

Matrix effects in simultaneous microwave induced plasma optical emission spectrometry: new perspectives on an old problem

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Table S1. Effect of 50 mg L⁻¹ of a single matrix element (either Al, B, Co, Cr, Cu, Fe, Mn, Ni, Ti, V, Zn, as well as the EIE Li, Na, K, Cs, Mg, Ca, or Ba) on the emission line signal of 105 emission lines of 42 elements (atom and ion lines). Data normalized to the signal obtained for each emission line in diluted (3 % v/v) nitric acid and reported in %. Color coding: blue – signal suppression, red – signal enhancement; RSDs < 2%, n=5, TE: Total line energy (excitation energy + ionization energy); IE: ionization energy; Plasma robustness expressed as the Mg II 280.270 nm / Mg I 285.210 nm ratio; M: matrix element

Emission Line	TE, eV	IP, eV	Matrix Elements																	
			Al	B	Co	Cr	Cu	Fe	Mn	Ni	Ti	V	Zn	Li	Na	K	Cs	Mg	Ca	Ba
Al I 308.215 nm	4.0	6.0	M	101	100	97	98	99	99	100	99	100	100	84	89	87	93	97	94	100
Al I 394.401 nm	3.1	6.0	M	101	102	101	102	101	100	102	100	101	103	84	90	88	95	98	98	101
Al I 396.152 nm	3.1	6.0	M	101	100	100	100	100	100	100	101	101	101	83	88	88	94	97	96	99
As I 189.042 nm	6.6	9.8	93	95	96	94	95	93	94	94	94	94	93	94	93	95	93	96	95	95
As I 193.759 nm	6.4	9.8	98	97	98	95	97	97	97	96	96	96	97	95	97	96	95	97	95	97
B I 249.677 nm	5.0	8.3	96	M	103	102	102	100	102	102	102	101	103	102	102	102	103	102	104	104
B I 249.773 nm	5.0	8.3	97	M	103	103	102	101	103	102	103	101	102	102	103	102	102	102	104	103
Ba II 233.527 nm	11.0	5.2	90	101	98	97	101	96	98	99	102	101	100	71	82	83	92	96	92	M
Ba II 455.404 nm	7.9	5.2	91	101	102	99	101	102	98	101	99	102	102	74	80	85	92	96	92	M
Be I 234.861 nm	5.3	9.3	99	102	103	102	101	100	102	100	99	99	101	102	102	102	102	100	103	103
Be II 313.042 nm	13.0	9.3	100	101	100	101	102	100	101	102	98	99	103	99	102	102	104	100	100	104
Bi I 222.825 nm	5.6	7.3	90	91	87	92	89	87	88	90	87	90	90	80	92	83	89	90	88	86
Bi I 223.061 nm	5.6	7.3	89	90	89	92	90	89	89	89	91	90	91	84	89	86	90	89	87	90
Bi I 306.772 nm	4.0	7.3	88	88	90	89	89	89	88	88	89	88	91	85	87	87	88	87	88	89
Ca II 317.933 nm	13.0	6.1	85	102	102	97	101	100	99	101	95	101	102	77	81	84	93	95	M	98
Ca II 393.366 nm	9.3	6.1	95	104	106	101	106	103	100	103	94	107	106	75	77	83	94	97	M	96
Ca II 396.847 nm	9.2	6.1	92	101	102	98	101	102	98	102	93	104	103	74	75	81	91	93	M	95
Cd I 228.802 nm	5.4	9.0	100	101	100	101	101	99	101	100	101	100	101	100	101	99	101	101	100	100
Cd II 214.438 nm	15.0	9.0	100	103	101	102	103	101	103	103	101	101	102	98	100	101	102	101	102	103
Cd II 226.502 nm	14.0	9.0	99	103	103	99	102	100	103	102	100	100	102	100	101	100	104	102	99	101
Ce II 413.38 nm	9.4	5.5	91	100	101	98	101	99	99	100	101	100	101	75	82	84	92	95	91	97
Ce II 448.691 nm	8.6	5.5	92	101	100	99	101	99	99	100	101	101	101	76	83	84	92	96	91	97
Co I 344.364 nm	4.1	7.9	101	104	M	103	100	95	98	101	108	103	104	95	94	90	94	92	103	99
Co I 345.35 nm	4.0	7.9	112	105	M	102	101	100	99	102	102	99	104	97	98	96	98	94	99	101
Co II 228.616 nm	14.0	7.9	102	106	M	101	102	102	101	101	101	102	104	94	99	100	104	97	99	105
Co II 238.892 nm	13.0	7.9	97	104	M	100	103	101	102	101	101	100	102	94	98	100	102	96	98	101
Cr I 357.869 nm	3.5	6.8	96	102	104	M	102	103	100	102	99	100	100	93	93	94	98	97	97	100
Cr I 425.435 nm	2.9	6.8	90	97	98	M	100	100	97	99	102	102	99	85	89	90	95	97	94	97
Cr II 205.552 nm	13.0	6.8	95	108	106	M	103	100	99	103	104	105	107	87	93	91	99	99	97	102
Cr II 267.716 nm	13.0	6.8	94	102	104	M	100	97	95	102	97	101	103	81	92	90	96	95	91	95
Cr II 283.563 nm	13.0	6.8	94	102	102	M	102	96	97	100	98	99	102	82	89	89	96	95	93	96
Cu I 324.754 nm	3.8	7.7	95	99	100	102	M	102	100	99	100	102	101	99	102	99	102	99	99	100
Cu I 327.396 nm	3.8	7.7	99	102	98	101	M	100	99	98	101	101	99	98	101	100	102	98	99	101

Emission Line	TE, eV	IP, eV	Matrix Elements																	
			Al	B	Co	Cr	Cu	Fe	Mn	Ni	Ti	V	Zn	Li	Na	K	Cs	Mg	Ca	Ba
Fe II 238.204 nm	13.0	7.9	98	104	102	99	102	M	101	102	100	100	102	92	96	97	100	99	98	100
Fe II 239.562 nm	13.0	7.9	98	105	100	101	103	M	103	101	102	100	103	92	97	101	102	99	99	101
Fe II 259.941 nm	13.0	7.9	98	103	102	100	102	M	100	101	100	100	102	91	97	98	101	98	97	101
Gd II 335.047 nm	10.0	6.1	93	102	102	99	102	99	99	102	100	99	102	80	86	88	94	95	92	98
Gd II 342.247 nm	10.0	6.1	93	101	102	99	102	101	99	101	99	101	103	79	86	88	96	95	92	99
Hf II 232.247 nm	12.0	6.8	99	104	103	102	105	103	107	106	103	99	105	100	103	95	105	104	101	100
Hf II 264.141 nm	13.0	6.8	104	105	104	105	104	103	104	104	104	103	104	95	102	103	106	103	104	104
Hf II 339.98 nm	10.0	6.8	96	102	103	103	100	101	101	104	101	102	100	93	97	98	94	99	100	101
K I 766.491 nm	1.6	4.3	112	98	101	104	99	100	102	99	101	103	101	131	124	M	114	107	113	105
La II 333.749 nm	9.7	5.6	89	100	103	100	101	100	99	100	100	101	100	73	81	82	92	95	92	98
La II 379.478 nm	9.1	5.6	91	102	102	99	101	100	99	102	100	101	103	74	81	83	92	96	92	99
La II 408.672 nm	8.6	5.6	92	101	102	99	102	100	99	101	100	100	103	76	82	84	92	96	94	100
Li I 670.78 nm	1.8	5.4	88	102	102	101	101	101	99	101	102	103	101	M	72	73	87	94	105	103
Lu II 261.542 nm	10.0	5.4	96	101	102	100	101	101	100	101	99	99	103	87	92	94	99	98	95	100
Lu II 291.139 nm	11.0	5.4	97	103	103	99	102	99	100	101	100	99	103	87	94	95	101	98	96	100
Lu II 307.76 nm	11.0	5.4	96	101	100	99	100	100	99	101	99	100	101	86	93	94	99	97	95	100
Mg I 285.213 nm	4.3	7.6	97	101	102	100	102	101	99	100	101	101	103	87	92	92	97	M	94	99
Mg II 280.27 nm	12.0	7.6	96	103	103	100	103	101	100	101	100	100	103	84	90	92	97	M	94	99
Mn I 403.076 nm	3.1	7.4	95	100	99	99	99	98	M	98	101	100	99	88	91	92	96	97	94	97
Mn II 257.611 nm	12.0	7.4	96	104	103	100	102	101	M	102	100	100	103	84	91	93	98	97	94	100
Mn II 259.373 nm	12.0	7.4	98	105	102	101	102	101	M	102	102	100	103	85	91	94	99	98	96	99
Mo II 202.03 nm	13.0	7.1	101	105	104	108	108	107	112	110	100	101	103	96	106	106	102	104	104	103
Mo II 281.615 nm	13.0	7.1	97	101	104	100	103	99	101	100	99	99	103	92	97	97	102	98	98	101
Mo II 379.825 nm	3.3	7.1	98	100	101	100	101	99	100	101	100	100	102	96	98	97	99	100	99	100
Na I 588.995 nm	2.1	5.1	97	101	100	100	100	99	98	98	101	100	99	79	M	85	91	97	104	104
Na I 589.592 nm	2.1	5.1	100	102	102	102	102	102	99	101	103	102	102	82	M	88	95	99	107	106
Nb II 269.706 nm	12.0	6.8	94	101	101	100	102	100	102	100	100	96	101	91	96	98	101	99	99	98
Nb II 309.418 nm	11.0	6.8	94	103	101	100	101	100	100	102	99	96	102	91	98	98	102	100	99	102
Nb II 313.079 nm	11.0	6.8	95	102	103	102	104	101	101	102	93	100	103	93	98	100	102	99	99	102
Ni I 232.003 nm	5.3	7.6	99	103	102	99	102	101	98	M	102	101	100	94	99	99	101	95	100	101
Ni I 352.454 nm	3.5	7.6	95	99	97	94	98	98	98	M	101	99	96	93	98	97	97	93	95	98
Pb I 368.346 nm	4.3	7.4	88	95	94	95	95	95	94	95	96	95	94	81	85	86	91	91	89	92
Pb I 405.778 nm	4.4	7.4	91	95	94	95	95	93	94	93	96	95	95	84	86	87	91	92	89	93
Pd I 324.27 nm	4.6	8.3	105	102	100	103	105	104	101	101	103	101	101	97	105	100	103	99	102	101
Pd I 340.458 nm	4.5	8.3	97	98	102	101	100	101	100	98	102	101	99	96	98	98	98	97	99	99
Pt I 299.797 nm	4.2	9.0	98	100	100	101	101	98	99	100	101	98	100	100	100	100	101	99	98	100
Pt I 306.471 nm	4.0	9.0	99	98	99	99	99	98	98	99	99	98	98	96	97	98	97	98	98	100
Rh I 343.489 nm	3.6	7.5	100	101	101	102	100	101	99	100	100	100	101	96	98	98	102	96	95	102
Rh I 369.236 nm	3.4	7.5	98	101	99	99	100	99	99	99	101	98	100	94	97	96	99	96	97	99
Sb I 206.833 nm	6.0	8.6	95	97	97	96	97	93	95	95	97	97	99	95	96	95	97	96	95	97
Sb I 217.581 nm	5.7	8.6	94	97	96	95	96	94	96	97	95	96	97	95	96	95	96	96	95	97
Sb I 231.147 nm	5.4	8.6	95	97	88	95	98	96	97	98	97	96	97	96	97	94	98	97	96	96

Emission Line	TE, eV	IP, eV	Matrix Elements																	
			Al	B	Co	Cr	Cu	Fe	Mn	Ni	Ti	V	Zn	Li	Na	K	Cs	Mg	Ca	Ba
Sc II 361.384 nm	10.0	6.6	96	103	102	100	103	101	100	102	100	101	103	77	91	93	99	97	95	100
Sc II 424.683 nm	9.8	6.6	92	100	100	99	100	99	98	100	98	99	100	76	89	90	96	95	92	98
Se I 196.09 nm	6.3	9.8	91	97	99	97	94	92	95	96	96	94	96	94	96	96	98	97	96	98
Se I 203.985 nm	6.3	9.8	95	98	104	92	95	87	83	88	100	99	99	91	98	96	95	98	96	98
Sr II 407.771 nm	10.0	5.7	88	99	98	96	99	98	96	98	97	95	98	72	79	82	89	92	89	96
Sr II 421.552 nm	10.0	5.7	92	103	102	97	102	102	100	102	102	101	104	74	82	84	93	96	93	100
Ta II 240.063 nm	13.0	7.5	92	102	101	102	99	96	103	101	101	100	105	92	99	100	100	101	100	96
Ta II 268.517 nm	12.0	7.5	96	101	103	101	102	101	103	102	101	99	102	94	99	101	105	100	99	102
Tb II 350.917 nm	9.4	5.9	89	98	94	90	98	94	97	95	100	98	99	76	85	86	90	94	90	95
Tb II 370.286 nm	9.3	5.9	92	100	101	97	101	99	98	100	98	99	100	80	86	88	95	96	91	98
Ti II 307.864 nm	11.0	6.8	95	102	100	98	100	100	99	101	M	99	101	86	93	94	98	98	96	100
Ti II 334.941 nm	11.0	6.8	96	101	101	100	101	100	99	101	M	99	103	87	93	95	101	97	96	102
Ti II 336.121 nm	11.0	6.8	92	104	104	101	100	103	100	102	M	100	101	87	97	96	99	98	99	100
Tm II 313.126 nm	10.0	6.2	94	99	100	99	101	100	100	102	99	100	103	83	90	92	98	97	92	100
Tm II 342.508 nm	9.8	6.2	91	101	102	98	101	100	99	100	99	99	101	81	88	91	95	96	93	98
Tm II 346.22 nm	9.8	6.2	94	101	100	97	100	99	99	100	100	99	102	80	88	91	96	96	92	99
V II 292.464 nm	11.0	6.7	96	102	103	99	103	96	99	100	99	M	101	87	94	95	100	97	97	99
V II 309.311 nm	11.0	6.7	96	97	99	99	101	99	100	101	100	M	103	87	93	97	100	99	96	102
V II 311.071 nm	11.0	6.7	96	103	101	99	101	99	101	102	100	M	102	88	98	95	101	99	98	101
W I 400.875 nm	3.5	7.9	92	97	98	97	96	97	97	95	98	96	96	94	96	95	95	97	98	99
W II 239.709 nm	14.0	7.9	99	105	98	106	97	108	98	97	102	100	97	96	97	112	109	100	100	106
Y II 360.073 nm	9.8	6.2	94	103	104	101	103	103	100	103	98	99	102	72	87	90	97	96	94	100
Y II 371.03 nm	9.7	6.2	93	101	102	98	102	100	99	101	99	99	102	70	86	89	95	95	92	98
Y II 377.433 nm	9.6	6.2	93	101	102	99	101	100	99	101	99	100	102	69	87	89	95	95	92	99
Zn I 213.856 nm	5.8	9.4	104	103	101	102	102	100	101	100	102	103	M	102	103	101	102	101	101	102
Zn II 202.548 nm	16.0	9.4	98	105	100	98	102	99	96	102	99	102	M	97	100	99	101	97	98	101
Zn II 206.191 nm	15.0	9.4	102	105	102	100	98	99	93	98	101	103	M	99	100	103	102	100	99	105
Zr II 339.198 nm	10.0	6.6	96	101	102	100	101	100	100	101	99	100	103	89	94	96	101	98	96	102
Zr II 343.823 nm	10.0	6.6	95	100	101	98	100	99	100	100	98	98	101	87	93	95	98	98	95	100
Zr II 357.247 nm	10.0	6.6	97	102	103	99	103	100	101	102	101	101	104	86	91	93	100	98	96	101
Plasma robustness			1.5	1.5	1.5	1.4	1.5	1.5	1.5	1.5	1.4	1.4	1.5	1.4	1.4	1.5	1.5	1.5	1.4	1.5

Table S2. The same dataset as in Table S1, but data sorted by increasing total line energy

Emission Line	TE, eV	IP, eV	Matrix Elements																	
			Al	B	Co	Cr	Cu	Fe	Mn	Ni	Ti	V	Zn	Li	Na	K	Cs	Mg	Ca	Ba
K I 766.491 nm	1.6	4.3	112	98	101	104	99	100	102	99	101	103	101	131	124	M	114	107	113	105
Li I 670.78 nm	1.8	5.4	88	102	102	101	101	101	99	101	102	103	101	M	72	73	87	94	105	103
Na I 588.995 nm	2.1	5.1	97	101	100	100	100	99	98	98	101	100	99	79	M	85	91	97	104	104
Na I 589.592 nm	2.1	5.1	100	102	102	102	102	102	99	101	103	102	102	82	M	88	95	99	107	106
Cr I 425.435 nm	2.9	6.8	90	97	98	M	100	100	97	99	102	102	99	85	89	90	95	97	94	97
Al I 394.401 nm	3.1	6.0	M	101	102	101	102	101	100	102	100	101	103	84	90	88	95	98	98	101
Al I 396.152 nm	3.1	6.0	M	101	100	100	100	100	100	100	101	101	101	83	88	88	94	97	96	99
Mn I 403.076 nm	3.1	7.4	95	100	99	99	99	98	M	98	101	100	99	88	91	92	96	97	94	97
Mo II 379.825 nm	3.3	7.1	98	100	101	100	101	99	100	101	100	100	102	96	98	97	99	100	99	100
Rh I 369.236 nm	3.4	7.5	98	101	99	99	100	99	99	99	101	98	100	94	97	96	99	96	97	99
Cr I 357.869 nm	3.5	6.8	96	102	104	M	102	103	100	102	99	100	100	93	93	94	98	97	97	100
Ni I 352.454 nm	3.5	7.6	95	99	97	94	98	98	98	M	101	99	96	93	98	97	97	93	95	98
W I 400.875 nm	3.5	7.9	92	97	98	97	96	97	97	95	98	96	96	94	96	95	95	97	98	99
Rh I 343.489 nm	3.6	7.5	100	101	101	102	100	101	99	100	100	100	101	96	98	98	102	96	95	102
Cu I 324.754 nm	3.8	7.7	95	99	100	102	M	102	100	99	100	102	101	99	102	99	102	99	99	100
Cu I 327.396 nm	3.8	7.7	99	102	98	101	M	100	99	98	101	101	99	98	101	100	102	98	99	101
Al I 308.215 nm	4.0	6.0	M	101	100	97	98	99	99	100	99	100	100	84	89	87	93	97	94	100
Bi I 306.772 nm	4.0	7.3	88	88	90	89	89	89	88	88	89	88	91	85	87	87	88	87	88	89
Co I 345.35 nm	4.0	7.9	112	105	M	102	101	100	99	102	102	99	104	97	98	96	98	94	99	101
Pt I 306.471 nm	4.0	9.0	99	98	99	99	99	98	98	99	99	98	98	96	97	98	97	98	98	100
Co I 344.364 nm	4.1	7.9	101	104	M	103	100	95	98	101	108	103	104	95	94	90	94	92	103	99
Pt I 299.797 nm	4.2	9.0	98	100	100	101	101	98	99	100	101	98	100	100	100	100	101	99	98	100
Mg I 285.213 nm	4.3	7.6	97	101	102	100	102	101	99	100	101	101	103	87	92	92	97	M	94	99
Pb I 368.346 nm	4.3	7.4	88	95	94	95	95	95	94	95	96	95	94	81	85	86	91	91	89	92
Pb I 405.778 nm	4.4	7.4	91	95	94	95	95	93	94	93	96	95	95	84	86	87	91	92	89	93
Pd I 340.458 nm	4.5	8.3	97	98	102	101	100	101	100	98	102	101	99	96	98	98	98	97	99	99
Pd I 324.27 nm	4.6	8.3	105	102	100	103	105	104	101	101	103	101	101	97	105	100	103	99	102	101
B I 249.677 nm	5.0	8.3	96	M	103	102	102	100	102	102	102	101	103	102	102	102	103	102	104	104
B I 249.773 nm	5.0	8.3	97	M	103	103	102	101	103	102	103	101	102	102	103	102	102	102	104	103
Be I 234.861 nm	5.3	9.3	99	102	103	102	101	100	102	100	99	99	101	102	102	102	102	100	103	103
Ni I 232.003 nm	5.3	7.6	99	103	102	99	102	101	98	M	102	101	100	94	99	99	101	95	100	101
Cd I 228.802 nm	5.4	9.0	100	101	100	101	101	99	101	100	101	100	101	100	101	99	101	101	100	100
Sb I 231.147 nm	5.4	8.6	95	97	88	95	98	96	97	98	97	96	97	96	97	94	98	97	96	96
Bi I 222.825 nm	5.6	7.3	90	91	87	92	89	87	88	90	87	90	90	80	92	83	89	90	88	86
Bi I 223.061 nm	5.6	7.3	89	90	89	92	90	89	89	89	91	90	91	84	89	86	90	89	87	90
Sb I 217.581 nm	5.7	8.6	94	97	96	95	96	94	96	97	95	96	97	95	96	95	96	96	95	97
Zn I 213.856 nm	5.8	9.4	104	103	101	102	102	100	101	100	102	103	M	102	103	101	102	101	101	102
Sb I 206.833 nm	6.0	8.6	95	97	97	96	97	93	95	95	97	97	99	95	96	95	97	96	95	97

Emission Line	TE, eV	IP, eV	Matrix Elements																	
			Al	B	Co	Cr	Cu	Fe	Mn	Ni	Ti	V	Zn	Li	Na	K	Cs	Mg	Ca	Ba
Se I 196.09 nm	6.3	9.8	91	97	99	97	94	92	95	96	96	94	96	94	96	98	97	96	98	
Se I 203.985 nm	6.3	9.8	95	98	104	92	95	87	83	88	100	99	99	91	98	96	95	98	96	98
As I 193.759 nm	6.4	9.8	98	97	98	95	97	97	97	96	96	96	97	95	97	96	95	97	95	97
As I 189.042 nm	6.6	9.8	93	95	96	94	95	93	94	94	94	94	93	94	93	95	93	96	95	95
Ba II 455.404 nm	7.9	5.2	91	101	102	99	101	102	98	101	99	102	102	74	80	85	92	96	92	M
Ce II 448.691 nm	8.6	5.5	92	101	100	99	101	99	99	100	101	101	101	76	83	84	92	96	91	97
La II 408.672 nm	8.6	5.6	92	101	102	99	102	100	99	101	100	100	103	76	82	84	92	96	94	100
La II 379.478 nm	9.1	5.6	91	102	102	99	101	100	99	102	100	101	103	74	81	83	92	96	92	99
Ca II 396.847 nm	9.2	6.1	92	101	102	98	101	102	98	102	93	104	103	74	75	81	91	93	M	95
Ca II 393.366 nm	9.3	6.1	95	104	106	101	106	103	100	103	94	107	106	75	77	83	94	97	M	96
Tb II 370.286 nm	9.3	5.9	92	100	101	97	101	99	98	100	98	99	100	80	86	88	95	96	91	98
Ce II 413.38 nm	9.4	5.5	91	100	101	98	101	99	99	100	101	100	101	75	82	84	92	95	91	97
Tb II 350.917 nm	9.4	5.9	89	98	94	90	98	94	97	95	100	98	99	76	85	86	90	94	90	95
Y II 377.433 nm	9.6	6.2	93	101	102	99	101	100	99	101	99	100	102	69	87	89	95	95	92	99
La II 333.749 nm	9.7	5.6	89	100	103	100	101	100	99	100	100	101	100	73	81	82	92	95	92	98
Y II 371.03 nm	9.7	6.2	93	101	102	98	102	100	99	101	99	99	102	70	86	89	95	95	92	98
Sc II 424.683 nm	9.8	6.6	92	100	100	99	100	99	98	100	98	99	100	76	89	90	96	95	92	98
Tm II 342.508 nm	9.8	6.2	91	101	102	98	101	100	99	100	99	99	101	81	88	91	95	96	93	98
Tm II 346.22 nm	9.8	6.2	94	101	100	97	100	99	99	100	100	99	102	80	88	91	96	96	92	99
Y II 360.073 nm	9.8	6.2	94	103	104	101	103	103	100	103	98	99	102	72	87	90	97	96	94	100
Gd II 335.047 nm	10.0	6.1	93	102	102	99	102	99	99	102	100	99	102	80	86	88	94	95	92	98
Gd II 342.247 nm	10.0	6.1	93	101	102	99	102	101	99	101	99	101	103	79	86	88	96	95	92	99
Hf II 339.98 nm	10.0	6.8	96	102	103	103	100	101	101	104	101	102	100	93	97	98	94	99	100	101
Lu II 261.542 nm	10.0	5.4	96	101	102	100	101	101	100	101	99	99	103	87	92	94	99	98	95	100
Sc II 361.384 nm	10.0	6.6	96	103	102	100	103	101	100	102	100	101	103	77	91	93	99	97	95	100
Sr II 407.771 nm	10.0	5.7	88	99	98	96	99	98	96	98	97	95	98	72	79	82	89	92	89	96
Sr II 421.552 nm	10.0	5.7	92	103	102	97	102	102	100	102	102	101	104	74	82	84	93	96	93	100
Tm II 313.126 nm	10.0	6.2	94	99	100	99	101	100	100	102	99	100	103	83	90	92	98	97	92	100
Zr II 339.198 nm	10.0	6.6	96	101	102	100	101	100	100	101	99	100	103	89	94	96	101	98	96	102
Zr II 343.823 nm	10.0	6.6	95	100	101	98	100	99	100	100	98	98	101	87	93	95	98	98	95	100
Zr II 357.247 nm	10.0	6.6	97	102	103	99	103	100	101	102	101	101	104	86	91	93	100	98	96	101
Ba II 233.527 nm	11.0	5.2	90	101	98	97	101	96	98	99	102	101	100	71	82	83	92	96	92	M
Lu II 291.139 nm	11.0	5.4	97	103	103	99	102	99	100	101	100	99	103	87	94	95	101	98	96	100
Lu II 307.76 nm	11.0	5.4	96	101	100	99	100	100	99	101	99	100	101	86	93	94	99	97	95	100
Nb II 309.418 nm	11.0	6.8	94	103	101	100	101	100	100	102	99	96	102	91	98	98	102	100	99	102
Nb II 313.079 nm	11.0	6.8	95	102	103	102	104	101	101	102	93	100	103	93	98	100	102	99	99	102

Emission Line	TE, eV	IP, eV	Matrix Elements																	
			Al	B	Co	Cr	Cu	Fe	Mn	Ni	Ti	V	Zn	Li	Na	K	Cs	Mg	Ca	Ba
Ti II 307.864 nm	11.0	6.8	95	102	100	98	100	100	99	101	M	99	101	86	93	94	98	98	96	100
Ti II 334.941 nm	11.0	6.8	96	101	101	100	101	100	99	101	M	99	103	87	93	95	101	97	96	102
Ti II 336.121 nm	11.0	6.8	92	104	104	101	100	103	100	102	M	100	101	87	97	96	99	98	99	100
V II 292.464 nm	11.0	6.7	96	102	103	99	103	96	99	100	99	M	101	87	94	95	100	97	97	99
V II 309.311 nm	11.0	6.7	96	97	99	99	101	99	100	101	100	M	103	87	93	97	100	99	96	102
V II 311.071 nm	11.0	6.7	96	103	101	99	101	99	101	102	100	M	102	88	98	95	101	99	98	101
Hf II 232.247 nm	12.0	6.8	99	104	103	102	105	103	107	106	103	99	105	100	103	95	105	104	101	100
Mg II 280.27 nm	12.0	7.6	96	103	103	100	103	101	100	101	100	100	103	84	90	92	97	M	94	99
Mn II 257.611 nm	12.0	7.4	96	104	103	100	102	101	M	102	100	100	103	84	91	93	98	97	94	100
Mn II 259.373 nm	12.0	7.4	98	105	102	101	102	101	M	102	102	100	103	85	91	94	99	98	96	99
Nb II 269.706 nm	12.0	6.8	94	101	101	100	102	100	102	100	100	96	101	91	96	98	101	99	99	98
Ta II 268.517 nm	12.0	7.5	96	101	103	101	102	101	103	102	101	99	102	94	99	101	105	100	99	102
Be II 313.042 nm	13.0	9.3	100	101	100	101	102	100	101	102	98	99	103	99	102	102	104	100	100	104
Ca II 317.933 nm	13.0	6.1	85	102	102	97	101	100	99	101	95	101	102	77	81	84	93	95	M	98
Co II 238.892 nm	13.0	7.9	97	104	M	100	103	101	102	101	101	100	102	94	98	100	102	96	98	101
Cr II 205.552 nm	13.0	6.8	95	108	106	M	103	100	99	103	104	105	107	87	93	91	99	99	97	102
Cr II 267.716 nm	13.0	6.8	94	102	104	M	100	97	95	102	97	101	103	81	92	90	96	95	91	95
Cr II 283.563 nm	13.0	6.8	94	102	102	M	102	96	97	100	98	99	102	82	89	89	96	95	93	96
Fe II 238.204 nm	13.0	7.9	98	104	102	99	102	M	101	102	100	100	102	92	96	97	100	99	98	100
Fe II 239.562 nm	13.0	7.9	98	105	100	101	103	M	103	101	102	100	103	92	97	101	102	99	99	101
Fe II 259.941 nm	13.0	7.9	98	103	102	100	102	M	100	101	100	100	102	91	97	98	101	98	97	101
Hf II 264.141 nm	13.0	6.8	104	105	104	105	104	103	104	104	104	103	104	95	102	103	106	103	104	104
Mo II 202.03 nm	13.0	7.1	101	105	104	108	108	107	112	110	100	101	103	96	106	106	102	104	104	103
Mo II 281.615 nm	13.0	7.1	97	101	104	100	103	99	101	100	99	99	103	92	97	97	102	98	98	101
Ta II 240.063 nm	13.0	7.5	92	102	101	102	99	96	103	101	101	100	105	92	99	100	100	101	100	96
Cd II 226.502 nm	14.0	9.0	99	103	103	99	102	100	103	102	100	100	102	100	101	100	104	102	99	101
Co II 228.616 nm	14.0	7.9	102	106	M	101	102	102	101	101	101	102	104	94	99	100	104	97	99	105
W II 239.709 nm	14.0	7.9	99	105	98	106	97	108	98	97	102	100	97	96	97	112	109	100	100	106
Cd II 214.438 nm	15.0	9.0	100	103	101	102	103	101	103	103	101	101	102	98	100	101	102	101	102	103
Zn II 206.191 nm	15.0	9.4	102	105	102	100	98	99	93	98	101	103	M	99	100	103	102	100	99	105
Zn II 202.548 nm	16.0	9.4	98	105	100	98	102	99	96	102	99	102	M	97	100	99	101	97	98	101