INSTRUCTION MANUAL

Jarrell-Ash
Division of Fisher Scientific Company

Spectrographic Master Plate or Film

Instructions for Use of the JARRELL-ASH MASTER PLATES in Qualitiative, Semi—quantitative and Quantitative Analyses

I. DESCRIPTION.

Jarrell-Ash Master Plates are helpful to the analyst in locating lines for spectrochemical analysis.

As Figure 1 shows, the master plate consists of:

a. A wavelength scale, in 10A intervals.

b. The sensitive lines for 69 elements and two bandheads for CN.

c. A representation of an iron arc spectrum. Not all lines which commonly appear in an iron spectrum are marked since, in many regions, the spectrum is too complex. At least three lines for each 10A are marked, and characteristic groupings of lines are preserved as far as possible.

d. The identification of the elements in two rows. This identification consists of a dot opposite the line in the top row, and an associated element symbol. Several dots may be used with one symbol if there are two or three close lines due to a single element. This arrangement is shown in Figure 1 at 2800A, where light lines have been drawn from the dots to the associated symbols.

e. The wavelengths numbered for every 100 Angstroms, shown as 27, 28, 29 etc. for 2700A, 2800A and 2900A, and for each 10A between, eg 1, 2, 3, etc. designating, for example 2810, 2820, 2830 A.

II. THE USE OF THE MASTER PLATE IN QUALITATIVE ANALYSIS.

The spectroscopist, generally, is not interested in the specific wavelength of an unknown line. Note in Figure 2, how the reference master plate spectrum is aligned with the unknown spectrum. The unknown spectrum was photographed in conjunction with an iron arc reference through a Hartmann diaphragm in the normal manner. The relative position of the master and sample plates was adjusted until the iron spectrum was in conjunction with the iron spectrum of the sample plate.

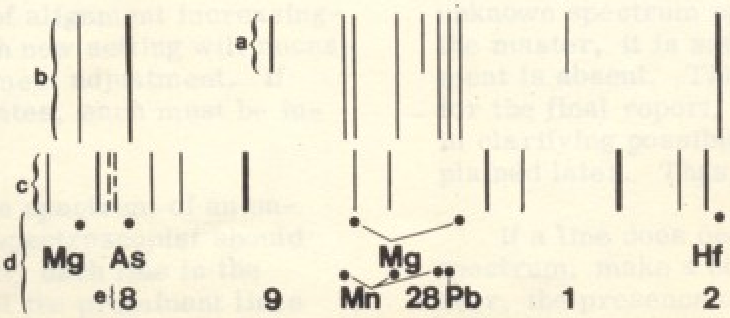

Figure 1.

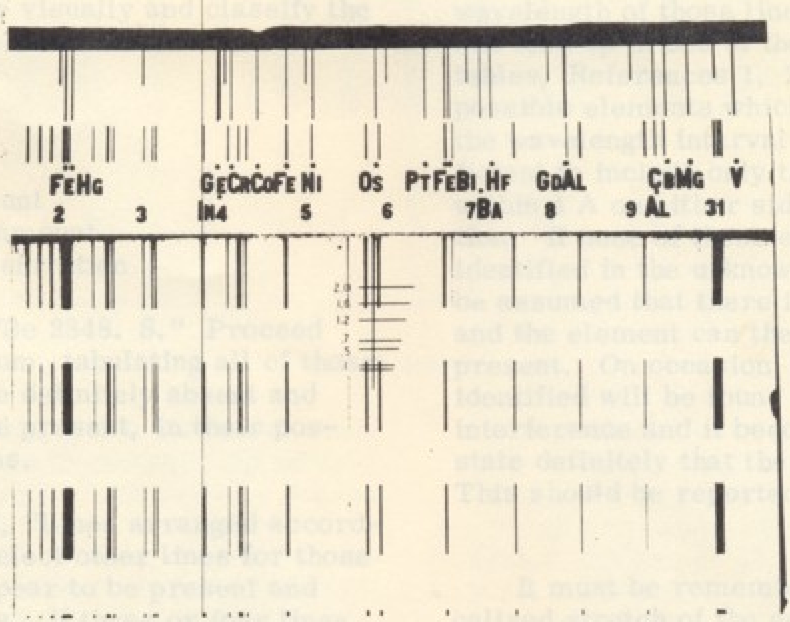

Figure 2.

Learn to identify quickly recognizable patterns in the iron reference in your unknowns, such as the Fe triplet at 3100A, or the CN bandheads at 4216, 3883 and 3590. Then move the master plate to bring this same pattern into exact alignment. Since there are differences in the exact focal length, there will be slight differences in dispersion at the plate. The master, made at a median dispersion, will seldom match the unknown exactly. The comparator microphotometer may have a magnification adjustment for one beam, which may be adjusted to match the spectra of the reference and unknown at one setting. However, as the plateholder is moved, the two spectra will go out of alignment increasingly. Therefore, each new setting will necessitate a slight alignment adjustment. If there are two 10" plates, each must be individually aligned.

In examining the spectrum of an unknown sample, the spectroscopist should not attempt to identify each line in the spectrum or even all the prominent lines present. Most of them will belong to the matrix element or elements. Instead a systematic search for the presence or absence of a line is conducted. The procedure is as follows:

1. Start at one end of the master and sample plates, or at some readily recognized position such as 3100A, and examine the unknown spectrum for the presence or absence of the element lines marked in the master plate. Refer particularly to the lines marked by an asterisk in Table I "Lines in Order of Wavelength." These are the most sensitive lines in a normal D. C. arc, and usually are the last to disappear as the concentration is reduced. Accordingly, if there is no line present in the unknown spectrum opposite these lines in the master, it is safe to say that the element is absent. This fact should be noted for the final report, but also for reference in clarifying possible interferences, as explained later. Thus, "Cd 2288 a" (absent).

If a line does occur in the unknown spectrum, make a note of this fact. However, the presence of a single line is never, in itself, sufficient evidence that the element is present. It may well be a weak line of the major matrix material whose wavelength is identical with or close to that of the unknown line, or it may be a strong line of some other minor element. Judge the intensity of the line visually and classify the element's possible concentration by some scale such as:

a = absent
t = trace
s = small amount
m = moderate amount
l = large concentration

Tabulate this, as "Be 2348. S." Proceed through the spectrum, tabulating all of those elements which are definitely absent and those which may be present, in their possible concentrations.

From Table II, "Lines arranged according to Element", select other lines for those elements which appear to be present and look for these lines. If three or four lines of an element are found to be present in the unknown spectrum, particularly if the lines are prominent or the spectrum as a whole is relatively simple, it is safe to assume that the element is definitely present. As a rule of thumb, it is safe to say that if three lines appear, the element is definitely present; if two lines appear, there is some doubt; and if only one line appears, the element is present either in very low concentration or its presence is doubtful.

When only one line of an element appears and this line is not listed in wavelength tables as one of the most sensitive lines, it is almost certain that the line found is not due to the element in question. On the other hand, when only one or two weak lines of an element are located and these are the more sensitive lines, the element in question may be present. In the latter case, the presence of the element may be confirmed by exposing the unknown sample again through the Hartmann diaphragm with a spectrum of a sample known to contain a small amount of the element in question so that the spectra are in juxtaposition. Strict coincidence between the known lines in the unknown and similar relative intensities can often be regarded as positive identification of the unknown element.

It is also possible to make a more positive decision for those elements for which only one or two lines appear by investigating possible interferences. Note the exact wavelength of those lines which do appear and look up in one of the various wavelength tables, References 1, 2, 3, 4 and 5, the possible elements which could interfere in the wavelength interval involved. It is sufficient to include only those lines which lie within 1 A on either side of the line in question. If none of these elements has been identified in the unknown spectrum, it can be assumed that there is no interference, and the element can then be reported as present. On occasion, all lines tentatively identified will be found to have a possible interference and it becomes impossible to state definitely that the element is present. This should be reported as such.

It must be remembered that due to localized stretch of the emulsion, particularly on film, it may be impossible to obtain exact alignment of the spectral lines. Even the most authoritative wavelength tables have occasional errors, particularly in ascribing lines to the wrong element. This is especially true of the rare earths and heavy elements. Accordingly, the analyst must be careful to check all possible interferences before reporting his results. Experience in analyzing various samples of the same general type will show which lines may be relied upon with confidence, but as soon as new major or minor elements are encountered, familiar lines must once more be confirmed as free from interference.

If many qualitative analyses are to be run, it is desirable to prepare a pre-printed form listing the various elements to be looked for, and their sensitive lines. A typical report form might look like that shown in Figure 3.

III. PROCEDURE FOR MEASURING WAVELENGTHS.

The wavelength of a line can be estimated visually to 1 A or better by noting its position relative to the two adjacent wavelength markers. Usually this suffices to identify the significant lines positively by reference to

Elements	Fe	Cu	Zn	Pb	Ag	Au	Cd	As	Sn	Al	Ni	Cr	Ti
Lines	3719, 3737 3020, 2941	3274, 3247	3345, 3303 3304	4057, 3683 2833, 2802	3383, 3281	2428, 2675	2288, 3610	2349, 2780 2860,	2840, 2863 3034, 3175	3961, 3944 3092, 3082	3414, 3002 3003, 3040	4254, 4289 3593, 3040	3349, 3361 3236
Sample #													
32	s	m	l	m	t	a	t	a	a	t	a	a	a
33	m	s	s	t	a	a	a	a	a	m	a	a	l

Figure 3.

the tables. However, there are times when it becomes desirable to measure the wavelength of a line exactly. This can be done as follows:

1. Measure on the screen the distance between the two wavelength fiducial lines on either side of the unknown line. For example, from the 2790A wavelength scale mark to the 2800 A mark measures 30.5 mm. This means that the reciprocal linear dispersion on the screen is $10 \div 30.5$ equals .33A/mm.

2. The unknown line lies 15.5 mm below the 2800 A marker, so that it is $15.5 \times .33 = 5.12$ A below 2800, or 2794.88A, which identifies it as probably Mn 2794.82A.

Frequently it is more accurate to identify a prominent line in the iron reference spectrum of the unknown, and to measure the separation between this line and the unknown line. Thus, a prominent line in the Fe spectrum can be identified clearly from an iron arc enlargement in Reference 3 or 6 as 2804.52A. Its separation from the unknown measures 29.5 mm toward lower wavelengths, or $29.5 \times .33 = 9.72$A. The unknown is, therefore, 2804.52 - 9.72 or 2794.80 A, which again identifies it as probably Mn 2794.82A.

IV. USE OF THE MASTER PLATES IN SEMI-QUANTITATIVE ANALYSIS.

Note that in Table I, many of the spectrum lines have an arc sensitivity listing. In order to estimate the concentration within an order of magnitude, examine several lines of one element and note which are present or absent. For example, silicon 2881.6 has an arc sensitivity of 0.001% and 2435.2 a sensitivity of 0.1%. If 2881.6 appears and 2435.2 is absent the concentration lies between 0.001% and 0.1%. It must be remembered, however, that many lines are enhanced or suppressed by the matrix material or other elements present in the matrix. For this reason, any estimates made on concentration must come not only from information of relative arc sensitivities, but also by experience of the spectroscopist with various matrix materials. It is very important when estimating concentration that some background be present in order to compensate for differences in line sensitivity due to variations in exposure, emulsion speed or instrumental speed. Otherwise, a weak exposure will hide some lines below the inertia level of the emulsion.

V. USE OF THE MASTER PLATES IN QUANTITATIVE ANALYSIS.

The Master Plates are also very useful when setting up quantitative procedures where a number of spectrum lines of known wavelength must frequently be examined for suitability. The iron spectrum and wavelength scale of the Master Plates makes it relatively simple to identify the analytical lines. Use the procedure outlined in Section III. However, most of the quantitatively useful lines are not actually marked since they often are not the more sensitive lines and hence, are not useful in qualitative analysis.

LITERATURE CITED

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TABLE I

SENSITIVE LINES ON 22-500 MASTER PLATES

LISTED IN WAVELENGTH ORDER

Wavelength	Element	Arc Sensitivty (%)	Comments
2135.976	Cu		Poor emulsion sensitivity
*2138.560	Zn		Poor emulsion sensitivity
2169.994	Pb		
2203.505	Pb		Poor emulsion sensitivity
2246.995	Cu		
*2288.018	Cd	0.001	Possible As interference
2288.120	As	0.003	Possible Cd interference
2304.235	Ba		
2311.469	Sb		
2335.269	Ba		
*2348.610	Be	0.0001	Some self absorption
*2349.840	As	0.01	
2383.250	Te	0.03	Possible Sb interference
*2385.760	Te	0.01	
*2427.950	Au	0.001	Some self absorption
2456.530	As		
*2478.573	C		
2496.778	B	0.001	Possible Fe interference
*2497.733	B	0.001	Possible Fe interference
2506.899	Si		
2524.118	Si		
2534.010	P	0.3	
*2535.650	P	0.1	Possible Fe interference
*2536.519	Hg	0.03	High self absorption
2553.280	P	0.1	
2554.930	P → 2561,80 Lu	0.3	
2567.987	Al	0.03	
2571.391	Zr		
2575.100	Al	0.03	
2576.104	Mn		
2595.761	Mn		
2598.062	Sb	0.003	Possible Fe interference
2608.962	Tl		
2614.178	Pb		
2651.178	Ge	0.001	
2652.489	Al	0.03	
*2659.454	Pt	0.001	
2663.166	Pb	0.01	
2675.950	Au	0.001	
2678.758	Ru	0.03	
2677.159	Cr		
2710.265	In		
2714.674	Ta		
2719.653	Ga		
2741.188	Li	0.01	
2767.870	Tl	0.01	
2776.690	Mg		
2780.197	As	0.03	

Wavelength	Element	Arc Sensitivity (%)	Comments
2794.817	Mn		
2795.530	Mg	0.0001	Some self absorption
2798.271	Mn		
2801.064	Mn	0.0003	High self absorption
2802.003	Pb		
2802.695	Mg	0.0001	Some self absorption
2820.224	Hf	0.01	
2824.369	Cu		
2830.295	Pt		
2833.069	Pb	0.001	High self absorption
2835.633	Cr		
*2839.989	Sn	0.001	Some self absorption
2843.252	Cr		
*2852.129	Mg	0.0001	Some self absorption
2860.452	As	0.1	
2863.327	Sn		
2870.413	Th		
2874.244	Ga		
*2877.915	Sb	0.01	
*2881.578	Si	0.001	
2894.840	Lu		
2896.446	W	0.01	
2897.975	Bi	0.01	
*2909.061	Os	0.03	
2911.390	Lu		
2916.481	Hf		
2918.32	Tl		
2924.792	Ir		
2929.794	Pt		
2936.77	Ho		
2938.298	Bi		
2941.343	Fe		
*2943.637	Ga	0.001	
2944.175	Ga		
2944.395	W		
2946.981	W		
2961.165	Cu	0.03	
3002.491	Ni		
3003.629	Ni		
3020.640	Fe	0.001	
3021.499	Hg		
*3039.064	Ge	0.001	Possible In interference
3039.356	In	0.001	Possible Ge interference
3040.846	Cr		
3044.005	Co		
3047.605	Fe		
3050.819	Ni	0.003	
3058.660	Os		
3064.712	Pt	0.001	
*3067.716	Bi	0.0003	Some self absorption
3071.591	Ba	0.1	
3072.877	Hf		
3082.000	Gd		
3082.155	Al	0.001	
3092.713	Al	0.001	
3094.183	~~Cb~~ Nb	0.01	

Wavelength	Element	Arc Sensitivity (%)	Comments
3096.899	Mg		
3102.299	V		
3108.605	Cu		
3110.706	V		
3118.383	V		
3122.781	Au	0.01	
3125.663	Hg	0.3	
3130.416	Be	0.0001	Some self absorption
3131.072	Be	0.0001	Some self absorption
3131.546	Hg		
3132.594	Mo	0.001	
3134.718	Hf		
3158.869	Ca		
3170.347	Mo	0.001	
3175.019	Sn		
3179.332	Ca		
3183.406	V	0.001	
3183.982	V	0.001	
3185.396	V	0.001	
3193.973	Mo		
3194.977	Cb	0.03	
3200.867	Ce		
3208.834	Mo		
*3220.780	Ir	0.03	
3224.430	~~Cb~~ Nb		
3232.499	Sb		
3232.610	Li	0.003	
3236.573	Ti		
3242.280	Y		
3245.120	La		
3247.540	Cu	0.0001	High self absorption
3256.090	In	0.001	
3258.564	In		
3261.057	Cd		
3262.290	Os		
3262.328	Sn		
3267.502	Sb	.03	
3267.945	Os		
3269.494	Ge		
*3273.962	Cu	0.0001	High self absorption
*3280.683	Ag	0.0001	High self absorption
3282.333	Zn		
3289.370	Yb		
3302.323	Na	0.01	Possible Zn interference; some self absorption
3302.588	Zn	0.01	Possible Na interference
3302.941	Zn		
3302.988	Na	0.01	Possible Zn interference
*3311.162	Ta	0.03	
3318.840	Ta		
3321.086	Be	0.001	
3321.343	Be	0.0001	
3323.092	Rh		

Wavelength	Element	Arc Sensitivity (%)	Comments
3331.007	Ta		
3337.488	La		
*3345.020	Zn	0.01	
*3349.035	Ti	0.0003	
3349.406	Ti		
3353.734	Sc		
3361.213	Ti		
3372.800	Ti — punto do Er	0.0003	
3382.891	Ag	0.0001	High self absorption
*3391.975	Zr	0.001	
3396.850	Rh	0.003	
3403.653	Cd		
*3404.580	Pd	0.0003	
3405.120	Co		
3406.664	Ta		
*3414.765	Ni	0.0003	
3421.240	Pd	0.003	
*3434.893	Rh	0.001	
*3436.737	Ru	0.001	
3438.230	Zr	0.001	
3446.370	K	1.0	Possible Ni interference
3447.380	K	1.0	Possible Fe interference
3451.808	Re		
*3453.505	Co	0.003	
3456.000	Ho		
*3460.470	Re	0.003	
3462.200	Tm		
3464.457	Sr	0.03	
3465.800	Co	0.001	
3466.201	Cd		
3472.480	Lu		
3474.022	Co		
3492.956	Ni	0.001	
3496.210	Zr		
3498.942	Ru	0.001	
3499.104	Er		
*3509.170	Tb		
3513.645	Ir		
3515.054	Ni		
3516.943	Pd		
3519.240	Tl		
3519.605	Zr		
3561.740	Tb		
3590.3	Cn (band head)		
3600.734	Yt		
3601.040	Th		
3601.193	Zr		
3610.510	Cd		
3613.836	Sc		
3641.408	W		
3642.785	Sc		
3646.196	Gd		
3650.146	Hg	0.1	CN interference

Wavelength	Element	Arc Sensitivity (%)	Comments
3653.496	Ti		
3672.579	U		
3683.471	Pb		
3685.196	Ti		
3692.357	Rh		
3692.652	Er		
3694.203	Yb		
*3710.290	Y		
*3719.935	Fe	0.0003	CN interference
3737.133	Fe		CN interference
3748.170	Ho		
3761.333	Tm		
3761.917	Tm		
3768.405	Gd		
3775.720	Tl		CN Interference
*3798.252	Mo		CN interference
3838.258	Mg		
3864.110	Mo		CN interference
3883.4	Cn (band head)		
*3891.020	Ho		
3891.785	Ba	0.1	Some CN interference
3905.528	Si		
3906.316	Er		
3907.476	Sc		
3933.666	Ca	0.00001	
3944.032	Al	0.0003	High self absorption
*3949.106	La		
3951.154	Nd		
*3961.527	Al	0.0003	High self absorption
3968.468	Ca	0.00001	
3987.994	Yb		
3988.518	La		
4000.454	Dy		
4008.753	W	0.01	Possible Ti interference
4012.388	Ce		
*4019.137	Th		
4023.688	Sc		
*4030.755	Mn	0.0003	CN interference
4033.073	Mn		
4034.490	Mn		
4040.762	Ce		
4044.140	K	0.1	CN interference; some self absorption
4045.983	Dy		
4046.561	Hg		
4047.201	K	0.1	CN interference; some self absorption
*4057.820	Pb	0.0003	CN interference
4058.938	Cb	0.003	Possible Fe and Mn interference
4062.817	Pr		
4077.714	Sr	0.0003	CN interference
4077.974	Dy		
4079.729	Cb		

Wavelength	Element	Arc Sensitivity (%)	Comments
4086.714	La		
4090.370	U		
4093.161	Hf		
4100.923	Cb		
4101.773	In	0.001	CN interference
4129.737	Eu		
4130.664	Ba		
4172.056	Ga	0.0003	CN interference
4177.321	Nd		
*4179.422	Pr		
*4186.599	Ce		
4201.851	Rb	0.01	Heavy CN interference
4205.046	Eu		
4215.524	Sr	0.0003	CN interference
4215.556	Rb	0.01	Heavy CN interference
4216.000	Cn (band head)		
4225.327	Pr		
*4226.728	Ca	0.0001	Some self absorption
*4241.669	U	0.1	
*4254.346	Cr	0.0001	Some self absorption
4289.721	Cr		
4294.614	W	0.01	Fe interference
*4303.573	Nd		
4333.734	La		
4341.688	U	0.1	
4358.350	Hg		
*4379.238	V	0.0003	
4381.859	Th	0.1	
4390.865	Sm		
4391.114	Th		
4424.342	Sm		
4434.321	Sm		
*4511.323	In	0.001	
4518.570	Lu		
*4554.042	Ba	0.0001	
4555.355	Cs	0.01	
4593.177	Cs	0.01	
4602.863	Li		
*4607.331	Sr	0.001	Some self absorption
4643.695	Y		

TABLE II

SENSITIVE LINES ON 22-500 MASTER PLATES

IN ELEMENT ORDER

Element	Wavelength
Ag	3382.891 [2800]
	*3280.683 [5500]
Al	*3961.527 [900]
	3944.032 [450]
	3092.713 [650]
	3082.155 [320]
	2660.393 [20]
	2652.489 [15]
	2575.100 [48]
	2567.987 [24]
As	2860.452 [90]
	2780.197 [140]
	2456.530 [36]
	*2349.840 [85]
	2288.120 [44]
Au	3122.781 [160]
	2675.950 [340]
	*2427.950 [200]
B	*2497.733 [480]
	2496.778 [240]
Ba	4554.042 [6500]
	4130.664 [150]
	3891.785 [140]
	3071.591 [19]
	2335.269 [55]
	2304.235 [28]
Be	3321.343 [100]
	3321.086 [60]
	3131.072 [320]
	3130.416 [480]
	2494.733 [100]
	*2348.610 [300]
Bi	*3067.716 [3600]
	2938.298 [320]
	2897.975 [400]
	2276.578 [5]

Element	Wavelength	
C	*2478.573	[10]
Ca	4226.728	[1100]
	3968.468	[2200]
	3933.666	[4200]
	3179.332	[50]
	3158.869	[20]
~~Cb~~ Nb	4100.923	[700]
	4079.729	[1200]
	4058.938	[1700]
	3194.977	[120]
	3094.183	[220]
Cd	3610.510	[360]
	3466.201	[250]
	3403.653	[80]
	3261.057	[32]
	*2288.018	[1500]
Ce	*4186.599	[250]
	4040.762	[150]
	4012.388	[190]
	(?)3200.867 3200,52	[4]
Cn (band head)	4216.000	
Co	3465.800	[320]
	3453.505	[1300]
	3405.120	[700]
	3044.005	[160]
Cr	4289.721	[850]
	4254.346	*[1700]
	3040.846	[70]
	2843.252	[190]
	2835.633	[280]
	2677.159	[200]
Cs	4593.177	[20]
	4555.355	[40]
Cu	*3273.962	[2500]
	3247.540	[5000]
	~~3108.605~~	
	2961.165	[24]
	2824.369	[50]
	2246.995	[4]

Element	Wavelength
Dy	4077.974 [600]
	4045.983 [1000]
	4000.454 [650]
Er	3906.316 (handwritten correction: 48, 4) [850]
	3692.652 [700]
	3499.104 [650]
Eu	4205.046 [4000]
	4129.737 [2200]
Fe	3737.133 [340]
	3719.935 [600]
	3047.605 [130]
	3020.640 [280]
	2941.343 [13]
Ga	2944.172 [150]
	*2943.637 [950]
	2874.244 [500]
	2719.653 [80]
Gd	3768.405 [850]
	3646.196 [700]
	3082.000 [180]
Ge	3269.494 [110]
	*3039.064 [750]
	2651.178 [1200]
Hf	4093.161 [48]
	3134.718 [95]
	3072.877 [240]
	2916.481 [220]
Hg	4358.350 [400]
	4046.561 [180]
	3650.146 [280]
	3131.546 [32]
	3125.663 [40]
	3021.499 [20]
	*2536,519 [1500]
Ho	3891.020 [1500]
	3748.170 [360]
	3456.000 [1800]
	(2)2936.77

Element	Wavelength
In	4101.773 [1700]
	3258.564 [300]
	3256.090 [1300]
	2710.265 [160]
Ir	3513.645 [320]
	*3220.780 [500]
	2924.792 [320]
K	4047.201 [16]
	4044.140 [32]
	(?)3447.380
	(2)3446.370
La	4333.734 [460]
	4086.714 [550]
	3988.518 [440]
	*3949.106 [900]
	3337.488 [200]
	3245.120 [70]
Li	3232.610 [17]
	2741.188 [20]
Lu	3472.480 [280]
	2911.390 [600]
	2894.840 [420]
Mg	3838.258 [500]
	3096.899 [14]
	2852.129 [6000]
	2802.695 [600]
	2795.530 [1000]
	2776.690 [38]
Mn	4034.490 [800]
	4033.073 [1400]
	*4030.755 [2000]
	2801.064 [480] → 2933,06 [140]
	2798.271 [650]
	2794.817 [800]
	2595.761 [32]
	2576.104 [1200]
Mo	3864.110 [2800]
	3208.834 [380]
	3193.973 [950]
	3170.347 [1100]
	3132.594 [1800]

Element	Wavelength
Na	3302.988 [15]
	3302.323 [30]
Nd	4303.573 [320]
	4177.321 [140]
	3951.154 [120]
Ni (?) el. h=22 ...	3515.054 [600]
	3492.956 [500]
	3414.765 [750]
	~~3040.819~~ 3050.82 [280]
	3003.629 [180]
	3002.491 [320]
Os	3267.945 [320]
	3262.290 [320]
	3058.660 [900]
	*2909.061 [900]
P	2554.930 [15]
	2553.280 [38]
	*2535.650 [60]
	2534.010 [22]
Pb	*4057.820 [3400]
	3683.471 [1400]
	2833.069 [950]
	2802.003 [1000]
	2663.166 [300]
	2614.178 [700]
	2203.505 [9]
	2169.994 [22]
Pd	3516.943 [1300]
	3421.240 [1400]
	3404.580 [2600]
Pt	3064.712 [320]
	2929.794 [170]
	2830.295 [140]
	*2659.454 [280]
Pr	4225.327 [340]
	*4179.422 [460]
	4062.817 [300]

Element	Wavelength
Rb	4215.556 [16]
	4201.851 [32]
Re	3460.470 [5500]
	3451.808 [1600]
Rh	3692.357 [800]
	3434.893 [700]
	3396.850 [480]
	3323.092 [360]
*Ru	3498.942 [850] *3587,20 [40]
	3436.737 [650] 3593,02 [700]
	2678.758 [75]
Sb	3267.502 [85]
	3232.499 [100]
	*2877.915 [140]
	2598.062 [900]
	2311.469 [45]
Sc	4023.688 [1800]
	3907.476 [1800]
	3642.785 [1200]
	3613.836 [2500]
	3353.734 [900]
Si	3905.528 [11]
	*2881.578 [260]
	2524.118 [240]
	2506.899 [170]
Sn	3262.328 [550]
	3175.019 [550]
	2863.327 [1000]
	*2839.989 [1400]
Sr	4607.331
	4077.714
	3464.457
Sm	4390.865
Ta	3406.664
	3331.007
	3318.840
	3311.162
	2714.674

Element	Wavelength
Tb	3561.740
	3509.170
Te	2385.760
	2383.250
Th	4391.114
	4381.859
	4019.137
	3601.040
	2870.413
Ti	3998.640 [650]
	3685.196 [260]
	3653.496 [600]
	3361.213 [600] dubleto
	3349.406 [1000]
	3349.035 [360]
	3236.573 [440]
Tl	3775.720
	3519.240
	2918.32
	2767.870
	2608.962
Tm	3761.917
	3761.333
	3462.200
U	4341.688
	4241.669
	4090.370
	3672.579
V	4379.238 [950]
	3185.396 [500]
	3183.982 [700]
	3183.406 [420]
	3118.383 [260]
	3110.706 [340]
	3102.299 [400]
W	4294.614 [450]
	4008.753 [950]
	3641.408 [30]
	2946.981 [300]
	2944.395 [300]
	2896.446 [190]

Element	Wavelength
Yb	3987.994
	3694.203
	3289.370
Yt Y	3710.290
	3600.734
	3242.280
Zn	3345.020 [140]
	3302.941 [28]
	3302.588 [90]
	3282.333 [20]
	*2138.560 [1000]
Zr	3601.193 [550]
	3519.605 [320]
	3496.210 [650]
	3438.230 [750]
	3391.975 [900]
	2571.391 [140]