4075.00	4074.897	0.015 (4)
4086.30	4086.15	0.01 (4)
4098.30		0.01 (4)
4116.11	4115.980	0.04
4121.48		0.015 (4)
4123.94	4123.79	0.01 (4)
4138.67	4138.52	0.01 (4)
4150.53	4150.37	0.03
4164.80	4164.636	0.02
4167.07	4166.96	0.02
4184.65	4184.473	0.07
4195.72	4195.533	0.1
4200.60	4200.466	0.15
4201.89	4201.728	0.15

The Ni Spark Spectrum

Eight doublets and 4 quartets have been measured; the quotients of intensity sums and statistical weights are found in Table XIII.

Table XIII.

	Multiplet Designation	Quotients							
1	$a^4D^1-d^4F^1$	—	1.2	1.0	1.3	—	1.7	1.4	1.65
2	$a^2P^1-b^2P$	5	4.95			5.8	4.55		
3	$a^2P^1-b^2D^1$	0.5	0.05			0.07	0.5		
4	$a^4G^1-d^4F^1$	1.6	2.0	2.35	2.9	1.9	1.7	2.0	1.8
5	$a^2G^1-d^2F^1$	1.6	2.1			1.7	1.3		
6	$a^4F-d^4F^1$	2.85	1.9	1.5	1.15	1.85	1.4	1.7	1.7
7	$a^2F-d^2F^1$	1.6	1.0			1.3	1.2		
8	$a^2D^1-d^2F^1$	0.87	0.85			1.3	1.1		
9	a^2G-b^2F	0.6	0.9			0.5	0.7		
10	$a^2D-a^2D^1$	2.8	1.1			2.6	1.3		
11	a^2D-a^2F	0.47	0.04			0.15	0.4		
12	$a^4P^1-a^4D^1$	3.2	2.15			5.0	3.25	0.85	—

For some of the multiplets the disagreement with the summation rule is not very great, for others, however, the divergencies are wide, e.g. in the case of Nos. 3 and 11, where the diagonal terms are by far the weakest.

Adding up the doublet and quartet systems and the intercombinations, we get the quotients of Table XIV.

Table XIV.

Combinations	Quotients											
a^4D^1, $a^4D^1-d^4F^1$, d^2F	—	1.5	1.65	1.3	0.9	0.85	—	1.7	1.4	1.65	1.7	2.0
a^4G^1, $a^2G^1-d^4F^1$, d^2F^1	1.6	2.0	2.35	2.9	1.6	2.1	1.9	1.7	2.0	1.8	1.7	1.3
a^4F, $a^2F-d^4F^1$, d^2F^1	2.85	1.9	1.7	1.16	1.6	1.15	1.85	1.4	1.7	1.8	1.3	1.5

If we add the multiplets which in the quartet systems start from a^4D^1, we find the quotients shown in Table XV.

Table XV.

Statistical weight	a^4D^1 1	2	3	4	a^4F^1 2	3	4	5	a^4G^1 3	4	5	6	Sum	Quotient
2					3.7	2.0			3.2				8.9	4.5
d^4F^1 3		3.4	0.3			2.3	3.5		2.5	3.5			15.5	5.2
4			4.0				3.3	2.6		3.3	6.1		19.3	4.8
5				6.6				5.8			3.8	10.7	26.9	5.4
Sum	—	3.4	4.3	6.6	3.7	4.3	6.8	8.4	5.7	6.8	9.9	10.7		
Quotient	—	1.7	1.4	1.7	1.9	1.4	1.7	1.7	1.9	1.7	2.0	1.8		

There is comparatively little difference between these quotients. If we add to them the small number of intercombinations that occur, we find 4.5|5.4|5.7|5.4|.

In the same way we find:

Table XVI.

	a^2D^1 2	3	a^2F 3	4	a^2G^1 4	5	Sum	Quotient
3	2.6		3.8	0.9	4.8		12.1	4.03
d^2F^1 4		3.4		4.0	1.9	6.6	15.9	3.98
Q tient	1.3	1.1	1.3	1.2	1.7	1.3		

These results are satisfactory if the occurring intercombinations are added, the quotients become 4.03 and 4.12.

In our material these two multiplets are the only ones which start from the same level. The quartet $a^4P^1-a^4D^1$ has the same original level as number of intercombinations. But we cannot conclude from these measurements, as there are other lines in the part of the spectrum that has not been examined which start from the same level. However, it is remarkable that the intensity ratios of this quartet are largely corrected by the additions of the intercombinations.

TABLE XVII.

	a^4P^1 1	a^4P^1 2	a^4P^1 3	a^2F^1 3	a^2F^1 4	a^2D 2	a^2D 3	Sum	Quotient
a^4D^1 1	2.7	0.5				0.5		3.7	3.7
2	2.3	2.0		0.4		1.0	0.4	6.1	3.6
3		4.0		0.9	1.1	1.3	3.9	11.2	3.7
4			2.6		2.7		7.2	12.5	3.1

In combining lines with a common final level we again meet with the difficulty that our materials are not complete; various lines that ought to be included do not occur in the spectral region that has been examined. Still the influence of the additions of the other intensities can be seen from Table XVIII.

TABLE XVIII.

	a^2D 2	a^2D 3
a^2F	0.3	1.25
a^2D^1	5.2	3.8
a^4D^1	2.8	11.5
a^4F	0.5	0.3
Sum	8.8	16.85
Quotient	4.4	5.6

	a^2P^1 1	a^2P^1 2
b^2D^1	0.07	1.05
b^2P	5.8	9.1
b^4D^1	1.2	
b^4P	1.0	2.8
a^2F		0.2
b^2F		0.4
Sum	8.07	13.55
Quotient	8.1	6.8

	a^4P^1 1	a^4P^1 2	a^4P^1 3
a^4D^1	5	6.5	2.6
a^2D^1		1.7	2.7
a^2F			1.2
a^4F		0.3	
Sum	5	8.5	6.5
Quotient	5	4.3	2.2

We have considered also the intensity ratio for doublet-quartet systems.

TABLE XIX.

Combinations	Ratio
$a^2D-d^2F^1$ and $a^4D^1-d^4F^1$	1:1.6
$a^2G^1-d^2F^1$ and $a^4G^1-d^4F^1$	1:2.4
$a^2F-d^2F^1$ and $a^4F-d^4F^1$	1:2.4

The last column is found after division by ν^4. The ratio 1:2 is found only approximately; this cannot be attributed to the occurring intercombination lines (3, 2 and 0 respectively) as in the last case where they do not occur, the divergency is the same as in the other two.

In the following intensity table (Table XX) an intensity of 100 has been awarded to line 2437.884.

TABLE XX. *Intensities of the lines of Ni II.* Intensities marked (1) are certain, (2) less certain, (3) doubtful, (4) inexact because of small intensity and irregularities in the plates.

λ (Kayser)	λ (I.A.)	Int.
2416.21	2416.13	29
2419.40		0.8
2429.17		0.5 (4)
2431.65	2431.57	1.2
2433.64	2433.57	6.7
2437.98	2437.884	100
2441.77		1.0
2441.90		0.6
2451.05		0.8
2454.09		0.6
2455.60	2455.51	1.8
	2459.32	0.3
2465.34		0.2
2472.27		1.0
2473.28	2473.13	13.4
2476.96		0.8
2484.41	2484.32	6.6
2497.92	2497.80	1.0
2503.47		0.8
2505.94	2505.84	7.3
2511.00	2510.87	98
2514.85	2514.75	3.4
	2520.33	0.15
	2525.42	4.0
2539.20	2539.09	2.6
2540.14		2.0
2546.01	2545.90	21
	2547.16	0.5 (4)
	2549.56	1.8
	2551.04	1.1
	2555.13	3.5
2557.98	2557.88	0.9
	2560.30	3.2
	2565.36	0.6 (4)
2566.12	2566.08	6.1
2584.10	2584.01	3.2
	2587.25	0.4
2588.40	2588.31	0.4
	2592.54	0.07
2601.22	2601.126	3.8
	2605.45	2.5
2606.50	2606.40	4.8
2610.20	2610.08	10.7
2611.78	2611.66	1.6
2615.29	2615.20	6.6
2623.25	2623.10	0.3 (4)
	2626.57	3.3
2630.40	2630.29	2.7
	2631.52	2.0
2632.98	2632.86	3.5
2647.15	2647.04	2.6
2648.85	2648.72	0.9
2655.6	2655.46	0.9 (2)
2656.05	2655.90	3.7 (1)
2659.8		2.5
2665.39	2665.25	2.0
2666.00	2665.86	0.8
2670.45	2670.33	1.0
2679.35	2679.25	2.3
2684.57	2684.41	5.8
2690.8	2690.62	1.9
2708.9	2708.78	3.3
2743.1	2743.01	4.0
2746.85		1.4
2759.15	2759.02	3.8
2760.82	2760.67	1.1
2768.9	2768.78	3.4
2775.45	2775.31	2.6
2794.93		0.7 (4)
2798.75		1.8
2802.4		0.2 (4)
2805.20		0.2 (4)
2805.80	2805.67	3.6
2808.47	2808.35	0.4
2821.45		2.3
	2825.23	1.1

λ (Kayser)	λ (I.A.)	Int.
2834.66		0.7
	2836.58	1.0
2842.55	2842.41	1.9
2863.84	2863.69	5.2
2864.4	2864.16	2.6
2865.63		0.6
	2881.24	0.3
	2882.54	0.8
2907.10		0.4
2913.71	2913.59	3.4
2914.11		0.2 (3)
	2942.71	0.15 (4)
2944.03		4.8
2947.56	2947.45	1.7
2969.32		0.6
2981.81		5.7
2984.30		2.8
2988.21	2988.05	1.2
2992.75		4.2
2994.60		6.6
3002.65		19
3003.76		15
3012.14		19
3019.27		3.7
3032.00		1.3
	3032.44	0.3
3038.09		13
3045.16		1.2
3050.99		21
3054.46		12
3057.79		16
3064.12	3063.93	0.5
3064.76		5.0
3080.90		3.5
3087.20	3087.07	2.7
3097.26		2.0
3099.26		1.5
3101.70		21 (3)
3102.02		12 (3)
3105.60		1.7
3114.25		2.2
3129.40		0.2
3134.21		16
3197.24		1.4
3214.21		1.2
3216.95		1.0
3217.95		2.0
3221.43		1.0
3221.80		2.2
3225.18		3.0
3227.14		1.0
3233.05		9.8
3234.76		2.5
3243.20		6.0
3248.57		1.1
3249.55		0.8
3250.90		1.7
3271.26		0.8
3275.03	3274.90	0.4
3282.85		0.8
3282.97		0.3 (3)
3287.06		0.5
3290.70	3290.54	0.3 (2)
3290.83	3290.69	0.5 (2)
3305.10		0.3 (4)
3312.46		1.0
3313.12		0.6
3315.80		7.0
3320.41		4.4
3322.46		3.1
3326.85		0.2 (4)
3350.56	3350.42	1.0
3359.24		0.4
3361.73		5.0
3362.94		0.2 (4)
3365.90		4.0 (1)

λ (Kayser)	λ (I.A.)	Int.
3366.31		4.3 (1)
3366.92		1.7 (1)
3369.71		20
3372.14		4.6
3374.13	3373.98	3.9 (3)
3374.36		2.9 (3)
3374.77		1.6 (3)
3380.74		21.5 (2)
3381.04		6.5 (2)
3391.20		11.4
3393.16		23
3396.25		0.5
	3397.82	0.2 (4)
3401.30		0.5
3401.90	3401.76	0.5
3403.45		0.8
3407.43	3407.30	2.7
3409.70		0.9
3413.61		5.0
3414.05		2.5
3414.91		34
3421.47		0.6
3423.88		14
3433.70		17
3437.42		14
3446.41		22.5
3453.06		12.5
3454.29	3454.16	1.3
3458.62		28
3461.84		23
3465.77	3465.62	2.0
3467.63		1.1
3469.61		2.0
3471.50	3471.35	2.3
3472.71		13.4
3483.95		7.2
3486.05		0.6
3493.13		25.5
3501.04		5.6
3502.74		0.3 (4)
3507.84		0.5
3510.52		15
3511.8		0.3 (4)
3514.13	3513.95	7.2
3515.21		30
3516.32		0.8
3518.76		0.5
3519.90		3.4
3524.69		33
3528.10		0.7
3548.32		2.4
3551.70		0.4 (4)
3553.65		0.4 (4)
3561.92		0.5
3566.55		23
3572.06		7.5
3576.91	3576.76	4.0
3588.07		0.5
3597.86		7.7
3602.44		0.9
3609.49		1.5
3610.68		8.1
3612.91		3.9
3619.54		25
3624.89		0.9
3664.26		1.1
3670.59		1.0
3674.29		1.2
3688.57		0.5
3722.62		0.5
3736.96		0.8
3739.38		0.4 (4)
3769.62	3769.45	2.6
3775.74		3.1
3783.67		3.6
3807.29		5.1
3858.50		9.7

The Co I Spectrum

In Table XXI the computed quotients are given for all the multiplets measured. The indication of the multiplets is that of Catalan and Bechert. The quotients with question marks between brackets are too large, owing to lines which are ordered doubly in the multiplets to which they refer. In quartet No. 30 one of the lines in the multiplet itself has been ordered doubly; 4 quotients had therefore to be left out.

Table XXI

No.	Level	Quotients											
4	F^1-D^1	40	46					29	34				
5	F^1-D^2	108	56					73	42				
6	$F^1-\bar{F}^1$	35	34					26	41				
7	$F^1-\bar{F}^2$	75	67					102	47				
8	F^1-G^1	72	61					77	90				
9	F^1-G^2	98	47					95	85				
15	p^2-d^3	6.1	6.5	7.5	8.0			10.3	8.3	15.5			
19	f^1-d^1	99	80	78	41			89	83	41	13		
20	f^1-d^2	16	16	15	10			10	12	11	6		
21	f^1-d^3	20	20	16	11			23	15	8	4.4		
22	f^2-d^1	35	76	71	52			29	54	51	38		
23	f^2-d^2	155	115	83	51			135	78	62	18		
24	f^2-d^3	4.4	4.8	7.4	7.6			5.7	5.9	6.4	2.4		
25	$f^1-\bar{f}^1$	89	72	[82]	30			75	70	60	[55]		
26	$f^1-\bar{f}^2$	59	30	22	17			38	36	29	17		
28	$f^2-\bar{f}^1$	[2.3]	2.4	3	7.7			1.0	[2.1]	3.5	8		
29	$f^2-\bar{f}^2$	132	118	[98]	49			157	[127]	79	49		
30	$f^2-\bar{f}^3$	11	—	11.5	—			21	—	12	—		
31	f^1-g^1	33	23	18	15			50	28	25	18		
32	f^1-g^2	38	30	10	7			25	30	29	14		
34	f^2-g^1	4.4	7.5	9.6	6.5			0.5	3.8	8.7	17.6		
35	f^2-g^2	142	89	61	26			88	97	93	80		
36	f^2-g^3	2.2	5.5	2.8	3.8			3.0	3.9	6.2	4.6		
81	$\delta^1-\phi^1$	1.6	2.6	2.6	3.3	4.4	1.1	2.2	2.2	3.0	3.4	5.3	
82	$\bar{\phi}^1-\phi^1$	2.9	3.0	3.8	2.8	2.3	12	4.3	4.6	3.7	1.5	7.5	8.2

None of the 25 multiplets follows the summation rule. Neither are equal quotients obtained when doublet and quartet systems are taken together with their intercombinations. For a few of these systems the results are found in Table XXII.

Table XXII.

Terms	Quotients											
f^1, F^1 and g^2G^2	101	57	39	44	59	7	25	32	34	22	112	148
f^1, F^1 and g^1G^1	73	66	33	23	19	15	50	28	31	18	77	91
f^1, F^1 and $\bar{f}^2-\bar{F}^2$	78	73	65	33	53	46	38	38	34	17	150	83
f^1, F^1 and d^2-D^2	109	58	16	16	16	19	10	14	12	6	74	51

If we take together the lines which originate from the same level we find the quotients of Table XXIII.

Table XXIII.

Term	Quotient			
g^1	38	31	28	21
G^1	110	84		
g^2	181	133	120	33
G^2	138	84		

Although for the level mentioned here the system is complete, the results are not appreciably better than for the separate multiplets; sometimes (for G^1) even worse.

For the other terms the system is incomplete; of these only for d^3 a considerable improvement is found. Here we combine f^1-d^3, f^2-d^3, F^1-d^3 and p^2-d^3 and find the quotients 31, 32, 32 and 28. However, p^1-d^3, p^2-d^3 and P^1-d^3 could not be taken into account as they did not occur in spectral region we investigated.

TABLE XXIV.

Final level	Quotients			
f^1	315	293	235	144
f^2	431	488	413	264
F^1	467	450		

Finally we can add all the lines with a common final level. In each of these 3 cases a few systems of lines are wanting (2, 2 and 3 respectively), but it is highly improbable that the quotients given, which have been derived from 16, 16 and 13 lines respectively, would be greatly influenced by these.

For the ratio of intensities of doublet and quartet systems the following values (after division by ν^4) are tabulated here:

TABLE XXV.

Multiplet	Ratio
F^1-D^1 and f^1-d^1	1:2
F^1-D^2 and f^1-d^2	1:0.22
$F^1-\overline{F}^1$ and $f^1-\overline{f}^1$	1:2.1
$F^1-\overline{F}^2$ and $f^1-\overline{f}^2$	1:0.4
F^1-G^1 and f^1-g^1	1:0.3
F^1-G^2 and f^1-g^2	1:0.22

In 4 of the 6 cases the doublet is even stronger than the quartet. This cannot be ascribed to the existing intercombinations as the divergencies in the case of the systems F^1-D^2 and F^1-G^1, where the intercombinations are weak, is much the same as in that of F^1-F^2 and F^1-G^2 with their strong intercombinations. Whereas the division by ν^4 yields a fairly correct ratio in 2 cases, it increases the error in the other 4 cases.

All the intensity values found are shown in Table XXVI in which an intensity of 100 has been awarded to the line 3334.151.

TABLE XXVI. *Intensities of the lines of Co I.* Intensities marked (1) are certain, (2) less certain, (3) doubtful, (4) inexact because of small intensity and irregularities in the plates.

λ(Kayser)	λ(I.A.)	Int.	λ(Kayser)	λ(I.A.)	Int.	λ(Kayser)	λ(I.A.)	Int.
2441.15		9.4	2451.84		1.2	2464.30		2.8
2443.00		2.7	2453.50		2.0	2464.58		2.8 (2)
2443.63	2443.55	5.1	2456.31		12	2464.71		4.5(2)
2443.89		2.2	2460.28		2.2	2467.80	2467.71	11
2446.60		0.9	2460.90	2460.81	11	2470.38		16
2449.24		1.4	2462.22		3.8	2473.02		10
2450.10		2.4	2463.85		6.0	2474.01	2473.92	8.7

TABLE XXVI (*continued*)

λ(Kayser)	λ(I.A.)	Int.
2476.73	2476.64	17
2483.70		15
2485.44		0.9
2486.53		3.4
2488.55		3.0
2489.36		3.3
2494.05		5.2
2494.83		9.5
2495.65	2495.56	13
2496.80		17
2500.60	2500.51	3.2
2504.63		17
2505.2		1.4
2506.55		7.7
2507.26		1.0
2511.12	2511.03	18
2513.01		9.3
2513.20		6.4
2517.90	2517.81	23
2519.90		5.4
2521.03		1.1
2521.49	2521.40	22
2525.09		6.5
2528.67		11
2529.06	2528.97	23
2530.22	2530.13	21
2530.65		6.8
2531.45		4.0
2532.26		21
2535.45		5.6
2536.02	2535.93	21
2536.55		19
2538.45		2.7
2542.05		5.2
2544.34	2544.25	20
2544.94		12
2548.40		20
2549.37		14
2553.09	2553.00	16
2553.44	2553.35	18
2555.15	2555.06	17
2556.85		12
2559.48		4.6
2561.37		2.0
2562.22	2562.13	19
2564.14		8.3
2567.42	2567.33	20
2572.32		8.8
2574.45	2574.36	18
2574.94		1.2
2575.82		4.2
2578.99		2.5
2580.43		20
2580.95		16
2582.35		7.8
2585.45	2585.36	11
2587.30		9.0
2590.70		11
2591.78		12
2594.26	2594.176	6.6
2595.31		1.9
	2596.000	0.6
2601.07	2600.991	4.9
2606.22		9.0
2610.86	2610.770	4.7
2613.60		1.4
2613.98		10
2614.23	2614.132	5.4
2614.45		0.9 (2)
2615.45		2.4
2616.34		4.1
2617.95		6.7
2619.36		5.0
2622.15	2622.064	14 (1)
2622.35	2622.252	5.9 (1)
2622.54	2622.434	11
2623.54	2623.450	11
2623.85		4.0
2627.13		3.5
2627.71	2627.641	23
2630.05		2.3
2640.33		1.5
2642.97		2.1
2644.89		4.9
2646.51	2646.420	24
2648.79	2648.648	51

λ(Kayser)	λ(I.A.)	Int.
2650.04	2650.271	11
2650.40		11
2653.84		0.5 (4)
2661.80		1.0
2663.61		0.6
2669.65		1.0
2674.04		1.3
2676.06	2675.987	10
2679.83		12
2680.20		2.6
2685.44	2685.340	17
2694.50		2.1
2694.76		2.2
2695.93	2695.853	20
2705.50		1.5
2705.94		3.7
2708.88		1.4
2716.05		13
2719.65		1.1
2722.20		1.4
2728.86		1.0
2731.20		5.7
2740.54		7.2
2745.17		8.0
2746.10		1.3
2750.20		3.5
2752.21		1.7
2758.67		1.0
2761.49	2761.375	9.6
2763.19		1.0
2764.30	2764.193	12
2766.31		1.0 (1)
2766.47	2766.37	4.2 (1)
2768.80		1.2
2772.80		1.6
2775.06	2774.964	4.4
2775.29		0.7 (1)
2775.67		1.5
2778.92		8.7
2786.00		2.2
2790.40		0.7
2791.13		1.7
2791.57		0.6
2792.55		2.2
2796.33	2796.236	5.4
2797.18		4.0
2803.87	2803.775	11
2804.25		1.0 (2)
2811.23		1.5
2811.64		2.6
2815.06	2814.979	1.1
2815.65	2815.557	16
2818.69	2818.596	2.2
2820.11	2820.003	3.6
2821.86		1.6
2823.78		1.2
2825.29		2.5
2826.91		1.9
2828.55		0.8
2834.02	2833.928	1.9
2834.55	2834.425	1.7
2837.26		4.7
2842.46		1.8
2850.15		4.3
2851.05	2850.956	1.1
2859.75	2859.660	2.4
2861.48		0.5
2862.70	2862.610	7.0
2867.57		0.4
2872.60		3.7
2878.65		1.4
2879.71		3.1
2882.34	2882.221	1.8
2886.55	2886.448	20
2892.37		1.8
2895.46		0.7 (3)
2895.57		1.6 (3)
2899.91	2899.801	3.3
2903.30		1.9
2904.40		0.6
2907.75		0.5
2911.70	2911.560	0.7
	2916.041	0.2 (4)
2919.66		1.3
2927.78		5.0
2928.91	2928.819	4.4

λ(Kayser)	λ(I.A.)	Int.
2929.62		5.1
	2936.551	0.5 (1)
	2942.630	0.5
2943.60		1.9
2955.50		1.6
2957.79		3.1 (2)
2969.70		0.7
2975.56		0.6
2977.56		0.5
2978.10		1.5
2982.37		1.0
2984.24		0.3 (4)
2987.28	2987.172	33
2989.70	2989.599	36
2996.67		1.0
2999.84		1.0 (2)
3000.66	3000.554	2.7
3005.86		3.2 (1)
3006.10		0.8 (1)
3013.70	3013.598	24
3015.77		3.8
3017.33		1.0 (3)
3017.66	3017.552	31
3019.23		0.7
3022.47		3.2
3023.66		0.5
3026.49		10.7
3028.31		0.6
3031.43		2.4
3034.55	3034.426	15
3038.42	3038.304	2.1
3039.66		3.3
3040.93		14
3042.60	3042.482	30
3044.11	3044.007	50
3045.13		0.7
3048.21		2.0 (2)
3049.00	3048.892	46
3050.64		3.6 (2)
3054.84	3054.724	4.4
3060.17		7.9
3061.15		1.5 (1)
3061.94	3061.825	49
3062.33	3062.198	8.8 (1)
3064.49	3064.375	16
3070.94		1.3 (1)
3072.06	3071.954	9.4 (2)
3072.45	3072.346	56
3073.64		3.3
3079.49	3079.390	4.9
3082.73	3082.614	42
3086.46		9.0 (2)
3086.89	3086.778	71
3087.86		2.1
3088.76	3088.676	0.9
3089.68	3089.593	38
3090.36		3.0
3095.81		2.7
3096.50		2.9 (1)
3096.80		1.8 (1)
3098.30	3098.195	35
3099.76		2.1
3102.49		4.0
3103.82		7.2 (1)
3104.12	3103.990	4.0 (1)
3106.03	3105.920	1.4 (2)
3106.22	3106.136	1.5 (2)
3107.15		2.5
3107.65		1.3
3109.60		3.3
3110.12		3.0
3110.94	3110.817	3.3
3111.45		1.4
3113.58		7.3
3118.35	3118.240	4.8
3118.76	3118.630	0.4 (1)
3121.54	3121.414	30 (3)
3121.69	3121.560	36 (3)
3126.85		3.4
3127.35	3127.244	4.6
3129.10	3128.997	1.5
3129.57		2.3
3132.33	3132.212	2.4
3136.81	3136.721	2.2
3137.47	3137.325	49
3140.08	3139.943	42

TABLE XXVI (*continued*)

λ(Kayser)	λ(I.A.)	Int.	λ(Kayser)	λ(I.A.)	Int.	λ(Kayser)	λ(I.A.)	Int.
3140.83		1.4	3342.10		3.2	3495.83	3495.685	176
	3143.812	0.6	3342.88		11	3496.80	3496.682	38 (2)
3145.16		1.8	3344.36		1.0 (4)	3496.90		38 (2)
3147.19	3147.060	56	3347.10		7.1	3502.45	3502.281	89 (2)
3149.43	3149.304	28	3348.28		11	3502.80	3502.620	159 (2)
3150.82		5.3 (2)	3351.70		1.6	3503.85		2.4 (3)
3150.93		6.3 (2)	3354.51	3354.386	92	3504.89		2.4 (3)
3152.84		6.8	3355.27		2.3	3506.47	3506.315	138
3154.91		42	3356.59		3.8	3510.00	3509.844	122 (1)
3157.23		1.3	3356.97		1.3	3510.59	3510.419	92 (1)
3158.92	3158.769	48	3358.13		0.7 (4)	3512.80	3512.643	128
3159.80	3159.660	16	3359.42		5.6	3513.61	3513.483	89
3161.78		4.6	3361.72		6.0	3518.50	3518.353	215
3164.66		0.3	3362.93		6.7	3520.23	3520.087	78
3168.19		4.5	3363.41		3.1	3521.73	3521.572	186
3169.90		10	3363.89		2.2	3523.55	3523.438	155
3173.30		0.6	3364.38		3.0	3526.97	3526.856	99
3174.29		1.3	3365.13		1.2	3529.19	3529.037	83
3175.06		3.2	3367.25	3367.114	94	3529.92	3529.815	151
3177.40		7.0	3368.72		1.2	3533.51	3533.363	100
3179.98		0.5	3370.48	3370.330	15	3534.91		12
3180.42		1.7	3373.40		5.9	3543.43		27
3182.25		6.6	3374.42		4.4	3546.85		2.6
3186.05		0.8	3376.34		1.5	3548.60		5.8
3186.46	3186.346	6.4	3377.20		4.7	3550.78	3550.599	64
3188.50		8.8	3378.86		5.4	3552.90	3552.719	3.0 (2)
3189.87	3189.756	3.6	3381.65		2.2	3553.16		15 (1)
3191.44	3191.300	1.8	3383.07		16	3553.31		3.0 (3)
3193.30	3193.162	3.2	3384.09		2.2	3558.93	3558.780	15
3198.79	3198.664	2.3	3385.38	3385.227	81	3561.03	3560.896	103
3199.44	3199.325	1.4	3388.29	3388.175	95	3562.25		5.0
320 .15	3203.030	2.0	3390.54		2.5 (2)	3563.09		5.3
3210.35		3.4	3390.92		3.8 (2)	3565.09	3564.955	103
3210.96		1.6	3395.55	3395.378	135	3569.59	3569.382	185
3219.31	3219.155	12	3398.96		1.4	3575.13	3574.964	99 (2)
3224.80		2.0	3402.14		3.9	3575.53	3575.361	114 (2)
3227.15		1.8	3403.33		0.6 (4)	3578.21		4.5
3235.69		9.2	3405.27	3405.120	144	3579.04		4.5 (3)
3237.18	3237.028	24	3407.02		1.0 (4)	3579.15		3.6 (3)
3239.08		1.1 (4)	3409.29	3409.176	124	3582.02		1.7
3243.99		22	3412.50	3412.335	128	3584.94	3584.796	7.2 (3)
3250.17	3249.994	10	3412.79	3412.636	64 (1)	3585.33	3585.159	109
3254.37		20	3415.66	3415.527	3.0 (1)	3587.30	3587.188	223
3258.16		2.3	3417.32	3417.158	118	3595.03	3594.869	101
3260.99		13	3417.84		8.0 (3)	3596.67		2.4
3263.35		2.4	3417.93	3417.796	8.0 (3)	3602.22	3602.081	114
3264.96	3264.842	7.4	3420.64		1.9 (3)	3605.52	3605.367	74
3271.92		9.8	3420.95		4.7 (3)	3611.89		14
3276.60		2.8	3421.77		1.4	3615.54		4.3
3277.44		2.3 (2)	3423.03		3.1	3618.15	3618.006	2.5
3277.80		2.3 (2)	3424.67		11	3620.56		2.7
3278.96		5.1	3426.60		1.3	3624.54		2.6 (1)
3279.39		4.2	3428.34		5.2	3625.18	3624.955	11 (1)
3280.74		18	3428.89		1.8	3627.98	3627.807	90
3283.60		38	3431.76	3431.579	71	3631.59	3631.340	50
3287.34		7.7	3433.18	3433.043	170	3633.01		7.4
3292.24		1.3 (4)	3437.10		1.4	3634.86		7.0
3298.83		4.6	3437.83		5.8	3637.44		1.7
3304.03		0.8 (3)	3439.05		5.8	3636.84		4.7
3304.29		1.7 (1)	3443.06	3442.924	84 (1)	3639.60		17
3305.27		1.0 (4)	3443.79	3443.646	140 (1)	3641.94		7.0
3305.87		1.0 (4)	3449.26	3449.171	170 (3)	3643.35		14
3306.54		0.8 (4)	3449.54	3449.443	153 (3)	3645.34		3.6
3307.31		7.9	3452.44		3.8	3647.85	3647.663	37
3308.65		3.0	3453.66	3453.513	155	3649.49		7.8
3308.96		4.7	3455.33	3455.236	99	3651.41		2.3
3312.33		10	3457.05	3456.936	9.3	3652.70	3652.544	45
3312.99		1.6	3460.86	3460.732	2.4	3654.59		4.0
3314.21		9.9	3461.33		15	3657.10	3656.965	7.5
3315.20		1.1 (4)	3462.94	3462.807	144	3658.06		1.0 (4)
3318.55		1.8	3465.96	3465.796	87	3662.32		22
3319.31		2.2 (1)	3469.11		1.5	3670.20		1.0 (4)
3319.66		14 (1)	3471.53		4.7	3676.72		17
3320.00		4.9 (1)	3472.85		2.0	3683.22		41
3322.41		15	3474.17	3474.019	169	3684.63		5.2
3325.44		15	3476.50		2.1	3690.91		4.1
3327.14		14	3478.00		1.8	3693.63		15 (3)
3328.34		1.1	3478.60		8.7 (3)	3702.30		16
3329.16		0.8 (4)	3478.90		5.2 (3)	3704.22	3704.061	83
3329.63		4.3	3480.17		3.5	3707.62		3.9
3333.55	3333.390	13	3483.58	3483.415	99	3709.00		21
3334.31	3334.151	100	3485.51		21	3712.35		2.9
3337.34	3337.175	6.4	3487.84		4.8	3726.79		1.2
3338.68		0.6 (4)	3489.57	3489.406	166	3730.63		27
3339.97		9.0	3490.89	3490.741	20	3732.59		55
3341.52		5.0	3491.49	3491.324	76	3733.65		22

TABLE XXVI (*continued*)

λ(Kayser)	λ(I.A.)	Int.
3736.08		12
3740.34		2.1
3745.65	3745.501	107
3750.07		14 (1)
3751.75		3.3
3754.47		1.5
3755.60		9.3
3759.83		1.0 (3)
3760.55		1.3 (3)
3774.75		2.9
3777.68		2.6
3783.87		0.6 (4)
3808.25	3808.106	7.2
3811.23	3811.070	1.9
3812.62		0.9
3814.62		3.1
3816.48		17 (2)
3816.61		13 (2)
3842.21	3842.056	137
3845.60	3845.474	235
3850.27		1.2 (2)
3851.09	3850.949	7.7
3852.00		2.4 (2)
3856.94		4.8
3861.31	3861.168	80
3863.75		1.0
3870.66		2.5
3873.23	3873.117	188 (1)
3874.09	3873.957	185 (1)
3877.01	3876.840	37
3882.06	3881.877	133
3884.79	3884.609	11 (1)
3885.45	3885.281	5.0 (2)
3894.25	3894.086	285
3895.15	3894.981	35 (1)
3898.54	3898.499	1.6
3904.23		1.9
3906.46	3906.296	16
3910.13	3909.941	26
3917.80		8.6
3920.90		5.3
3922.90	3922.764	8.1
3925.33		0.9
3929.43		1.1
3934.07	3933.921	4.5
3934.85		1.1
3936.13	3935.974	146
3939.00		0.8
3941.06	3940.895	20
3941.91	3941.735	39 (1)
3945.51	3945.323	27
3946.75		1.0 (2)
3947.26	3947.132	1.3 (2)
3952.46	3952.329	2.1 (3)
3953.10	3952.923	55
3956.42	3956.276	0.8
3958.10	3957.935	26
3961.15		3.3
3969.28		11

λ(Kayser)	λ(I.A.)	Int.
3972.69		3.5 (2)
3973.31	3973.148	13
3974.90	3974.732	17
3978.78	3978.656	11 (3)
3978.99		7.1 (3)
3979.67	3979.525	20 (1)
3987.25	3987.121	4.1
3990.45	3990.307	5.9
3991.68		7.7 (2)
3991.83	3991.693	7.0 (2)
3994.70	3994.541	1.0 (3)
3995.45	3995.312	244
3998.09	3997.909	125
3998.69	3998.554	1.0 (3)
4003.85		0.5
4011.10	4011.098	1.1
4014.09	4013.950	4.8
4019.45	4019.300	2.7
4021.07	4020.904	38
4023.55		2.1
4027.18	4027.044	11
4035.74		5.9
4040.57		0.7 (3)
4040.95		0.5 (3)
4045.56	4045.397	51
4049.43		0.6 (4)
4053.10		1.3
4057.10		2.0 (1)
4057.36	4057.199	4.5 (1)
4058.36	4058.188	9.6 (1)
4058.76	4058.603	5.5 (1)
4063.34	4063.19	2.0
4066.56	4066.378	36
4068.72	4068.553	9.4
4076.30	4076.134	3.1
4077.56		1.4
4082.75	4082.606	2.0
4086.49	4086.307	32
4092.56	4092.397	135
4104.57	4104.430	0.8 (2)
4104.91		1.8 (2)
4110.70	4110.544	77
4118.96	4118.784	232
4121.52	4121.329	306
	4130.538	0.4 (4)
4132.30	4132.15	3.0
4150.62	4150.442	0.5 (4)
4158.59		0.8
4162.38		1.3
4179.44		0.5
4187.46	4187.248	1.5
4190.88	4190.709	15
4193.02		0.8 (4)
4198.56	4198.424	0.7 (4)
4234.17	4233.996	1.8
4242.07		1.0
4245.75		0.2 (4)
4248.35		0.2 (4)
4252.46	4252.303	6.9

λ(Kayser)	λ(I.A.)	Int.
4270.60	4270.423	1.0
4285.95	4285.787	2.8
4292.42		0.7
4303.41	4303.236	1.3
4309.61	4309.418	0.4
4331.43		1.2
4339.81		2.8
4371.31		1.4
4373.81		1.4 (1)
4375.11	4374.940	1.4 (1)
4391.70	4391.59	1.2 (1)
4392.02		1.0 (1)
4402.86		1.0
4417.55	4417.425	1.5
4421.54	4421.359	1.3
4431.79		0.8
4445.88	4445.730	1.4
4467.09	4466.888	4.7
4469.75	4469.569	10
4471.76	4471 578	4.0
4478.50	4478.345	1.6
4484.11	4483.946	1.5 (2)
4494.94		0.6
4517.26	4517.121	2.8
4528.08	4527.936	0.8 (2)
4531.12	4530.985	48
4534.16	4533.998	6.1
4543.98	4543.836	5.5
4549.83		11
4565.79		17
4570.21		1.4
4580.34	4580.133	2.6 (2)
4581.80	4581.618	25
4594.82		3.2
4597.09		3.0
4623.20	4623.024	1.1
4625.92		1.0
4629.52	4629.380	19
4657.56	4657.399	0.2
4663.59	4663.411	11
4682.53	4682.363	6.6
4693.36	4693.193	2.8
4698.56	4698.370	1.4
4704.57		0.7
4728.14	4727.924	2.2
4735.04	4734.834	0.8
4737.95	4737.776	1.1
4749.89	4749.684	6.8
4754.59	4754.372	1.3
4756.93		0.8
4767.33		0.8 (2)
4768.26	4768.096	1.2 (2)
4771.27	4771.105	2.8
4776.49	4776.328	3.1
4780.14	4780.001	5.7
4793.03	4792.867	8.5
4813.67	4813.482	12
4840.42	4840.267	14
4868.05	4867.680	18