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Spectrum of quadruply ionized zinc: Zn v

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The $3d^8$-$3d^74p$ transitions in Zn V have been studied using spectrograms obtained on 2-, 3-, and 6.60-m grazing incidence spectrographs. The source used was a low-inductance-triggered spark. All levels of the $3d^8$ configuration and 93 of 110 levels of the $3d^74p$ configuration have been established. The energy parameters obtained from least-squares-fit calculations and Hartree-Fock calculations in the Ni III-to-Ge VII isoelectronic sequence are compared. Two-hundred and sixty-six (266) lines have been classified in the region 260 – 385 Å.

I. INTRODUCTION

The ground-state configuration of quadruply ionized zinc (Zn V) is $3d^8$ with ^3F as the lowest term. In 1974 Dick[1] reported the ground-state intervals $^3F_3$-$^3F_4$ (2466 cm^{-1}) and $^3F_2$-$^3F_3$ (1570 cm^{-1}), but he did not publish any classified lines. The Zn V spectrum belongs to the Fe I isoelectronic sequence and is of astrophysical interest. Zinc has been identified in solar corona and solar photosphere.[2] The spectra of Fe I,[3] Co II,[4] Ni III,[5] and Cu IV,[6] have been studied quite extensively.

In the past few years the spectra of the various stages of ionization of nickel[7,8] and copper[9,10] have been studied at the Zeeman Laboratory (Amsterdam). Therefore, a similar program for studying various spectra of zinc (Zn V, Zn VI, and Zn VII) was undertaken by two of the authors (Y.N.J. and Th.A.M.VK.), and some of the results were reported at Pisa, Italy.[11]

The need for spectroscopic data on highly ionized molybdenum for support of tokamak fusion research has stimulated the study of Mo XVII and isoelectronic ions.[12–14] Two of the authors (L.I.P. and A.N.R.) at the Institute for Spectroscopy (Moscow) were engaged in the implementation of their program to identify spectra between Cu IV (Ref. 6) and Mo XVII.[14] The work on Ga VI (Ref. 15) and Ge VII (Ref. 16) has already been reported. Our two groups got in touch with each other after almost identical results on Br IX (Refs. 17 and 18) appeared separately. The result is this joint publication.

II. EXPERIMENTAL

The spectrum of zinc was photographed in the region 200 – 1000 Å on a variety of spectrographs located at the Zeeman Laboratory (Amsterdam) and the Institute of Spectroscpy (Moscow). Even though a sliding spark source[19] has been used successfully for the nickel and copper spectra, it could not be used efficiently for the zinc exposures as the zinc sublimated quite rapidly. The source used in both laboratories was a triggered spark.[20] Spectroscopically pure zinc was introduced into the cavity of an aluminum, yttrium, or titanium electrode. Exposures were also taken with pure zinc electrodes. The lines belonging to different ionization stages were discriminated by comparing the intensity of the lines on various exposures taken under different experimental conditions, viz., the variation of the charging potential and the introduction of a series inductance. The plates were measured on semiautomatic comparators.[24,25] Additional experimental details are given in Table I.

The entire Zn V $3d^8$-$3d^74p$ transition array appeared in the wavelength region 260 – 385 Å. The plate factor of the Amsterdam spectrograph (6.60 m, 1200 lines/mm) is slightly lower than that of the Moscow spectrograph (3 m, 3600 lines/mm)

TABLE I. Details of the experimental setup at the Zeeman Laboratory (Amsterdam) and the Institute for Spectroscopy (Moscow) for zinc exposures.

	Zeeman Laboratory	Institute for Spectroscopy
Spectrograph	200–600 Å	200–350 Å
	6.60-m grazing incidence	3-m grazing incidence
	1200-lines/mm grating	3600-lines/mm holographic grating
	$i=85°$,[a] $\delta=0.364$ Å/mm (325 Å)[a]	$i=85°$, $\delta=0.441$ Å/mm (325 Å)
	500–1000 Å	$\lambda>300$ Å
	6.65-m normal incidence	2-m grazing incidence
		(Hilger E-580)
	2400-lines/mm holographic grating	1200-lines/mm grating
Source	Triggered spark[b]	Triggered spark
	$c=8$ μF; low inductance	$c=10$ μF, low inductance
	8 kV	4 kV
	Variable series inductance	
Plates	Kodak SWR	ORWO UV-2
Measurements	Semiautomatic comparator COSPINSCA[c]	Semiautomatic microphotometer[e]
Standards	Internal[d]: Al, Y	Internal: Ti,[f] Al
λ calculations	2nd or 3rd degree polynomial fit	3rd degree polynomial fit

[a] i is the angle of incidence and δ is the plate factor of the spectrograph.
[b] Feldman *et al.* (Ref. 20).
[c] Poppe *et al.* (Ref. 24).
[d] Kaufman *et al.* (Ref. 21); Reader *et al.* (Ref. 22).
[e] Kovalev *et al.* (Ref. 25).
[f] Svensson *et al.* (Ref. 23).

(see Table I) in the region 260–347 Å. Beyond 347 Å, the plate factor of the Amsterdam spectrograph is much lower than the Moscow spectrograph (2 m, 1200 lines/mm). Therefore, the measurements from two laboratories complemented each other. Since Ti standards were better spaced and better developed than yttrium standards, the accuracy of the Moscow observations was slightly better, and consequently the wavelength values for most of the lines used in the present analysis have been taken from the Moscow observations. The accuracy of the measurements in the entire region is about ±0.003 Å.

III. RESULTS AND DISCUSSION

All lines used in the present analysis have Zn V ionization characteristics. Hartree-Fock (HF) calculations[26] were carried out for the $3d^8$ and $3d^74p$ configurations of Zn V. The energy parameters for the least-squares-fit (LSF) calculations[27] were estimated by comparing LSF-HF parameter ratios in the Fe I isoelectronic sequence from Ni III to Ge VII. This is shown in Figs. 1(a) and 1(b). The variation is strikingly smooth. The final LSF parameters used in the present calculations are given in Table II. The parameter "T" (Ref. 27) was fixed at -6.7 for the $3d^8$ configuration and -6.9 for the $3d^74p$ configuration, as suggested by Hansen and Raassen[28] for these cases.

All levels of the $3d^8$ configuration and 93 out of 110 levels of the $3d^74p$ configuration have been established. The values of all the levels along with their three largest LS components are given in Table III. The agreement between the observed and the calculated level values is very good. Five levels of the $3d^74p$ configuration, viz., $(^2P)^3P^o_0$ (312 967 cm^{-1}), $(^2P)^1S^o_0$ (317 469 cm^{-1}), $(^2P)^1D^o_2$ (320 871 cm^{-1}), $(^4P)^3P^o_0$ (322 975 cm^{-1}), and $(^2P)^1P^o_1$ (326 188 cm^{-1}), show a larger deviation (Δ) than 200 cm^{-1} from their calculated values. However, we must point out that the large deviations for these levels are quite consistent with the corresponding values in the Fe I isoelectronic se-

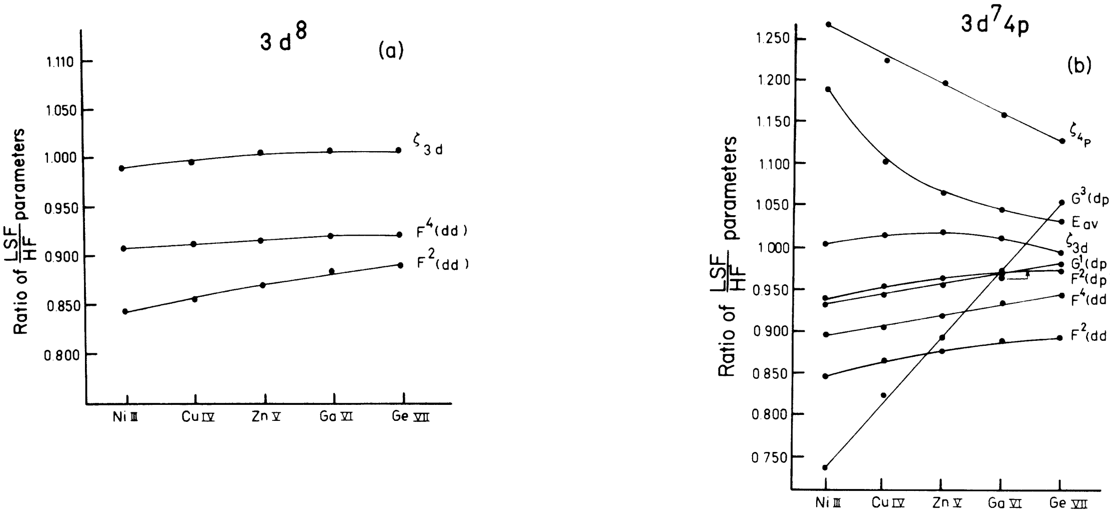

FIG. 1. (a) and (b) Comparison of the least-squares-fit (LSF) and Hartree-Fock (HF) parameters in the Fe I isoelectronic sequence from Ni III to Ge VII for the $3d^8$ and $3d^74p$ configurations. The LSF-HF parameter values for Ni III are from unpublished material by one of the authors (Th. A.M. VKJ). The variation is quite smooth for all the parameters in both configurations.

quence. Two levels, $(^4F)^5F^o_4$ (283 960 cm^{-1}) and $(1\,^2D)^1D^o_2$ (381 720 cm^{-1}), are doubtful and need confirmation even though the deviations Δ are relatively small. The calculated intensities of the transitions from these levels to $3d^8$ configuration levels are very small. Where known elsewhere in the isoelectronic sequence, they are generally established by means of transitions to other configura-

TABLE II. LSF and HF parameter values (cm^{-1}) for the parameters of the $3d^8$ and $3d^74p$ configurations of Zn V.

Parameter	$3d^8$ LSF	$3d^8$ HF	$3d^8$ LSF-HF	$3d^74p$ LSF	$3d^74p$ HF	$3d^74p$ LSF-HF
E_{av}	16073±161			320765±59	301276	1.065
$F^2(dd)$	108805±180	125053	0.870	114737±94	131372	0.873
$F^4(dd)$	71510±401	78416	0.912	74831±168	82671	0.905
$F^2(dp)$				26539±100	27682	0.959
$G^1(dp)$				8956±56	9422	0.951
$G^3(dp)$				7644±130	8727	0.876
ξ_{3d}	1200±20	1199	1.001	1316±14	1289	1.021
ξ_{4p}				2050±28	1707	1.201
β	−450±41			−406±20		
T	−6.7[a]			−6.9[a]		
α_1[c]	53±4			32±4		
α_2[c]				28±4		
σ[b]	47			100		

[a] Parameter held fixed in the least-squares calculations.

[b] σ = mean error = $[\sum(\text{exp. value} - \text{calc. value})^2/(m-n)]^{1/2}$ where m = number of known levels and n = number of free parameters.

[c] α_1 and α_2 are defined by Poppe (Ref. 27).

TABLE III. Energy levels and their *LS*-percentage compositions of the $3d^8$ and $3d^74p$ configurations of Zn V.

Level designation	J	Level[a] (cm^{-1})	Δ[b]	*LS*-percentage composition[c]
$3d^8$ configuration				
^3F	4	0	−14	100%
	3	2 466	5	100%
	2	4 036	9	$98\% + \underline{2}\%\ ^1D$
^1D	2	18 400	16	$79\% + 20\%\ ^3P + 1\%\ ^3F$
^3P	2	22 663	−68	$\underline{80}\% + 19\%\ ^1D + 1\%\ ^3F$
	1	23 107	31	100%
	0	23 510	21	100%
^1G	4	30 600	0	100%
^1S	0	69 904	0	100%
$3d^74p$ configuration				
$(^4F)\ ^5F$	5	[284 101]		$88\% + \underline{9}\%\ (^4F)^5G + \underline{3}\%\ (^4F)^3G$
	4	283 960?	23	$\underline{48}\% + 42\%\ (^4F)^5D + 3\%\ (^4P)^5D$
	3	[285 586]		$\underline{66}\% + 26\%\ (^4F)^5D + \underline{4}\%\ (^4F)^5G$
	2	[286 901]		$80\% + 14\%\ (^4F)^5D + \underline{3}\%\ (^4F)^5G$
	1	[287 837]		$\underline{92}\% + 6\%\ (^4F)^5D + \underline{1}\%\ (^4F)^3D$
$(^4F)\ ^5D$	4	[286 901]		$45\% + 36\%\ (^4F)^5F + \underline{13}\%\ (^4F)^5G$
	3	[288 677]		$57\% + 17\%\ (^4F)^5F + \underline{17}\%\ (^4F)^5G$
	2	[289 915]		$61\% + \underline{22}\%\ (^4F)^5G + \underline{8}\%\ (^4P)^5D$
	1	[290 756]		$81\% + \underline{12}\%\ (^4P)^5D + 6\%\ (^4F)^5F$
	0	[291 066]		$86\% + \underline{13}\%\ (^4P)^5D$
$(^4F)\ ^5G$	6	[288 478]		$\underline{99}\% + \underline{1}\%\ (^2G)^3H$
	5	288 904	39	$70\% + 18\%\ (^4F)^3G + 12\%\ (^4F)^5F$
	4	289 827	65	$\underline{72}\% + \underline{14}\%\ (^4F)^5F + \underline{8}\%\ (^4F)^3G$
	3	290 425	69	$\underline{72}\% + \underline{14}\%\ (^4F)^5F + \underline{7}\%\ (^4F)^5D$
	2	290 731	64	$71\% + 13\%(^4F)^5D + 10\%(^4F)^5F$
$(^4F)\ ^3G$	5	292 720	−19	$78\% + \underline{21}\%\ (^4F)^5G$
	4	295 170	−14	$87\% + \underline{11}\%\ (^4F)^5G + 1\%\ (^4F)^3F$
	3	296 798	−29	$80\% + \underline{14}\%\ (^4F)^3D + \underline{3}\%\ (^4F)^5G$
$(^4F)\ ^3F$	4	293 462	−4	$\underline{87}\% + 4\%\ (^2G)^3F + 2\%\ (^4F)^3G$
	3	295 293	−1	$\underline{80}\% + 8\%\ (^4F)^3D + 5\%\ (^2G)^3F$
	2	296 756	26	$\underline{86}\% + 5\%\ (^2G)^3F + 4\%\ (^4F)^3D$
$(^4F)\ ^3D$	3	297 033	−67	$70\% + 13\%\ (^4F)^3G + 9\%\ (^4F)^3F$
	2	298 374	−86	$84\% + 4\%\ (^4F)^3F + \underline{3}\%\ (^4P)^3D$
	1	299 372	−79	$88\% + \underline{3}\%\ (^4P)^3D + \underline{3}\%\ (^2P)^3D$
$(^4P)\ ^5S$	2	[299 288]		$\underline{96}\% + \underline{1}\%\ (^2P)^3P + 1\%\ (^4P)^5P$
$(^4P)\ ^3S$	1	309 659	−46	$18\% + 27\%\ (^2P)^3P + \underline{26}\%\ (^4P)^5D$
$(^2G)\ ^3F$	4	311 358	72	$\underline{44}\% + \underline{26}\%\ (^4P)^5D + 8\%\ (^2G)^3G$
	3	314 197	49	$66\% + \underline{21}\%\ (^2G)^3G + 4\%\ (^4F)^3F$
	2	316 583	114	$\underline{92}\% + \underline{5}\%\ (^4F)^3F + 1\%\ (1\,^2D)^3F$
$(^4P)\ ^5D$	4	311 794	35	$65\% + \underline{12}\%\ (^2G)^3F + 6\%\ (^4F)^5D$
	3	310 520	32	$73\% + 9\%\ (^4P)^3D + 8\%\ (^4F)^5D$
	2	310 266	61	$66\% + 10\%\ (^4F)^5D + 6\%\ ((^2P)^3D$
	1	311 292	−136	$\underline{52}\% + \underline{20}\%\ (^4P)^3S + \underline{6}\%\ (^4F)^5D$
	0	[310 826]		$\underline{69}\% + 17\%\ (^2P)^3P + \underline{12}\%\ (^4F)^5D$
$(^2G)\ ^3H$	6	[313 197]		$94\% + 4\%\ (^2H)^3I + \underline{1}\%\ (^2H)^1I$
	5	311 295	60	$63\% + 18\%\ (^2G)^1H + \underline{12}\%\ (^2G)^3G$
	4	312 537	73	$\underline{82}\% + \underline{5}\%\ (^2G)^1G + 4\%\ (^2G)^3F$
$(^2P)\ ^3P$	2	313 642	−141	$59\% + \underline{8}\%\ (3\,^2D)^3P + 7\%\ (^4P)^3D$
	1	314 229	−169	$\underline{41}\% + 19\%\ (^4P)^3S + 17\%\ (^4P)^5P$
	0	312 967	−280	$\underline{61}\% + \underline{15}\%\ (^4P)^5D + 13\%\ (3\,^2D)^3P$

TABLE III. *(Continued).*

Level designation	J	Level[a] (cm^{-1})	Δ[b]	LS-percentage composition[c]
$3d^74p$ configuration				
$(^2G)\,^1G$	4	314 835	68	$\underline{43}\%+\underline{28}\%\ (^2G)^3F+\underline{17}\%\ (^2H)^1G$
$(^4P)\,^5P$	3	315 241	116	$\underline{57}\%+20\%\ (^4P)^3D+\underline{10}\%\ (^2P)^3D$
	2	315 800	79	$\underline{50}\%+20\%\ (^4P)^3D+\underline{9}\%\ (^4P)^5D$
	1	316 028	59	$\underline{53}\%+23\%\ (^4P)^3S+\underline{9}\%\ (^2P)^3D$
$(^2G)\,^3G$	5	315 595	−83	$\underline{79}\%+\underline{13}\%\ (^2G)^1H+\underline{3}\%\ (^2G)^3H$
	4	316 827	−107	$71\%+11\%\ (^2G)^3H+\underline{8}\%\ (^2G)^1G$
	3	317 220	−96	$\underline{43}\%+22\%\ (^2G)^1F+\underline{12}\%\ (^2G)^3F$
$(^2G)\,^1F$	3	315 839	33	$\underline{35}\%+15\%\ (^4P)^3D+\underline{9}\%\ (^2G)^3G$
$(^4P)\,^3D$	3	316 340	38	$\underline{39}\%+\underline{22}\%\ (^2G)^3G+\underline{16}\%\ (^4P)^5P$
	2	319 984	20	$22\%+31\%\ (^4P)^3P+\underline{17}\%\ (^2P)^3D$
	1	316 645	24	$\underline{40}\%+\underline{29}\%\ (^2P)^3D+13\%\ (^4P)^5P$
$(^2G)\,^1H$	5	316 785	28	$61\%+\underline{29}\%\ (^2G)^3H+\underline{6}\%\ (^2G)^3G$
$(^2P)\,^1S$	0	317 469	−353	$60\%+\underline{30}\%\ (^4P)^3P+6\%\ (^2P)^3P$
$(^2H)\,^3G$	5	317 977	−19	$90\%+\underline{5}\%\ (^2F)^3G+\underline{1}\%\ (^2H)^3H$
	4	320 039	23	$\underline{85}\%+7\%\ (^2F)^3G+3\%\ (^2G)^3F$
	3	321 771	45	$75\%+\underline{7}\%\ (^2F)^3G+\underline{4}\ (3\%\,^2D)^1F$
$(^4P)\,^3P$	2	318 438	−81	$\underline{48}\%+17\%\ (^4P)^3D+12\%\ (3\,^2D)^3P$
	1	320 773	149	$46\%+20\%\ (3\,^2D)^3D+7\%\ (^2P)^1P$
	0	322 975	−284	$63\%+36\%\ (^2P)^1S+\underline{1}\%\ (^2P)^3P$
$(^2P)\,^3D$	3	319 632	−35	$63\%+\underline{9}\%\ (^4P)^5P+7\%\ (3\,^2D)^3F$
	2	314 956	87	$20\%+25\%\ (^4P)^5P+19\%\ (^2P)^1D$
	1	319 472	57	$\underline{25}\%+\underline{29}\%\ (^4P)^3P+21\%\ (^4P)^3D$
$(3\,^2D)\,^3D$	3	320 708	191	$50\%+\underline{14}\%\ (3\,^2D)^3F+\underline{14}\%\ (1\,^2D)^3D$
	2	322 224	−56	$\underline{26}\%+\underline{27}\%\ (^2P)^3D+14\%\ (^2P)^1D$
	1	321 831	33	$22\%+23\%\ (^2P)^1P+18\%\ (^2P)^3D$
$(^2H)\,^3I$	7	[320 794]		100%
	6	[319 106]		$65\%+31\%\ (^2H)^1I+\underline{3}\%\ (^2H)^3H$
	5	320 257	−145	$90\%+\underline{5}\%\ (^2G)^3H+\underline{2}\%\ (^2G)^3H$
$(^2P)\,^1D$	2	320 871	200	$18\%+21\%(3\,^2D)^3D+20\%\ (^2P)^3D$
$(^2H)\,^1I$	6	[323 784]		$66\%+\underline{30}\%\ (^2H)^3I+4\%\ (^2G)^3H$
$(3\,^2D)\,^3F$	4	323 887	−67	$77\%+\underline{20}\%\ (1\,^2D)^3F+\underline{2}\%\ (^2F)^3F$
	3	324 525	47	$46\%+\underline{11}\%\ (^2P)^3D+\underline{10}\%\ (1\,^2D)^3F$
	2	325 069	−17	$50\%+12\%\ (3\,^2D)^3D+\underline{10}\%\ (1\,^2D)^3F$
$(^2P)\,^3S$	1	325 476	−75	$\underline{62}\%+\underline{8}\%\ (^2P)^1P+\underline{8}\%\ (^2P)^3P$
$(^2P)\,^1P$	1	326 188	231	$42\%+\underline{13}\%\ (^2P)^3S+\underline{11}\%\ (3\,^2D)^3D$
$(3\,^2D)\,^1D$	2	326 663	88	$\underline{33}\%+22\%\ (3\,^2D)^3P+17\%\ (^2P)^1D$
$(^2H)\,^3H$	6	[327 019]		$\underline{96}\%+\underline{2}\%\ (^2H)^1I+\underline{1}\%\ (^2H)^3I$
	5	327 582	−1	$92\%+4\%\ (^2H)^1H+2\%\ (^2H)^3G$
	4	328 375	26	$94\%+\underline{2}\%\ (^2H)^1G+1\%\ (^2H)^3G$
$(3\,^2D)\,^3P$	2	329 083	92	$34\%+19\%\ (3\,^2D)^1D+11\%\ (^2P)^3P$
	1	331 086	−13	$\underline{48}\%+13\%\ (^2P)^1P+10\%\ (1\,^2D)^3P$
	0	331 870	103	$\underline{67}\%+\underline{15}\%\ (^2P)^3P+12\%\ (1\,^2D)^3P$
$(^2H)\,^1G$	4	329 533	−125	$65\%+\underline{32}\%\ (^2G)^1G+\underline{2}\%\ (^2F)^1G$
$(3\,^2D)^1F$	3	330 068	−12	$\underline{55}\%+16\%\ (^2G)^1F+13\%\ (1\,^2D)^1F$
$(3\,^2D)\,^1P$	1	332 177	−28	$72\%+\underline{11}\%\ (1\,^2D)^1P+\underline{6}\%\ (3\,^2D)^3P$
$(^2H)\,^1H$	5	333 453	−76	$\underline{94}\%+3\%\ (^2H)^3H+\underline{1}\%\ (^2G)^1H$
$(^2F)\,^1D$	2	341 626	135	$\underline{54}\%+\underline{34}\%\ (^2F)^3F+5\%\ (^2F)^3D$
$(^2F)\,^3D$	3	344 071	−20	$51\%+\underline{28}\%\ (^2F)^3F+\underline{8}\%\ (^2F)^3G$
	2	345 622	28	$\underline{79}\%+\underline{11}\%\ (^2F)^1D+\underline{5}\%(1\,^2D)^3D$
	1	345 790	107	$\underline{90}\%+\underline{5}\%+(1\,^2D)^3D+2\%\ (3\,^2D)^3D$

TABLE III. *(Continued).*

Level designation	J	Level[a] (cm^{-1})	Δ[b]	LS-percentage composition[c]
$3d^74p$ configuration				
$(^2F)\ ^3F$	4	345 725	33	$\underline{36}\%+\underline{38}\%\ (^2F)^3G+21\%\ (^2F)^1G$
	3	345 144	28	$46\%+34\%\ (^2F)^3D+11\%\ (^2F)^3G$
	2	344 774	55	$59\%+\underline{30}\%\ (^2F)^1D+5\%\ (^2F)^3D$
$(^2F)\ ^3G$	5	345 787	4	$\underline{93}\%+\underline{6}\%\ (^2H)^3G+1\%\ (^2G)^3G$
	4	343 224	−59	$53\%+\underline{26}\%\ (^2F)^3F+14\%\ (^2F)^1G$
	3	342 618	54	$68\%+\underline{19}\%\ (^2F)^3F+8\%\ (^2H)^3G$
$(^2F)\ ^1G$	4	346 200	−82	$63\%+33\%\ (^2F)^3F+\underline{2}\%\ (1\,^2D)^3F$
$(^2F)\ ^1F$	3	352 554	−64	$95\%+2\%\ (^2F)^3D+\underline{1}\%\ (^2F)^3G$
$(1\,^2D)\ ^3P$	2	368 833	−50	$76\%+\underline{21}\%\ (3\,^2D)^3P+1\%\ (1\,^2D)^3D$
	1	369 297	−47	$\underline{78}\%+\underline{17}\%\ (3\,^2D)^3P+3\%\ (1\,^2D)^1P$
	0	369 840	−27	$\underline{82}\%+\underline{17}\%\ (3\,^2D)^3P+1\%\ (^2P)^3P$
$(1\,^2D)\ ^3F$	4	374 240	−15	$74\%+22\%\ (3\,^2D)^3F+2\%\ (^2F)^3F$
	3	372 362	−32	$\underline{73}\%+\underline{19}\%\ (3\,^2D)^3F+\underline{3}\%\ (^2F)^3F$
	2	371 052	−58	$76\%+18\%\ (3\,^2D)^3F+3\%\ (^2F)^3F$
$(1\,^2D)^1P$	1	376 435	27	$\underline{77}\%+\underline{11}\%\ (3\,^2D)^1P+\underline{5}\%\ (1\,^2D)^3D$
$(1\,^2D)\ ^1F$	3	377 146	20	$73\%+20\%\ (3\,^2D)^1F+\underline{3}\%\ (1\,^2D)^3F$
$(1\,^2D)\ ^1D$	2	381 720?	−11	$\underline{59}\%+\underline{22}\%\ (3\,^2D)^1D+\underline{10}\%\ (1\,^2D)^3D$
$(1\,^2D)\ ^3D$	3	382 415	44	$\underline{69}\%+\underline{24}\%\ (3\,^2D)^3D+\underline{3}\%\ (1\,^2D)^1F$
	2	380 903	12	$\underline{63}\%+\underline{19}\%\ (3\,^2D)^3D+11\%\ (1\,^2D)^1D$
	1	380 466	45	$69\%+21\%\ (3\,^2D)^3D+\underline{6}\%\ (1\,^2D)^1P$

[a] The level values given in parentheses correspond to the calculated values of the levels.

[b] Δ = observed value − calculated value. The calculated value is the one obtained from the LSF calculation.

[c] Only three largest percentages are given. The first percentage corresponds to the designated level. If the percentage is underlined, its corresponding eigenvector is negative.

tions. The lines used to establish these levels in Zn V have proper ionization characteristics and have not been otherwise classified. We also have a tentative value for the level $(^4P)^5S^o_2$ (298 805 cm^{-1}), based on a single line 337.451 Å (250) corresponding to the transition $3d^8\,^3F_3$-$(^4P)^5S^o_2$. This was the only unclassified line in the region where it was expected from the LSF calculations. However, the intensity of the line is much higher than the calculated value. This level has to be confirmed too, and has been omitted from Table III.

The designations of the levels are generally based on the LS component having the highest percentage. The designations of the levels of the $3d^8$ configuration are quite unambiguous, as the corresponding LS component in all cases is 79% or higher. In the $3d^74p$ configuration, the largest percentage component of 87 levels is 50% or higher, and, therefore, the designations could be easily assigned. One-hundred and two (102) level designations correspond to the largest component, five to the second largest, and three to the third largest. To keep consistency with the Fe I isoelectronic sequence,[3–6] we grouped the levels into mulitplets in increasing order, starting with the highest J value of the multiplet. The structure of the $3d^8$ and $3d^74p$ configuration is shown in Figs. 2(a) and 2(b).

Two-hundred and sixty-six (266) lines have been classified in this spectrum; eleven of them are doubly classified, and are listed in Table IV. The observed relative spectral line intensities, I_1 (on a scale of 0 − 1000), were obtained from comparator measurements by means of a photoplate characteristic curve. The theoretical intensities, I_2, were calculated on the basis of transition probabilities.[27] The classification of the line is given in the last

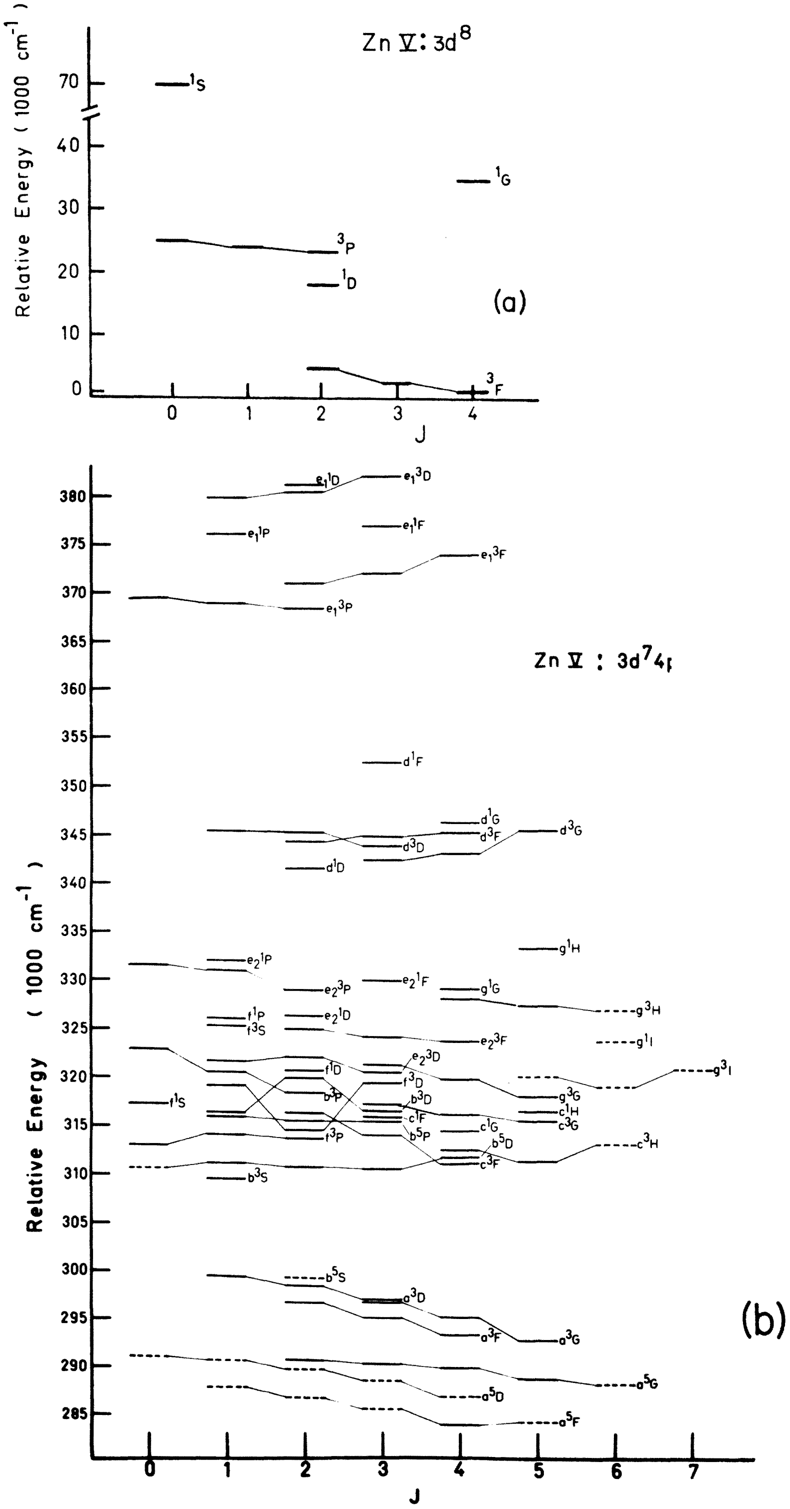

FIG. 2. (a) and (b) The structure of the $3d^8$ and $3d^74p$ configurations of Zn V. The levels have been grouped into multiplets in the LS-coupling scheme. The dashed lines correspond to the calculated values of the missing levels. For the sake of clarity in (b), the parents (^4F), (^4P), (^2g), (^2F), ($1\,^2D$), ($3\,^2D$), (^2P), and (^2g) have been replaced by a, b, c, d, e_1, e_2, f, and g, respectively.

TABLE IV. Classified lines of Zn V.

λ (Å)	σ (cm^{-1})	I_1^{a}	I_2^{a}	Even level	Odd level
261.496	382 415	30	22	3D8 3F4	(1 2D)4P 3D3
263.196	379 945	1	2	3D8 3F3	(1 2D)4P 3D3
264.242	378 441	25	16	3D8 3F3	(1 2D)4P 3D2
267.208	374 240	15	14	3D8 3F4	(1 2D)4P 3F4
270.343	369 900	10	12	3D8 3F3	(1 2D)4P 3F3
272.468	367 016	15	10	3D8 3F2	(1 2D)4P 3F2
275.240	363 319	5	3	3D8 1D2	(1 2D)4P 1D2
277.963	359 760	15	15	3D8 3P2	(1 2D)4P 3D3
279.146	358 235	5	6	3D8 3P2	(1 2D)4P 3D2
279.488	357 797	5	8	3D8 3P1	(1 2D)4P 3D2
279.829	357 361	3	4	3D8 3P1	(1 2D)4P 3D1
280.152	356 949	2	4	3D8 3P0	(1 2D)4P 3D1
284.244	351 810	5	6	3D8 1G4	(1 2D)4P 3D3
284.986	350 894	10	6	3D8 1D2	(1 2D)4P 3P1
285.364	350 430	25	18	3D8 1D2	(1 2D)4P 3P2
288.407	346 732	50	35	3D8 3P1	(1 2D)4P 3P0
288.488	346 635	60	33	3D8 3P2	(1 2D)4P 3P1
288.562	346 546	270	250	3D8 1G4	(1 2D)4P 1F3
288.845	346 206	20	5	3D8 3F4	(2F)4P 1G4
288.859	346 190	50	23	3D8 3P1	(1 2D)4P 3P1
288.876	346 169	180	104	3D8 3P2	(1 2D)4P 3P2
289.196	345 786	70	6	3D8 3P0	(1 2D)4P 3P1
				3D8 3F4	(2F)4P 3G5
289.246	345 726	190	57	3D8 3P1	(1 2D)4P 3P2
				3D8 3F4	(2F)4P 3F4
289.731	345 148	80	22	3D8 3F4	(2F)4P 3F3
290.638	344 071	60	17	3D8 3F4	(2F)4P 3D3
291.325	343 259	20	6	3D8 3F3	(2F)4P 3F4
291.354	343 225	20	6	3D8 3F4	(2F)4P 3G4
291.411	343 158	100	26	3D8 3F3	(2F)4P 3D2
292.135	342 307	10	5	3D8 3F3	(2F)4P 3F2
292.607	341 755	90	23	3D8 1G4	(1 2D)4P 3F3
				3D8 3F2	(2F)4P 3D1
292.737	341 604	40	11	3D8 3F3	(2F)4P 3D3
292.748	341 591	20	4	3D8 3F2	(2F)4P 3D2
293.163	341 107	10	3	3D8 3F2	(2F)4P 3F3
293.464	340 757	10	2	3D8 3F3	(2F)4P 3G4
293.481	340 738	10	3	3D8 3F2	(2F)4P 3F2
293.987	340 151	20	4	3D8 3F3	(2F)4P 3G3
294.089	340 033	10	2	3D8 3F2	(2F)4P 3D3
295.349	338 582	30	3	3D8 3F2	(2F)4P 3G3
296.214	337 594	30	9	3D8 3F2	(2F)4P 1D2
299.264	334 153	90	23	3D8 1D2	(2F)4P 1F3
299.892	333 453	5	2	3D8 3F4	(2H)4P 1H5
302.962	330 074	5	3	3D8 3F4	(3 2D)4P 1F3
303.130	329 891	60	26	3D8 3P2	(2F)4P 1F3
305.246	327 605	20	6	3D8 3F3	(3 2D)4P 1F3
305.266	327 583	10	3	3D8 3F4	(2H)4P 3H5
305.445	327 391	5	2	3D8 1D2	(2F)4P 3D1
306.051	326 743	70	23	3D8 1D2	(2F)4P 3F3
306.401	326 370	140	34	3D8 1D2	(2F)4P 3F2
306.834	325 909	20	2	3D8 3F3	(2H)4P 3H4

TABLE IV. *(Continued).*

λ(Å)	σ (cm^{-1})	I_1^{a}	I_2^{a}	Even level	Odd level
307.063	325 666	140	36	3D8 1D2	(2F)4P 3D3
308.140	324 528	15	3	3D8 3F4	(3 2D)4P 3F3
308.449	324 203	25	7	3D8 3F3	(3 2D)4P 1D2
308.747	323 890	330	58	3D8 3F4	(3 2D)4P 3F4
309.383	323 224	210	53	3D8 1D2	(2F)4P 1D2
309.478	323 125	10	3	3D8 3P2	(2F)4P 3D1
309.637	322 959	310	64	3D8 3P2	(2F)4P 3D2
309.904	322 681	200	53	3D8 3P1	(2F)4P 3D1
309.955	322 627	10	3	3D8 3F2	(3 2D)4P 1D2
309.977	322 605	70	9	3D8 3F3	(3 2D)4P 3F2
310.066	322 512	400	135	3D8 3P1	(2F)4P 3D2
310.098	322 479	400	101	3D8 3P2	(2F)4P 3F3
310.293	322 276	250	65	3D8 3P0	(2F)4P 3D1
310.412	322 152	120	35	3D8 3F2	(2P)4P 1P1
310.504	322 057	190	31	3D8 3F3	(3 2D)4P 3F3
310.605	321 952	550	365	3D8 1G4	(2F)4P 1F3
310.778	321 773	20	3	3D8 3F4	(2H)4P 3G3
311.121	321 418	80	9	3D8 3F3	(3 2D)4P 3F4
311.137	321 402	400	137	3D8 3P2	(2F)4P 3D3
311.495	321 032	100	17	3D8 3F2	(3 2D)4P 3F2
311.809	320 709	400	109	3D8 3F4	(3 2D)4P 3D3
312.460	320 041	150	3	3D8 3F4	(2H)4P 3G4
312.551	319 948	5	1	3D8 3P2	(2F)4P 3G3
312.736	319 759	450	138	3D8 3F3	(3 2D)4P 3D2
312.859	319 633	600	226	3D8 3F4	(2P)4P 3D3
313.180	319 305	20	3	3D8 3F3	(2H)4P 3G3
313.955	318 517	20	6	3D8 3P1	(2F)4P 1D2
314.068	318 402	50	23	3D8 3F3	(2P)4P 1D2
314.227	318 241	300	50	3D8 3F3	(3 2D)4P 3D3
314.280	318 188	340	66	3D8 3F2	(3 2D)4P 3D2
314.488	317 977	800	483	3D8 3F4	(2H)4P 3G5
314.668	317 795	500	138	3D8 3F2	(3 2D)4P 3D1
314.730	317 733	700	299	3D8 3F2	(2H)4P 3G3
314.891	317 570	750	432	3D8 3F3	(2H)4P 3G4
314.943	317 518	550	90	3D8 3F3	(4P)4P 3D2
315.239	317 220	230	25	3D8 3F4	(2G)4P 3G3
315.293	317 165	120	11	3D8 3F3	(2P)4P 3D3
315.629	316 828	200	20	3D8 3F4	(2G)4P 3G4
				3D8 3F2	(2P)4P 1D2
315.671	316 786	170	30	3D8 3F4	(2G)4P 1H5
315.787	316 669	80	9	3D8 3F2	(3 2D)4P 3D3
316.485	315 971	350	40	3D8 3F3	(4P)4P 3P2
316.857	315 600	430	54	3D8 1G4	(2F)4P 1G4
316.862	315 595	550	90	3D8 3F4	(2G)4P 3G5
				3D8 3F2	(2P)4P 3D3
317.024	315 434	250	24	3D8 3F2	(2P)4P 3D1
317.217	315 242	500	50	3D8 3F4	(4P)4P 5P3
317.340	315 119	100	23	3D8 1G4	(2F)4P 3F4
317.626	314 836	650	118	3D8 3F4	(2G)4P 1G4
317.712	314 750	170	19	3D8 3F3	(2G)4P 3G3
317.921	314 544	10	4	3D8 1G4	(2F)4P 3F3
318.108	314 359	220	35	3D8 3F3	(2G)4P 3G4

TABLE IV. *(Continued).*

λ (Å)	σ (cm^{-1})	$I_1{}^a$	$I_2{}^a$	Even level	Odd level
318.270	314 199	190	21	3D8 3F4	(2G)4P 3F3
318.351	314 119	210	24	3D8 3F3	(2G)4P 3F2
318.601	313 872	400	43	3D8 3F3	(4P)4P 3D3
318.699	313 776	450	122	3D8 1D2	(3 2D)4P 1P1
319.016	313 464	40	9	3D8 1G4	(2F)4P 3D3
319.111	313 371	480	58	3D8 3F3	(2G)4P 1F3
319.305	313 180	20	1	3D8 3F2	(2G)4P 3G3
319.811	312 685	270	36	3D8 1D2	(3 2D)4P 3P1
319.881	312 616	90	15	3D8 1G4	(2F)4P 3G4
319.954	312 545	850	221	3D8 3F2	(2G)4P 3F2
319.962	312 537	750	29	3D8 3F4	(2G)4P 3H4
320.012	312 488	20	3	3D8 3F3	(2P)4P 3D2
320.135	312 368	110	9	3D8 3F3	(2G)4P 1G4
320.204	312 301	180	22	3D8 3F2	(4P)4P 3D3
320.723	311 796	650	68	3D8 3F2	(2G)4P 1F3
				3D8 3F4	(4P)4P 5D4
320.790	311 730	800	207	3D8 3F3	(2G)4P 3F3
320.860	311 662	650	141	3D8 1D2	(3 2D)4P 1F3
321.173	311 359	800	223	3D8 3F4	(2G)4P 3F4
321.238	311 296	110	11	3D8 3F4	(2G)4P 3H5
321.628	310 918	10	2	3D8 3F2	(2P)4P 3D2
321.874	310 681	190	34	3D8 1D2	(3 2D)4P 3P2
322.000	310 559	30	18	3D8 1S0	(1 2D)4P 3D1
322.414	310 160	300	32	3D8 3F2	(2G)4P 3F3
323.087	309 514	140	39	3D8 3P2	(3 2D)4P 1P1
323.282	309 327	110	7	3D8 3F3	(4P)4P 5D4
323.550	309 071	100	13	3D8 3P1	(3 2D)4P 1P1
323.737	308 893	170	16	3D8 3F3	(2G)4P 3F4
323.872	308 764	200	26	3D8 3P1	(3 2D)4P 3P0
323.974	308 667	60	9	3D8 3P0	(3 2D)4P 1P1
324.229	308 424	400	69	3D8 3P2	(3 2D)4P 3P1
324.401	308 260	800	249	3D8 1D2	(3 2D)4P 1D2
324.623	308 050	20	1	3D8 3F3	(4P)4P 5D3
324.696	307 980	150	26	3D8 3P1	(3 2D)4P 3P1
324.902	307 785	330	20	3D8 1D2	(2P)4P 1P1
325.122	307 577	120	21	3D8 3P0	(3 2D)4P 3P1
325.307	307 402	220	25	3D8 3P2	(3 2D)4P 1F3
325.656	307 072	500	90	3D8 1D2	(2P)4P 3S1
326.088	306 666	40	40	3D8 1D2	(3 2D)4P 3F2
326.231	306 531	400	202	3D8 1S0	(1 2D)4P 1P1
326.349	306 420	700	166	3D8 3P2	(3 2D)4P 3P2
326.670	306 119	270	26	3D8 1D2	(3 2D)4P 3F3
326.821	305 978	220	29	3D8 3P1	(3 2D)4P 3P2
329.135	303 827	20	3	3D8 1D2	(3 2D)4P 3D2
329.424	303 560	30	5	3D8 3P1	(3 2D)4P 1D2
329.461	303 526	240	53	3D8 3P2	(2P)4P 1P1
329.563	303 432	110	10	3D8 1D2	(3 2D)4P 3D1
329.630	303 370	180	23	3D8 1D2	(2H)4P 3G3
329.944	303 082	30	13	3D8 3P1	(2P)4P 1P1
330.194	302 852	750	369	3D8 1G4	(2H)4P 1H5
330.235	302 815	250	45	3D8 3P2	(2P)4P 3S1

TABLE IV. *(Continued)*.

(λ Å)	σ (cm^{-1})	I_1[a]	I_2[a]	Even level	Odd level
330.383	302 679	110	25	3D8 3P0	(2P)4P 1P1
330.611	302 470	6	2	3D8 1D2	(2P)4P 1D2
330.683	302 404	3	2	3D8 3P2	(3 2D)4P 3F2
330.720	302 371	140	31	3D8 3P1	(2P)4P 3S1
				3D8 1D2	(4P)4P 3P1
330.788	302 308	100	18	3D8 1D2	(3 2D)4P 3D3
331.165	301 964	90	9	3D8 3P1	(3 2D)4P 3F2
				3D8 3P0	(2P)4P 3S1
331.279	301 860	250	45	3D8 3P2	(3 2D)4P 3F3
331.583	301 584	50	6	3D8 1D2	(4P)4P 3D2
331.970	301 232	60	6	3D8 1D2	(2P)4P 3D3
332.148	301 071	50	5	3D8 1D2	(2P)4P 3D1
333.290	300 039	60	9	3D8 1D2	(4P)4P 3P2
333.480	299 868	90	13	3D8 3P1	(4P)4P 3P0
333.820	299 563	20	3	3D8 3P2	(3 2D)4P 3D2
333.921	299 472	350	98	3D8 1G4	(3 2D)4P 1F3
334.006	299 396	2	5	3D8 1S0	(1 2D)4P 3P1
334.255	299 173	70	20	3D8 3P2	(3 2D)4P 3D1
334.313	299 121	130	24	3D8 3P1	(3 2D)4P 3D2
334.524	298 932	770	1000	3D8 1G4	(2H)4P 1G4
334.650	298 820	360	68	3D8 1D2	(2G)4P 3G3
334.753	298 728	15	4	3D8 3P1	(3 2D)4P 3D1
335.206	298 324	30	9	3D8 3P0	(3 2D)4P 3D1
335.338	298 207	10	1	3D8 3P2	(2P)4P 1D2
335.444	298 112	110	13	3D8 3P2	(4P)4P 3P1
335.518	298 047	120	27	3D8 3P2	(3 2D)4P 3D3
335.636	297 942	240	40	3D8 1D2	(4P)4P 3D3
335.827	297 772	150	8	3D8 1G4	(2H)4P 3H4
335.836	297 764	90	14	3D8 3P1	(2P)4P 1D2
335.946	297 667	30	8	3D8 3P1	(4P)4P 3P1
335.991	297 627	60	11	3D8 1D2	(4P)4P 5P1
336.202	297 440	340	62	3D8 1D2	(2G)4P 1F3
336.335	297 323	80	13	3D8 3P2	(4P)4P 3D2
336.660	297 036	680	237	3D8 3F4	(4F)4P 3D3
336.723	296 980	110	17	3D8 1G4	(2H)4P 3H5
336.735	296 969	30	2	3D8 3P2	(2P)4P 3D3
336.836	296 880	25	1	3D8 3P1	(4P)4P 3D2
336.928	296 799	450	37	3D8 3F4	(4F)4P 3G3
				3D8 3P2	(2P)4P 3D1
337.206	296 555	10	2	3D8 1D2	(2P)4P 3D2
337.880	295 963	100	19	3D8 3P0	(2P)4P 3D1
337.943	295 908	620	176	3D8 3F3	(4F)4P 3D2
338.034	295 828	40	5	3D8 1D2	(2P)4P 3P1
338.067	295 799	20	3	3D8 1D2	(2G)4P 3F3
338.093	295 777	90	12	3D8 3P2	(4P)4P 3P2
338.597	295 336	550	103	3D8 3P1	(4P)4P 3P2
				3D8 3F2	(4F)4P 3D1
338.708	295 240	80	9	3D8 1D2	(2P)4P 3P2
338.788	295 170	200	15	3D8 3F4	(4F)4P 3G4
339.484	294 565	100	4	3D8 3F3	(4F)4P 3D3
339.492	294 558	80	7	3D8 3P2	(2G)4P 3G3
339.717	294 363	15	2	3D8 3P1	(2P)4P 1S0
339.755	294 330	30	4	3D8 3F3	(4F)4P 3G3

TABLE IV. *(Continued).*

λ (Å)	σ (cm^{-1})	I_1[a]	I_2[a]	Even level	Odd level
339.801	294 290	40	0.8	3D8 3F3	(4F)4P 3F2
340.159	293 980	30	6	3D8 3P2	(4P)4P 3D1
340.222	293 926	110	18	3D8 1G4	(3 2D)4P 3F3
340.760	293 462	800	322	3D8 3F4	(4F)4P 3F4
340.873	293 364	80	15	3D8 3P2	(4P)4P 5P1
341.090	293 178	400	48	3D8 3P2	(2G)4P 1F3
341.139	293 136	100	10	3D8 3P0	(4P)4P 3D1
341.302	292 996	30	2	3D8 3F2	(4F)4P 3D3
341.389	292 921	240	37	3D8 3P1	(4P)4P 5P1
341.425	292 890	60	9	3D8 1D2	(4P)4P 5D1
341.499	292 827	680	228	3D8 3F3	(4F)4P 3F3
341.579	292 758	190	21	3D8 3F2	(4F)4P 3G3
341.623	292 720	730	42	3D8 3F4	(4F)4P 3G5
				3D8 3F2	(4F)4P 3F2
341.640	292 706	360	27	3D8 3F3	(4F)4P 3G4
341.654	292 694	100	14	3D8 3P1	(4P)4P 5P2
341.787	292 580	70	6	3D8 3P2	(4P)4P 5P3
341.862	292 516	50	8	3D8 3P0	(4P)4P 5P1
342.121	292 294	20	2	3D8 3P2	(2P)4P 3D2
342.329	292 117	1	1	3D8 1D2	(4P)4P 5D3
342.642	291 850	15	1	3D8 3P1	(2P)4P 3D2
342.974	291 567	70	9	3D8 3P2	(2P)4P 3P1
343.341	291 256	300	25	3D8 1D2	(4P)4P 3S1
				3D8 3F2	(4F)4P 3F3
343.497	291 123	250	37	3D8 3P1	(2P)4P 3P1
343.648	290 995	300	29	3D8 3F3	(4F)4P 3F4
343.665	290 981	150	13	3D8 3P2	(2P)4P 3P2
343.975	290 719	25	5	3D8 3P0	(2P)4P 3P1
344.196	290 532	5	2	3D8 3P1	(2P)4P 3P2
344.325	290 423	10	1	3D8 3F4	(4F)4P 5G3
344.995	289 859	20	3	3D8 3P1	(2P)4P 3P0
345.032	289 828	220	13	3D8 3F4	(4F)4P 5G4
345.236	289 657	80	11	3D8 1G4	(2H)4P 3I5
345.976	289 037	1	1	3D8 1G4	(2P)4P 3D3
346.136	288 904	190	10	3D8 3F4	(4F)4P 5G5
346.463	288 631	120	20	3D8 3P2	(4P)4P 5D1
346.903	288 265	10	1	3D8 3F3	(4F)4P 5G2
346.996	288 188	20	5	3D8 3P1	(4P)4P 5D1
347.272	287 959	110	7	3D8 3F3	(4F)4P 5G3
347.393	287 858	40	5	3D8 3P2	(4P)4P 5D3
347.483	287 784	30	6	3D8 3P0	(4P)4P 5D1
347.971	287 380	10	2	3D8 1G4	(2H)4P 3G5
347.994	287 361	5	1	3D8 3F3	(4F)4P 5G4
348.239	287 159	20	3	3D8 3P1	(4P)4P 5D2
348.436	286 997	170	17	3D8 3P2	(4P)4P 3S1
348.803	286 695	50	3	3D8 3F2	(4F)4P 5G2
348.887	286 626	70	11	3D8 1G4	(2G)4P 3G3
348.976	286 553	40	5	3D8 3P1	(4P)4P 3S1
349.382	286 220	15	1	3D8 1G4	(2G)4P 3G4
349.416	286 192	370	45	3D8 1G4	(2G)4P 1H5
349.469	286 148	20	1	3D8 3P0	(4P)4P 3S1

TABLE IV. *(Continued).*

λ (Å)	σ (cm^{-1})	I_1[a]	I_2[a]	Even level	Odd level
349.791	285 885	20	1	3*D*8 3*F*2	(4*F*)4*P* 5*D*2
349.960	285 747	50	5	3*D*8 1*G*4	(4*P*)4*P* 3*D*3
350.577	285 244	90	10	3*D*8 1*G*4	(2*G*)4*P* 1*F*3
350.883	284 995	320	16	3*D*8 1*G*4	(2*G*)4*P* 3*G*5
352.162	283 960	60	5	3*D*8 3*F*4	(4*F*)4*P* 5*F*4
355.245	281 496	5	0.5	3*D*8 3*F*3	(4*F*)4*P* 5*F*4
356.259	280 695	90	8	3*D*8 1*G*4	(2*G*)4*P* 3*H*5
357.179	279 972	30	7	3*D*8 1*D*2	(4*F*)4*P* 3*D*2
358.894	278 634	90	32	3*D*8 1*D*2	(4*F*)4*P* 3*D*3
359.198	278 398	30	10	3*D*8 1*D*2	(4*F*)4*P* 3*G*3
361.969	276 267	90	27	3*D*8 3*P*1	(4*F*)4*P* 3*D*1
362.503	275 860	110	36	3*D*8 3*P*0	(4*F*)4*P* 3*D*1
362.700	275 710	110	19	3*D*8 3*P*2	(4*F*)4*P* 3*D*2
363.281	275 269	260	76	3*D*8 3*P*1	(4*F*)4*P* 3*D*2
364.469	274 372	340	90	3*D*8 3*P*2	(4*F*)4*P* 3*D*3
364.785	274 134	130	15	3*D*8 3*P*2	(4*F*)4*P* 3*G*3
366.797	272 630	60	9	3*D*8 3*P*2	(4*F*)4*P* 3*F*3
381.270	262 281	30	25	3*D*8 1*S*0	(3 2*D*)4*P* 1*P*1

[a] I_1 and I_2 are the observed intensity and the calculated intensity of the line, respectively. Both intensities are on a scale of 0 — 1000.

two columns of Table IV. In this we have reproduced the computer output. Thus the classification of the first line, 261.496 Å: 3*D*8 3*F*4 (1 2*D*)4*P* 3*D*3 in the usual spectroscopic notation, should read $3d^8\,{}^3F_4$-$3d^7(1\,{}^2D)4p\,{}^3D_3^\circ$. The numbers 1 and 3 in the designations of the $3d^7$ $(1,3\,{}^2D)4p$ levels are Racah's seniority numbers.[29]

Seventeen (17) levels of the $3d^74p$ configuration could not be established. Six of the seventeen levels have J values of 6 and 7, and therefore, do not give transitions to the levels of the $3d^8$ configuration ($J \leq 4$). The others are almost pure quintets, whose transitions to the levels of $3d^8$ configuration are calculated to be very weak. All these levels, along with the doubtful ones, can probably be established by means of the $3d^74s$-$3d^74p$ transition array. We have already photographed the zinc spectrum in the appropriate region on a 6.65-m normal incidence spectrograph, and the analysis is in progress.

IV. CONCLUSION

We established all levels of the $3d^8$ configuration and 85% of the levels of the $3d^74p$ configuration of Fe I-like Zn V. The agreement between the least-squares-fit calculated level values, and the observed level values is better than 0.1%. A smooth variation of least-squares-fit and Hartree-Fock energy parameters has been observed in the Ni III-to-Ge VII isoelectronic sequence. The analysis will provide a basis for studying $3d^74s$-$3d^74p$ transitions in Zn V-type spectra and aid in bridging the gap between Ge VII and Sr XIII in the Fe I sequence.

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