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ATOMIC STRUCTURE CALCULATION OF ENERGY LEVELS AND OSCILLATOR STRENGTHS IN Mo ION, I

($3p^6 3d^8 - 3p^5 3d^9$, $3d^8 - 3d^7 4p$ and $3d^8 - 3d^7 4f$ TRANSITIONS IN Mo XVII)

February 1983

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Atomic Structure Calculation of Energy Levels and Oscillator Strengths in Mo Ion, I

($3p^6 3d^8$ - $3p^5 3d^9$, $3d^8$ - $3d^7 4p$ and $3d^8$ - $3d^7 4f$ Transitions in Mo XVII)

Keishi ISHII*

(Received January 31, 1983)

Energy levels are calculated for $3d^8$, $3p^5 3d^9$, $3d^7 4p$ and $3d^7 4f$ configurations in Mo XVII, a member of Fe-isoelectronic sequence. Wavelengths and oscillator strengths for the $3p^6 3d^8$-$3p^5 3d^9$, $3d^8$-$3d^7 4p$ and $3d^8$-$3d^7 4f$ electric dipole transitions are also calculated. The calculated energy levels are presented in diagrams and in numerical tables as well. The calculated wavelengths and oscillator strengths are also given in tables and figures, where the weighted oscillator strengths are plotted as a function of wavelength.

Keywords: Mo XVII, Spectroscopy, Energy Level, Oscillator Strength, Plasma Diagnostic, Cowan Program

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Moイオンのエネルギー準位と振動子強度の計算・I
(Mo XVIIの $3p^6 3d^8 - 3p^5 3d^9$, $3d^8 - 3d^7 4p$ および $3d^8 - 3d^7 4f$ 遷移)

石 井 慶 之*

(1983 年1月31日受理)

核融合プラズマにおける不純物イオン問題解明に必要とされる分光学的データに関する研究の一環として，Mo多価イオンの中でFeの等電子系列の1つであるMo XVIIの電子配置$3d^8$, $3p^5 3d^9$, $3d^7 4p$及び$3d^7 4f$に関係したエネルギー準位の理論計算を行った。計算の基礎は，Hartree－XR波動函数とスレータ・コンドン原理に置いたCowanの計算プログラムである。

更に$3p^6 3d^8 - 3p^5 3d^9$, $3d^8 - 3d^7 4p$及び$3d^8 - 3d^7 4f$遷移の波長と振動子強度の計算も又実施し，それ等の結果は波長及びエネルギー図表として集録されてある。

本報告は昭和57年度日本原子力研究所委託研究の一部である。

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I. INTRODUCTION

Various ionization stages of high-Z ions are responsible for energy losses in fusion plasma. Molybdenum is often used as one of the structural material in the interior of fusion devices, because of its high refractory property.

The spectrum of Mo XVII has been studied by Mansfield et al.,[1] Kononov,[2] Bogdanovichene et al.,[3] Burkhalter et al.,[4] and Reader and Ryabtsev.[5] In all the works, the $3p^6 3d^8$-$3p^5 3d^9$ transition were mostly dealt with. The theoretical calculation was successfully used for supporting the correct identification of the recorded, complicated spectra in all the works cited above. The $3d^8$-$3d^7 4p$ transition was studied only by Mansfield et al.[1] The observed spectrum was compared with the theoretical one and showed good agreement in its general feature. But the multiplet resolution was not high enough to identify each lines in detail.

In this report, we have refined the theoretical calculation for the well established energy levels of $3p^6 3d^8$ and $3p^5 3d^9$ configurations, and extended it to the $3d^7 4p$ and $3d^7 4f$ configurations. The calculation performed was based on the Hartree-XR wavefunctions[6,7] and the Slater-Condon theory,[8,9] together with the optimization of the Slater parameters in order to minimize the discrepancies between the calculated energy levels and the observed ones for the $3p^6 3d^8$ and $3p^5 3d^9$ configurations.

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Ab initio values of the Slater radial integrals were first

computed with the Hartree-XR program developed by Cowan[6] and Cowan and Griffin[7]: the average energy of each configuration Eav, the electrostatic direct and exchange integrals F^k and G^k, and the spin-orbit integrals ζ . The electric dipole radial integrals $(n\ell|r|n'\ell')$ were also computed.

Then the energy levels were evaluated with the atomic structure code[8,9] using these "Slater integrals" after scaling down as explained below. The least-squares optimization was applied to the $3p^6 3d^8$ and $3p^5 3d^9$ configurations. The observed energy levels were taken from the work by Reader and Ryabtsev.[5] The accuracy of the optimization was measured by the root mean-squares deviation (Δ) and/or the average deviation (σ) given by

$$\Delta = \sqrt{\sum_i \left(E_{calc}(i) - E_{obs}(i)\right)^2 / (N_\ell - N_p)} \quad ,$$

$$\sigma = \sqrt{\sum_i \left(E_{calc}(i) - E_{obs}(i)\right)^2 / N_\ell} \quad ,$$

where $E_{calc}(i)$ and $E_{obs}(i)$ are the calculated and the observed energies of the i-th level, N_ℓ is the number of the observed levels, and N_p is the number of the adjustable parameters included in the optimization.

Finally the wavelengths and the oscillator strengths were calculated by using the atomic structure code[8,9] again.

III. RESULTS

The parameter values of the Slater integrals and the deviations for the $3p^6 3d^8$ and $3p^5 3d^9$ configurations are listed in TABLE 1.

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III. RESULTS

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TABLE 1 Parameter values and deviations of least-squares-fit for $3d^8$ and $3p^5 3d^9$ configurations. All values are in $10^3 cm^{-1}$.

Parameter	Hartree-XR	Fitted	Fitted/HXR
$3p^6 3d^8$			
E_{av}	0.000	47.735	
$F^2(3d,3d)$	257.737	238.019	0.924
$F^4(3d,3d)$	164.760	149.180	0.905
ζ_{3d}	12.281	11.080	0.902
$\alpha(3d,3d)$	------	0.135	
$\beta(3d,3d)$	------	-0.267	
Δ		0.335	
σ		0.194	
$3p^5 3d^9$			
E_{av}	1360.271	1382.216	1.016
$F^2(3p,3d)$	237.321	228.262	0.962
$G^1(3p,3d)$	272.173	235.915	0.867
$G^3(3p,3d)$	175.167	165.598	0.945
ζ_{3p}	103.046	99.562	0.966
ζ_{3d}	12.196	10.920	0.895
$F^1(3p,3d)$	-------	14.060	
$G^2(3p,3d)$	-------	-6.749	
Δ		0.420	
σ		0.243	

The introduction of $\beta(3d,3d)$ reduced the σ of $208cm^{-1}$ [5] to $194cm^{-1}$ for the $3p^6 3d^8$ configuration. The calculated energy levels are given in TABLE 2, with percentage composition in LS-basis representation. Although the three levels with J=2 (^3F, ^3P and ^1D) are strongly mixed with each other, the coupling is close to LS, i.e., the average purity reaches to 78 %. The energy levels are also shown in FIGURE 1.

In the least-squares fit calculation for the $3p^5 3d^9$ configuration, the "illegal-k" electrostatic direct and exchange interactions[10] defined by $F^1(3d,3d)$ and $G^2(3d,3d)$ were included. This reduced the deviation Δ from $2042cm^{-1}$ to $420cm^{-1}$, and the deviation σ from $1444cm^{-1}$ to $243cm^{-1}$. The calculated energy levels are listed in TABLE 3, together with their percentage compositions in terms of jj-coupling scheme. Here the notation (J1,J2) stands for $(3p^5\ {}^2P_{J1}, 3d^9\ {}^2D_{J2})$. Only those compositions whose value is greater than 10 % are listed. The level can be designated to the first entry. There are strong admixtures between (3/2,3/2) and (3/2,5/2) levels, especially. The average purity in LS- and jj-coupling schemes are 63 % and 80 %, respectively, so the jj-coupling notation was taken up in the TABLE 3. The energy level diagram corresponding to TABLE 3 is given in FIGURE 2.

In the fourth column of TABLE 1, the ratios of the fitted to the ab initio value of the Slater integrals are shown. The ratios, which we call the scaling factor hereafter, are fairly close to unity for both configurations. Since the optimization seemed from these results to have been performed successfully, it was then assumed that the estimated scaling factors would be

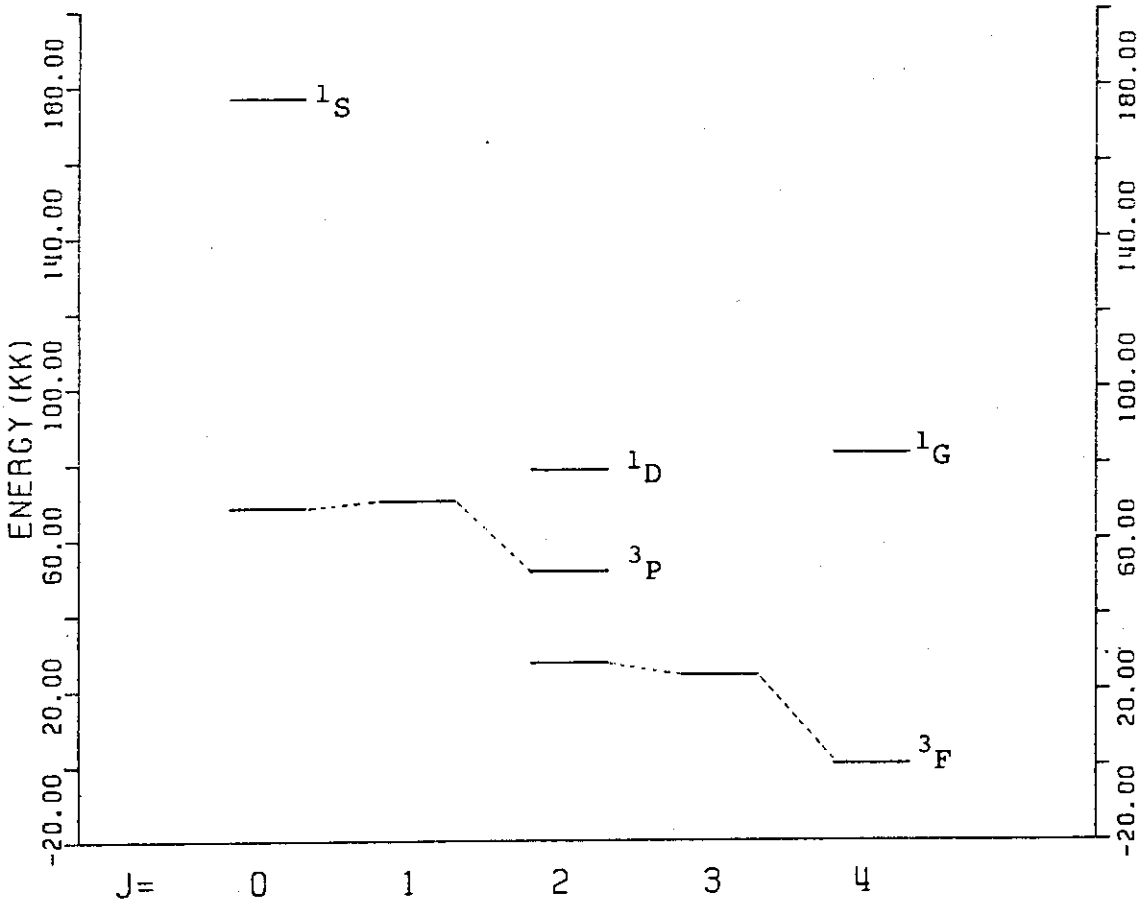

Fig. 1 Structure of $3p^6 3d^8$ configuration of Mo XVII. Level designations are in LS-coupling.

TABLE 2 Calculated energy levels and percentage compositions for $3p^6 3d^8$ configuration of Mo XVII. Negative eigenvectors are preceded by minus sign.

No	J	E(kK)	Percentage Composition
1	0	68.298	93% 3P, -7% 1S
2	0	176.808	93% 1S, -7% 3P
1	1	70.034	100% 3P
1	2	27.000	56% 3F, -35% 1D, -9% 3P
2	2	51.199	54% 3P, 33% 3F, 13% 1D
3	2	78.140	52% 1D, 37% 3P, -11% 3F
1	3	23.891	100% 3F
1	4	0.211	98% 3F
2	4	82.448	98% 1G

EXPLANATION OF TABLES AND FIGURES

No	Number of levels in each J-value
J	J-value of the level
E(kK)	Energy in $10^3 cm^{-1}$
Percentage Composition	Square of eigenvector component. Abreviated notations are used:
(Example)	
3P	$3d^8\ ^3P$
(3/2,3/2)	$(3p^5\ ^2P_{3/2}, 3d^9\ ^2D_{3/2})$
((4P)1/2,1/2)	$(3d^7\ ^4P_{1/2}, 4p\ ^2P_{1/2})$
((2D3)3/2,3/2)	$(3d^7\ ^2_3D_{3/2}, 4p\ ^2P_{3/2})$

TABLE 3 Calculated energy levels and percentage compositions for $3p^5 3d^9$ configuration of Mo XVII. Negative eigenvectors are preceded by minus sign.

No	J	E(kK)	Percentage Composition
1	0	1356.742	100%(3/2,3/2)
1	1	1352.423	75%(3/2,3/2),-25%(3/2,5/2)
2	1	1391.691	-66%(3/2,5/2),-24%(3/2,3/2), 11%(1/2,3/2)
3	1	1563.714	89%(1/2,3/2), 10%(3/2,5/2)
1	2	1281.538	-77%(3/2,5/2),-22%(3/2,3/2)
2	2	1342.459	76%(3/2,3/2),-22%(3/2,5/2)
3	2	1445.858	-98%(1/2,3/2)
4	2	1471.473	98%(1/2,5/2)
1	3	1310.828	-59%(3/2,3/2), 35%(3/2,5/2), -6%(1/2,5/2)
2	3	1370.365	-58%(3/2,5/2),-23%(1/2,5/2),-19%(3/2,3/2)
3	3	1544.596	-71%(1/2,5/2), 21%(3/2,3/2), 7%(3/2,5/2)
1	4	1262.864	100%(3/2,5/2)

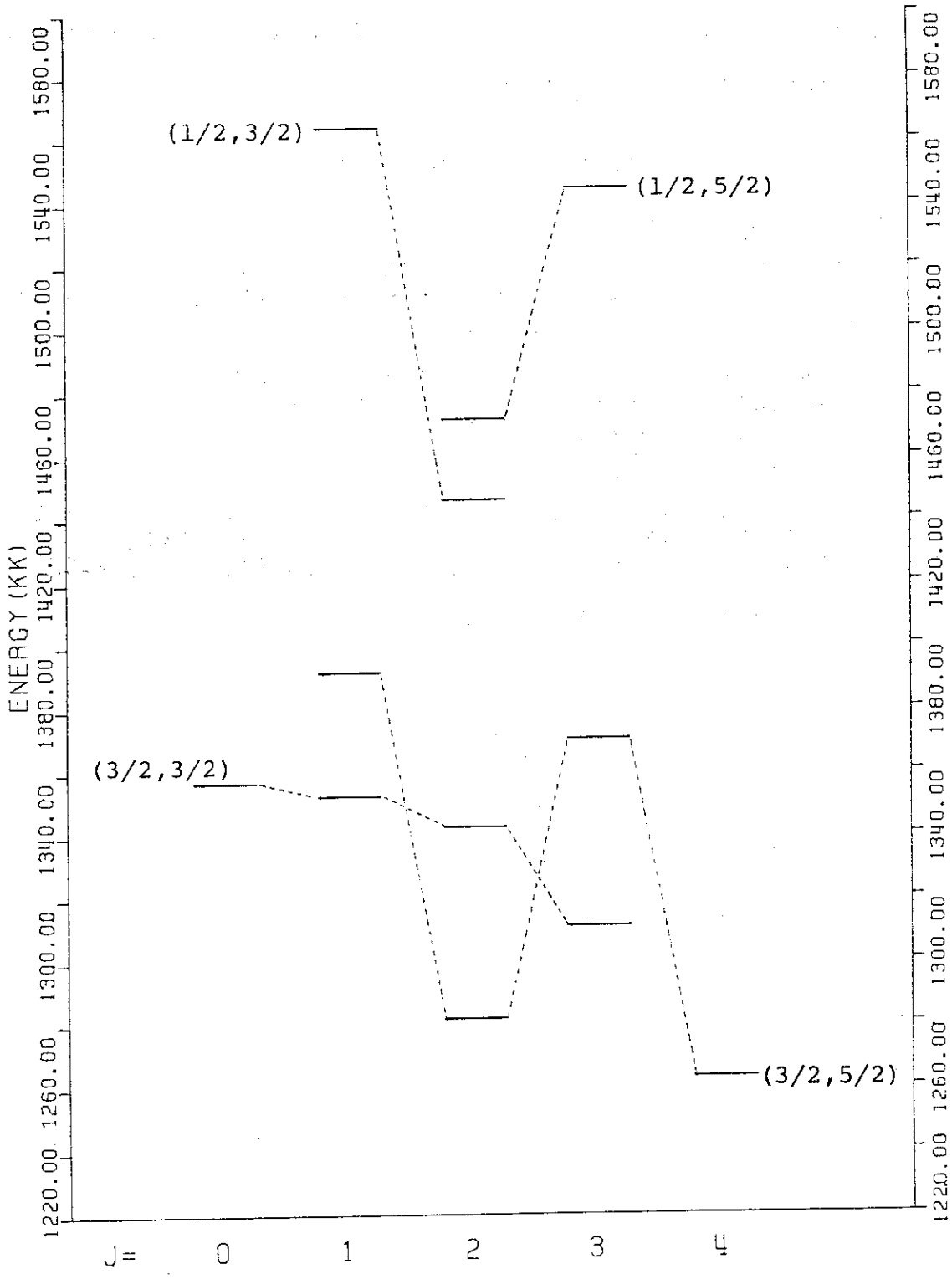

Fig. 2 Structure of $3p^5 3d^9$ configuration of Mo XVII. Level designations are in jj-coupling.

applicable to the other configurations.

We have again computed ab initio values of the Slater integrals of $3d^7 4p$ and $3d^7 4f$ configurations using the same program[6,7]. The Slater integrals thus obtained were scaled down before being used to evaluate energy levels. The effective interaction parameters, such as α and β for $3d^7$ subshell, and F^1 and G^2 between $3d^7$ and 4ℓ subshells, were not included, because no experimentally established level is available at present. The results for the $3d^7 4p$ configuration are given in TABLE 4, with percentage compositions in jj-coupling scheme, of which only the leading two are listed. We have reproduced the computer output to save and facilitate the printing. Therefore, for example, ((4P)1/2,1/2) in the first line in TABLE 4 should be read as $(3d^7(^4P_{1/2}),4p_{1/2})$, and ((2D3)3/2,3/2) in the fifth line should be read as $(3d^7(^2_3D_{3/2}),4p_{3/2})$ in the usual jj-notation. The lower prefices v attached to ^2D, such as ^2_3D, of $3d^7$ subshell stand for the Racah's seniority numbers. The level designation may be named after the first composition, even when it is smaller than the second one. Average purity in jj-coupling scheme is higher than that in LS-one and is about 54 %. It can be seen that the levels are strongly mixed up each other among themselves with the same J-values. The energy level diagram is drawn in FIGURE 3 corresponding to TABLE 4. The calculated energy levels of $3d^7 4f$ configuration are listed in TABLE 5. The average purity in jj-coupling scheme is 44 %, which is slightly higher than that in LS-one of 42 %. The corresponding energy level diagram is given in FIGURE 4. Judging from the FIGURE 4, the most appropriate coupling scheme may be the JK-one. No percentage composition is

TABLE 4 Calculated energy levels and percentage compositions for $3d^7 4p$ configuration of Mo XVII. Negative eigenvectors are preceded by minus sign.

No	J	E(kK)	Percentage Composition
1	0	2300.697	43%((4P)1/2,1/2), 33%((4F)3/2,3/2)
2	0	2333.665	33%((4F)3/2,3/2), -27%((4P)1/2,1/2)
3	0	2340.006	42%((2P)1/2,1/2), -25%((2P)3/2,3/2)
4	0	2353.482	-23%((2P)3/2,3/2), -23%((2P)1/2,1/2)
5	0	2391.663	-65%((4P)3/2,3/2), 12%((2P)3/2,3/2)
6	0	2419.097	-68%((2D3)3/2,3/2), 26%((2P)3/2,3/2)
7	0	2477.737	-90%((2D1)3/2,3/2), -4%((2D3)3/2,3/2)
1	1	2279.667	-63%((4F)3/2,1/2), 12%((2D3)3/2,1/2)
2	1	2295.965	-22%((2P)3/2,1/2), -35%((4P)3/2,1/2)
3	1	2311.805	32%((4P)1/2,1/2), 22%((2P)3/2,1/2)
4	1	2326.368	56%((4F)3/2,3/2), 12%((2P)1/2,1/2)
5	1	2333.209	32%((4F)5/2,3/2), 23%((4P)1/2,1/2)
6	1	2340.449	-34%((4P)3/2,1/2), 24%((4F)5/2,3/2)
7	1	2355.510	-28%((4P)3/2,3/2), -26%((2P)3/2,3/2)
8	1	2357.152	31%((2P)1/2,1/2), -14%((4P)1/2,1/2)
9	1	2361.495	74%((4P)5/2,3/2), -8%((2P)3/2,3/2)
10	1	2371.846	32%((4P)1/2,3/2), 24%((2P)1/2,3/2)
11	1	2372.948	-16%((2D3)3/2,3/2), 20%((4P)3/2,3/2)
12	1	2387.383	18%((2D3)3/2,1/2), 18%((4P)3/2,3/2)
13	1	2391.220	33%((2D3)5/2,3/2), 24%((4P)1/2,3/2)
14	1	2401.481	-38%((2P)1/2,3/2), -21%((2D3)5/2,3/2)
15	1	2416.975	27%((2P)3/2,3/2), -29%((2F)5/2,3/2)
16	1	2423.345	49%((2F)5/2,3/2), -17%((2D3)3/2,3/2)
17	1	2459.206	-65%((2D1)3/2,1/2), 13%((2D1)3/2,3/2)
18	1	2487.834	46%((2D1)3/2,3/2), 21%((2D1)5/2,3/2)
19	1	2502.765	-53%((2D1)5/2,3/2), 28%((2D1)3/2,3/2)
1	2	2274.208	-77%((4F)5/2,1/2), 5%((2D3)5/2,1/2)
2	2	2283.997	74%((4F)3/2,1/2), -11%((2D3)3/2,1/2)
3	2	2292.111	21%((2P)3/2,1/2), 39%((4P)3/2,1/2)
4	2	2294.521	-65%((4P)5/2,1/2), 8%((4P)5/2,3/2)
5	2	2318.267	-43%((4F)5/2,3/2), -20%((4F)3/2,3/2)
6	2	2319.975	29%((4F)7/2,3/2), 22%((4F)3/2,3/2)
7	2	2329.388	-36%((4F)3/2,3/2), 24%((4F)5/2,3/2)
8	2	2336.443	24%((4P)3/2,1/2), -11%((2D3)3/2,1/2)
9	2	2339.618	-27%((2P)3/2,3/2), -14%((2D3)5/2,1/2)
10	2	2349.147	10%((2D3)5/2,1/2),-16%((4P)3/2,1/2)
11	2	2355.830	35%((4P)5/2,3/2), 15%((2D3)5/2,1/2)
12	2	2364.802	65%((2G)7/2,3/2), - 7%((2F)5/2,1/2)
13	2	2367.020	-21%((2D3)3/2,1/2), 11%((2F)5/2,1/2)
14	2	2367.719	-32%((4P)1/2,3/2), -20%((2P)1/2,3/2)
15	2	2377.335	-45%((2F)5/2,1/2), 8%((4P)1/2,3/2)
16	2	2382.830	13%((4P)3/2,3/2), -15%((2P)1/2,3/2)
17	2	2390.961	20%((2D3)5/2,3/2), 16%((2F)5/2,1/2)
18	2	2397.793	-36%((2P)1/2,3/2), -16%((2D3)5/2,3/2)
19	2	2406.731	37%((2D3)3/2,3/2),-23%((2P)3/2,3/2)

TABLE 4 (Continued).

20	2	2418.501	-68%((2F)5/2,3/2),	13%((2D1)3/2,1/2)
21	2	2429.118	-76%((2F)7/2,3/2),	7%((2D3)3/2,3/2)
22	2	2453.652	69%((2D1)3/2,1/2),	11%((2F)5/2,3/2)
23	2	2456.811	55%((2D1)5/2,1/2),	18%((2D3)5/2,1/2)
24	2	2500.089	-76%((2D1)3/2,3/2),	-15%((2D3)3/2,3/2)
25	2	2509.906	56%((2D1)5/2,3/2),	23%((2D3)5/2,3/2)
1	3	2264.475	-86%((4F)7/2,1/2),	6%((4F)9/2,3/2)
2	3	2277.940	73%((4F)5/2,1/2),	-6%((2D3)5/2,1/2)
3	3	2296.721	25%((4F)9/2,3/2),	-21%((4P)5/2,1/2)
4	3	2306.266	-37%((4F)7/2,3/2),	31%((4F)9/2,3/2)
5	3	2319.171	49%((4F)5/2,3/2),	14%((4P)5/2,1/2)
6	3	2321.706	37%((4P)5/2,1/2),	15%((4F)9/2,3/2)
7	3	2328.636	60%((4F)3/2,3/2),	-10%((2D3)3/2,3/2)
8	3	2332.631	-67%((2G)7/2,1/2),	-9%((4F)5/2,3/2)
9	3	2341.844	28%((2D3)5/2,1/2),	14%((4P)3/2,3/2)
10	3	2347.655	27%((2P)3/2,3/2),	23%((4P)3/2,3/2)
11	3	2349.052	29%((2G)9/2,3/2),	23%((2H)9/2,3/2)
12	3	2358.932	79%((4P)5/2,3/2),	5%((2D1)5/2,3/2)
13	3	2363.162	-58%((2G)7/2,3/2),	-20%((2F)5/2,1/2)
14	3	2370.846	26%((2D3)5/2,3/2),	-12%((4P)3/2,3/2)
15	3	2375.939	25%((4P)3/2,3/2),	-12%((2P)3/2,3/2)
16	3	2384.845	-23%((2F)5/2,1/2),	18%((2G)7/2,3/2)
17	3	2392.587	38%((2F)7/2,1/2),	-20%((2H)9/2,3/2)
18	3	2398.618	25%((2H)9/2,3/2),	21%((2F)5/2,1/2)
19	3	2419.937	-69%((2F)5/2,3/2),	-11%((2F)7/2,3/2)
20	3	2421.571	-43%((2D3)3/2,3/2),	21%((2P)3/2,3/2)
21	3	2444.153	-67%((2F)7/2,3/2),	16%((2F)5/2,3/2)
22	3	2465.725	-55%((2D1)5/2,1/2),	-20%((2D3)5/2,1/2)
23	3	2491.362	-83%((2D1)3/2,3/2),	-9%((2D3)3/2,3/2)
24	3	2515.820	-64%((2D1)5/2,3/2),	-26%((2D3)5/2,3/2)
1	4	2244.097	-87%((4F)9/2,1/2),	- 9%((2G)9/2,1/2)
2	4	2269.750	90%((4F)7/2,1/2),	- 3%((4F)9/2,3/2)
3	4	2292.306	-68%((4F)9/2,3/2),	-10%((2G)9/2,1/2)
4	4	2303.516	-60%((4F)7/2,3/2),	17%((2G)9/2,1/2)
5	4	2312.910	-36%((2G)9/2,1/2),	-15%((4F)7/2,3/2)
6	4	2321.244	74%((4F)5/2,3/2),	-9%((4F)7/2,3/2)
7	4	2325.621	84%((2G)7/2,1/2),	-5%((2F)7/2,1/2)
8	4	2344.932	74%((4P)5/2,3/2),	12%((2G)9/2,3/2)
9	4	2348.257	51%((2G)9/2,3/2),	11%((2H)11/2,3/2)
10	4	2353.814	-45%((2H)9/2,1/2),	19%((2H)11/2,3/2)
11	4	2363.844	-58%((2G)7/2,3/2),	20%((2H)11/2,3/2)
12	4	2379.582	-62%((2D3)5/2,3/2),	16%((2D1)5/2,3/2)
13	4	2383.479	29%((2H)11/2,3/2),	32%((2G)7/2,3/2)
14	4	2389.913	-41%((2H)9/2,3/2),	31%((2F)7/2,1/2)
15	4	2401.427	-46%((2F)7/2,1/2),	-32%((2H)9/2,3/2)
16	4	2422.385	85%((2F)5/2,3/2),	5%((2H)9/2,3/2)
17	4	2431.861	-88%((2F)7/2,3/2),	4%((2D1)5/2,3/2)
18	4	2494.117	-67%((2D1)5/2,3/2),	-23%((2D3)5/2,3/2)
1	5	2248.462	-87%((4F)9/2,1/2),	-7%((2G)9/2,1/2)
2	5	2283.990	83%((4F)9/2,3/2),	6%((2G)9/2,3/2)
3	5	2307.719	83%((4F)7/2,3/2),	-9%((2G)9/2,1/2)

TABLE 4 (Continued).

4	5	2309.731	58%((2G)9/2,1/2), 19%((2H)9/2,1/2)
5	5	2329.453	86%((2H)11/2,1/2), -7%((2H)11/2,3/2)
6	5	2348.046	43%((2H)9/2,1/2), 24%((2G)9/2,3/2)
7	5	2354.452	52%((2G)9/2,3/2), -30%((2H)9/2,1/2)
8	5	2366.901	-91%((2G)7/2,3/2), 3%((2F)7/2,3/2)
9	5	2380.953	76%((2H)11/2,3/2), 9%((2H)9/2,3/2)
10	5	2405.903	70%((2H)9/2,3/2), -12%((2G)9/2,3/2)
11	5	2430.416	89%((2F)7/2,3/2), 3%((2G)7/2,3/2)
1	6	2284.318	-92%((4F)9/2,3/2), -8%((2G)9/2,3/2)
2	6	2329.124	95%((2H)11/2,1/2), 2%((2H)11/2,3/2)
3	6	2344.930	-69%((2G)9/2,3/2), -20%((2H)9/2,3/2)
4	6	2378.152	-96%((2H)11/2,3/2), 2%((2H)11/2,1/2)
5	6	2387.208	-77%((2H)9/2,3/2), 21%((2G)9/2,3/2)
1	7	2362.230	100%((2H)11/2,3/2)

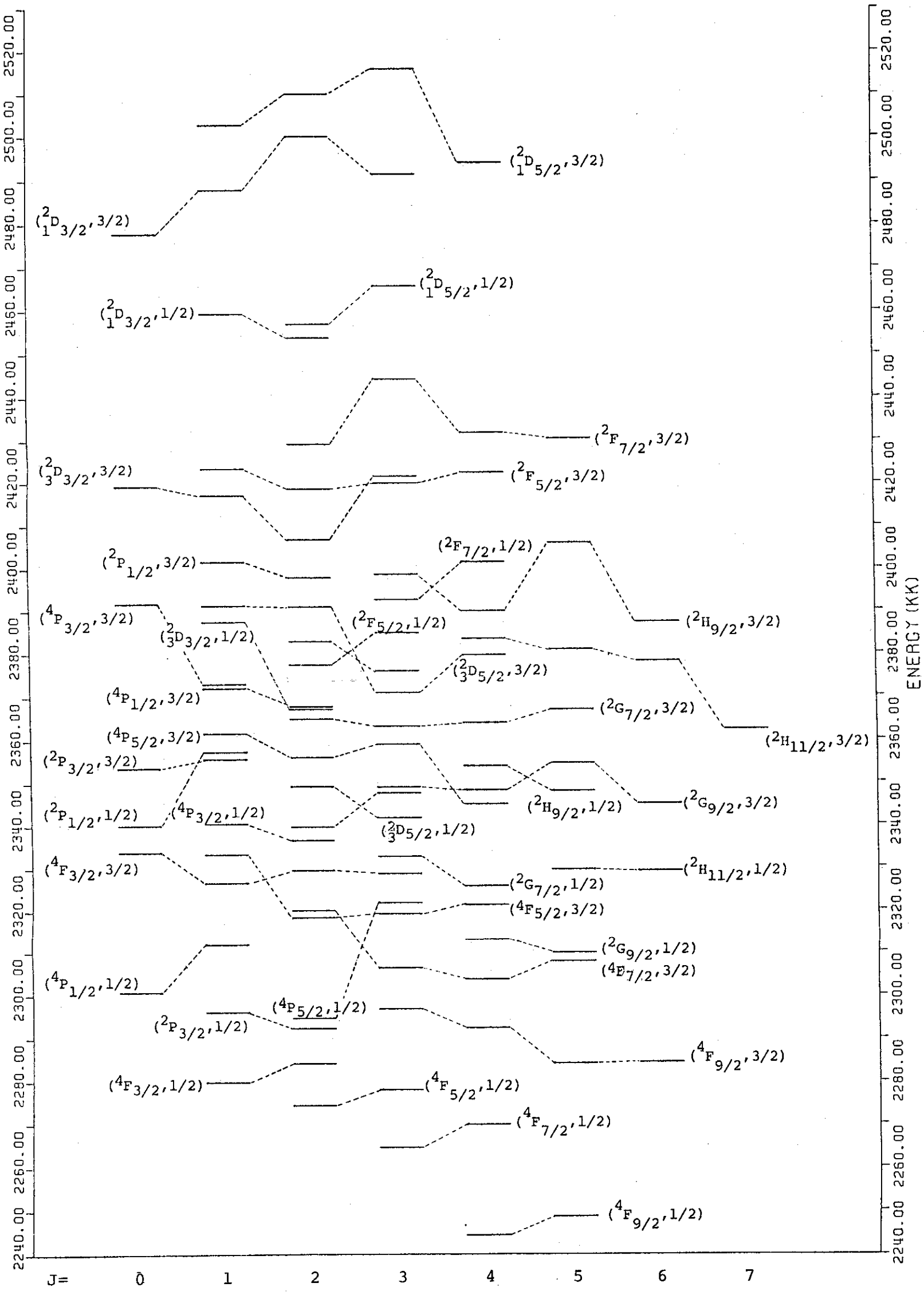

Fig. 3 Structure of $3d^7 4p$ configuration of Mo XVII.
Level designations are in jj-coupling.

TABLE 5 Calculated energy levels for $3d^7 4f$ configuration of Mo XVII.

No	J	E(kK)
1	0.0	3137.617
2	0.0	3150.764
3	0.0	3157.077
4	0.0	3180.752
5	0.0	3215.655
6	0.0	3229.110
7	0.0	3260.700
8	0.0	3311.846
1	1.0	3122.012
2	1.0	3128.866
3	1.0	3139.023
4	1.0	3140.662
5	1.0	3150.084
6	1.0	3154.846
7	1.0	3163.021
8	1.0	3171.803
9	1.0	3177.970
10	1.0	3186.819
11	1.0	3188.014
12	1.0	3192.750
13	1.0	3210.496
14	1.0	3216.363
15	1.0	3229.356
16	1.0	3238.519
17	1.0	3248.704
18	1.0	3257.624
19	1.0	3263.014
20	1.0	3271.922
21	1.0	3285.596
22	1.0	3308.882
23	1.0	3328.054
24	1.0	3371.502
1	2.0	3104.433
2	2.0	3113.973
3	2.0	3122.228
4	2.0	3131.876
5	2.0	3132.265
6	2.0	3141.149
7	2.0	3145.993
8	2.0	3153.506
9	2.0	3156.779
10	2.0	3161.323
11	2.0	3164.681
12	2.0	3172.719
13	2.0	3174.909
14	2.0	3178.321
15	2.0	3182.311
16	2.0	3187.305
17	2.0	3189.717
18	2.0	3192.524
19	2.0	3198.781
20	2.0	3200.812
21	2.0	3211.226
22	2.0	3219.017
23	2.0	3221.273
24	2.0	3229.363
25	2.0	3233.805
26	2.0	3245.303
27	2.0	3248.232
28	2.0	3253.580
29	2.0	3264.771
30	2.0	3268.749
31	2.0	3274.774
32	2.0	3302.907
33	2.0	3311.705
34	2.0	3319.558
35	2.0	3330.172
1	3.0	3104.481
2	3.0	3113.760
3	3.0	3123.015
4	3.0	3130.702
5	3.0	3135.342
6	3.0	3139.854
7	3.0	3144.647
8	3.0	3149.728
9	3.0	3156.667
10	3.0	3161.873
11	3.0	3169.868
12	3.0	3172.916
13	3.0	3176.016
14	3.0	3183.299
15	3.0	3184.334
16	3.0	3186.273
17	3.0	3190.602
18	3.0	3193.921
19	3.0	3198.095
20	3.0	3200.874
21	3.0	3205.305
22	3.0	3210.282
23	3.0	3211.251
24	3.0	3212.529
25	3.0	3223.478
26	3.0	3230.102
27	3.0	3236.252
28	3.0	3240.185
29	3.0	3245.195
30	3.0	3249.857
31	3.0	3255.909
32	3.0	3259.560
33	3.0	3268.854
34	3.0	3289.149
35	3.0	3317.286
36	3.0	3324.611
37	3.0	3329.516
38	3.0	3335.907
1	4.0	3099.831
2	4.0	3115.880
3	4.0	3128.395
4	4.0	3130.984
5	4.0	3133.477
6	4.0	3139.979
7	4.0	3141.466
8	4.0	3147.834
9	4.0	3153.806
10	4.0	3163.053
11	4.0	3167.914
12	4.0	3176.112
13	4.0	3177.800
14	4.0	3180.093
15	4.0	3183.536
16	4.0	3187.477
17	4.0	3190.107
18	4.0	3193.006
19	4.0	3197.415
20	4.0	3198.627
21	4.0	3204.467
22	4.0	3210.655
23	4.0	3214.996
24	4.0	3218.354
25	4.0	3224.179
26	4.0	3231.623
27	4.0	3239.564
28	4.0	3241.178
29	4.0	3248.393
30	4.0	3252.741
31	4.0	3257.793
32	4.0	3282.185
33	4.0	3302.924
34	4.0	3320.120
35	4.0	3330.297
36	4.0	3335.505

TABLE 5 (Continued).

No	J	E(kK)
1	5.0	3096.554
2	5.0	3114.623
3	5.0	3123.850
4	5.0	3129.033
5	5.0	3136.719
6	5.0	3146.011
7	5.0	3150.421
8	5.0	3161.338
9	5.0	3169.313
10	5.0	3172.069
11	5.0	3176.612
12	5.0	3181.680
13	5.0	3186.294
14	5.0	3190.163
15	5.0	3191.059
16	5.0	3200.846
17	5.0	3202.322
18	5.0	3209.229
19	5.0	3216.792
20	5.0	3225.774
21	5.0	3229.319
22	5.0	3235.643
23	5.0	3245.436
24	5.0	3247.996
25	5.0	3258.271
26	5.0	3285.499
27	5.0	3305.852
28	5.0	3331.971
29	5.0	3335.591
1	6.0	3095.537
2	6.0	3108.458
3	6.0	3124.294
4	6.0	3129.484
5	6.0	3141.518
6	6.0	3162.578
7	6.0	3166.440
8	6.0	3170.074
9	6.0	3182.567
10	6.0	3186.064
11	6.0	3194.259
12	6.0	3198.862
13	6.0	3201.003
14	6.0	3213.312
15	6.0	3217.547
16	6.0	3239.823
17	6.0	3249.167
18	6.0	3253.415
19	6.0	3310.847
1	7.0	3103.637
2	7.0	3111.968
3	7.0	3129.216
4	7.0	3163.354
5	7.0	3168.221
6	7.0	3185.750
7	7.0	3195.795
8	7.0	3200.057
9	7.0	3202.203
10	7.0	3219.671
11	7.0	3247.818
1	8.0	3106.267
2	8.0	3162.605
3	8.0	3179.217
4	8.0	3192.159
5	8.0	3203.015
1	9.0	3179.020

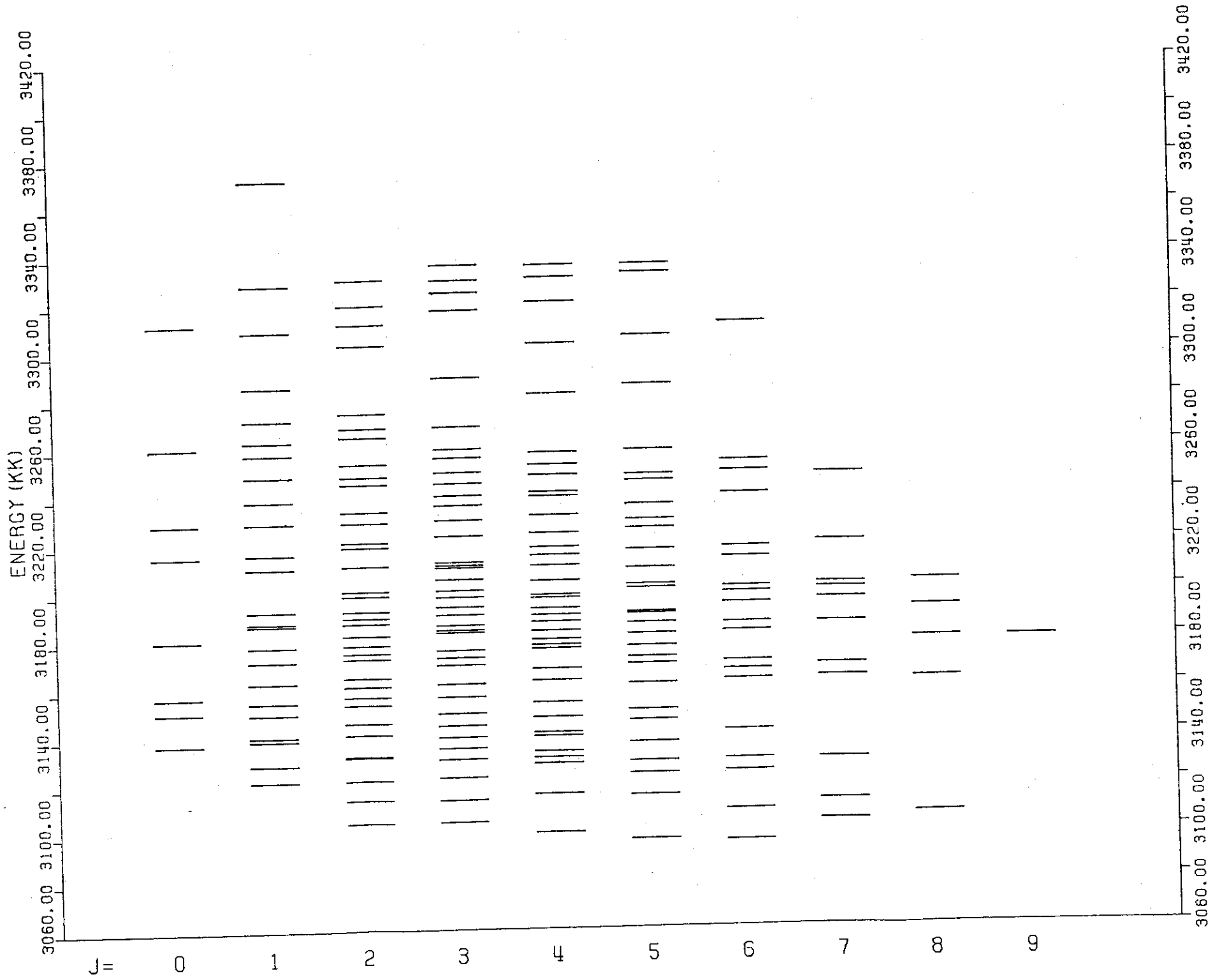

Fig. 4 Structure of $3d^7 4f$ configuration of Mo XVII.

TABLE 6 Parameter values of the Slater integrals for $3d^74p$ and $3d^74f$ configurations. Units in $10^3 cm^{-1}$.

Parameter	Hartree-XR	Adopted
$3d^74p$		
E_{av}	2339.018	2360.658
$F^2(3d,3d)$	262.312	242.245
$F^4(3d,3d)$	167.879	151.998
ζ_{3d}	12.696	11.368
ζ_{4p}	28.887	25.865
$F^2(3d,4p)$	76.215	73.304
$G^1(3d,4p)$	25.773	22.340
$G^3(3d,4p)$	25.502	24.104
$3d^74f$		
E_{av}	3175.306	3196.946
$F^2(3d,3d)$	262.747	242.647
$F^4(3d,3d)$	168.164	152.256
ζ_{3d}	12.757	11.423
ζ_{4f}	0.380	0.340
$F^2(3d,4f)$	73.458	70.678
$F^4(3d,4f)$	36.792	35.387
$G^1(3d,4f)$	58.051	50.319
$G^3(3d,4f)$	34.241	32.365
$G^5(3d,4f)$	23.716	22.416

given for this configuration, because of its being too much complex structure. The adopted Slater integrals are listed in TABLE 6 for both configurations. There is, of course, some uncertainty in the E_{av}'s, because no experimentally established level is available at present. However, a little change in E_{av}'s has no effect on the relative position of the levels, and it just shifts it up or down as a whole. This is exactly the same for the general feature of the line pattern.

Wavelengths, oscillator strengths and transition probabilities have been calculated for $3p^6 3d^8$-$3p^5 3d^9$ transition arrays at first, by use of the atomic structure code.[8,9] The adopted Slater integrals are those listed in the column "Fitted" in TABLE 1. The results are presented in TABLE 7 for all the multiplets with weighted oscillator strength $gf \geq 0.01$ in order of decreasing wavelength, with the observed wavelengths and intensities[5] for comparison. The level designation are given in LS- and jj-coupling schemes for $3p^6 3d^8$ and $3p^5 3d^9$ configurations, respectively. The average deviation σ between the calculated and the observed wavelengths is 0.021 Å, and the calculated gf-values are generally consistent with the observed intensities in their relative magnitudes. The calculated spectrum is illustrated in the lower part of FIGURE 5, where the gf-value is plotted as a function of wavelength. The observed spectrum reproduced from Table 1 in Ref. 5) is given in the upper part of FIGURE 5.

We have extended the same calculation to the $3d^8$-$3d^7 4p$ and $3d^8$-$3d^7 4f$ transition arrays. The results for $3d^8$-$3d^7 4p$ transition are listed in TABLE 8 and that for $3d^8$-$3d^7 4f$ in TABLE 9. In TABLE 8, the level designation is named after the first entry of

TABLE 7 Calculated wavelengths, weighted oscillator strengths for $3d^8$ - $3p^5 3d^9$ transition array of Mo XVII. Observed wavelengths and intensities are given for comparison (from ref.5).

No	$3d^8$ Conf Term	J	$3p^5 3d^9$ Conf Term	J	Calculated WL(A)	gf	Observed WL(A)	Int
1	1G	4	(3/2,5/2)	4	84.716	0.0220	-----	
2	1D	2	(3/2,5/2)	2	83.098	0.1390	83.079	50
3	3P	1	(3/2,5/2)	2	82.542	0.0552	82.556	20
4	1S	0	(3/2,5/2)	1	82.312	0.0671	-----	
5	1G	4	(3/2,3/2)	3	81.408	0.0651	81.382	20
6	3P	2	(3/2,5/2)	2	81.278	0.2102	81.261	100
7	1D	2	(3/2,3/2)	3	81.124	0.1000	81.080	20
8	3F	3	(3/2,5/2)	4	80.712	0.0834	80.732	30
9	3F	2	(3/2,5/2)	2	79.711	0.8405	79.711	700
10	3F	3	(3/2,5/2)	2	79.514	0.0214	79.532	5
11	3P	2	(3/2,3/2)	3	79.388	0.0344	79.359	5
12	3F	4	(3/2,5/2)	4	79.198	1.2509	79.186	1500
13	1D	2	(3/2,3/2)	2	79.094	0.2753	79.062	100
14	1D	2	(3/2,3/2)	1	78.476	0.0288	------	
15	3P	1	(3/2,3/2)	1	77.980	0.3308	78.019	40
16	3F	2	(3/2,3/2)	3	77.892	0.0630	------	
17	3P	0	(3/2,3/2)	1	77.874	0.1881	77.898	15
18	3P	1	(3/2,3/2)	0	77.718	0.3463	77.727	30
19	3F	3	(3/2,3/2)	3	77.704	0.2324	77.706	20
20	1G	4	(3/2,5/2)	3	77.645	0.4131	77.666	30
21	3P	2	(3/2,3/2)	2	77.444	0.3798	77.410	20
22	1D	2	(3/2,5/2)	3	77.386	0.0185	77.396	5
23	3P	2	(3/2,3/2)	1	76.851	0.5542	76.863	200
24	3F	4	(3/2,3/2)	3	76.300	1.4428	76.269	800
25	3F	2	(3/2,3/2)	2	76.019	0.0596	------	
26	3F	3	(3/2,3/2)	2	75.840	1.2709	75.840	150
27	3P	2	(3/2,5/2)	3	75.805	0.3293	75.816	15
28	3P	1	(3/2,5/2)	1	75.663	0.0148	------	
29	3P	0	(3/2,5/2)	1	75.563	0.2441	75.580	15
30	3P	2	(3/2,5/2)	1	74.599	0.0773	74.600	5
31	3F	3	(3/2,5/2)	3	74.268	0.7907	74.306	200
32	3F	2	(3/2,5/2)	1	73.277	1.0679	73.289	200
33	1D	2	(1/2,3/2)	2	73.115	0.7932	73.122	150
34	3F	4	(3/2,5/2)	3	72.984	1.5360	72.990	300
35	1S	0	(1/2,3/2)	1	72.103	0.4204	72.092	20

TABLE 7 (Continued).

36	1D	2	(1/2,5/2)	2	71.770	0.2139	71.750	5
37	3P	2	(1/2,3/2)	2	71.702	0.1584	71.705	7
38	3P	1	(1/2,5/2)	2	71.355	0.6900	71.359	30
39	3F	2	(1/2,3/2)	2	70.479	0.1787	70.494	5
40	3P	2	(1/2,5/2)	2	70.409	0.4005	70.386	15
41	3F	3	(1/2,3/2)	2	70.325	0.0217	70.367	3
42	3F	2	(1/2,5/2)	2	69.229	0.1052	------	
43	3F	3	(1/2,5/2)	2	69.081	0.8094	69.088	30
44	1G	4	(1/2,5/2)	3	68.393	4.1490	68.390	800
45	1D	2	(1/2,5/2)	3	68.192	0.1400	68.188	3
46	1D	2	(1/2,3/2)	1	67.314	0.7638	67.302	15
47	3P	0	(1/2,3/2)	1	66.871	0.0418	------	
48	3P	2	(1/2,3/2)	1	66.115	0.2548	66.100	3
49	3F	2	(1/2,5/2)	3	65.894	0.0619	65.891	1
50	3F	3	(1/2,5/2)	3	65.759	0.1855	65.770	4
51	3F	4	(1/2,5/2)	3	64.751	0.0269	------	

TABLE 7 - 9

Term(in TABLE 7)	Level designation
Term(in TABLE 8 & 9)	Level energy
WL(A)	Wavelength in Å Unit
gf	Weighted oscillator strength
gA	Weighted transition probability
(0.1234E+11)	(0.1234×10^{11})

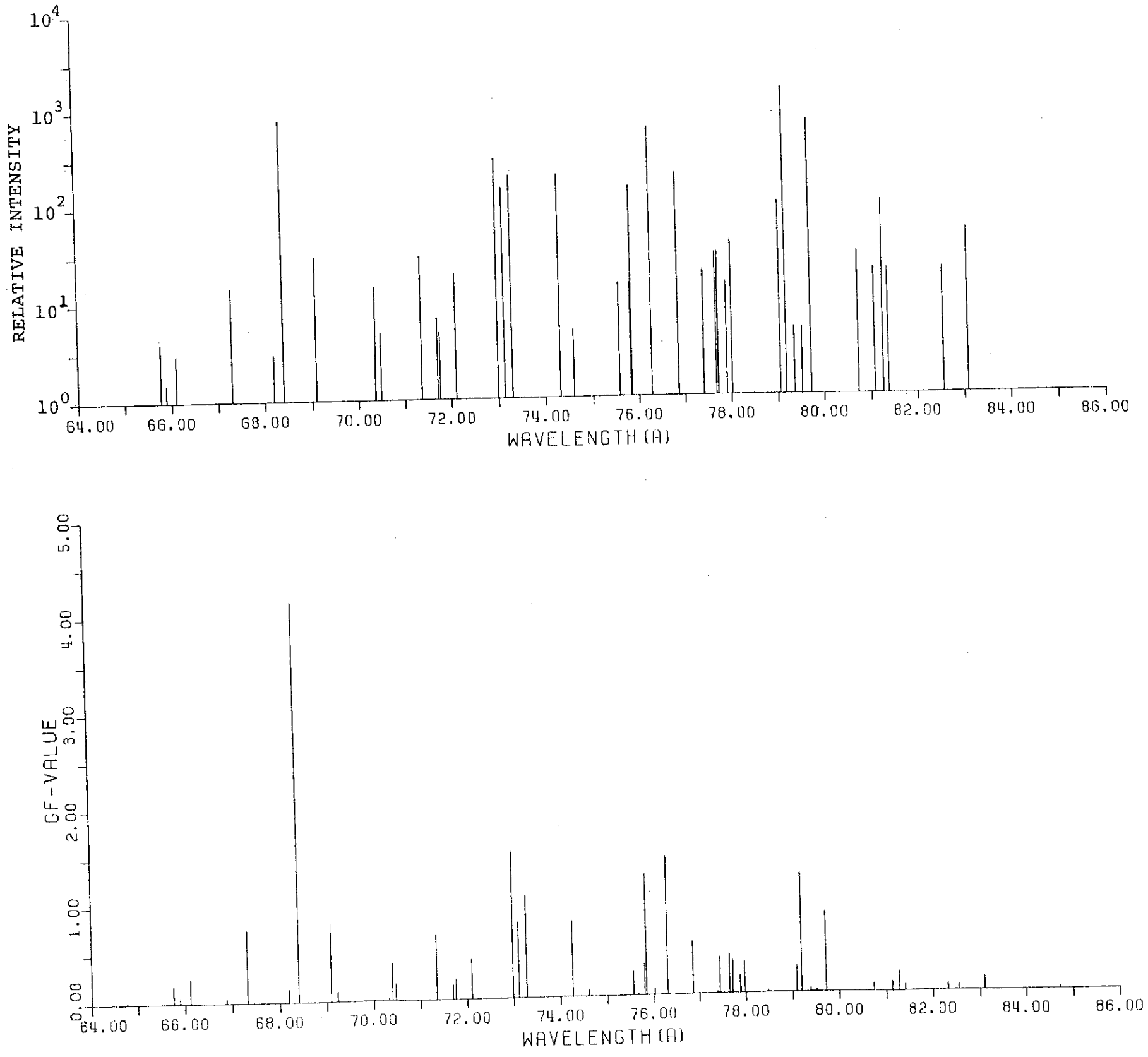

Fig. 5 Comparison of calculated (lower) and observed (upper) line patterns for $3p^6 3d^8 - 3p^5 3d^9$ transition in Mo XVII. The observed one is reproduced from Table 1 of ref.5.

TABLE 8 Calculated wavelengths, weighted oscillator strengths and weighted transition probabilities for $3d^8$ - $3d^74p$ transition array in Mo XVII.

Line No	$3d^8$ Conf Term	J	$3d^74p$ Conf Term	J	WL(A)	gf	gA(sec^{-1})
1	70.034	1	2274.208	2	45.368	0.0043	0.1389E+11
2	70.034	1	2279.666	1	45.256	0.0032	0.1028E+11
3	176.808	0	2387.382	1	45.237	0.0023	0.7518E+10
4	68.297	0	2279.666	1	45.221	0.0036	0.1186E+11
5	51.199	2	2264.474	3	45.182	0.0047	0.1547E+11
6	70.034	1	2283.997	2	45.168	0.0029	0.9425E+10
7	176.808	0	2391.219	1	45.159	0.0129	0.4234E+11
8	78.140	2	2296.720	3	45.074	0.0095	0.3120E+11
9	70.034	1	2292.110	2	45.003	0.0047	0.1564E+11
10	51.199	2	2274.208	2	44.984	0.0034	0.1121E+11
11	176.808	0	2401.480	1	44.950	0.0205	0.6757E+11
12	82.447	4	2309.730	5	44.898	0.0036	0.1204E+11
13	68.297	0	2295.965	1	44.890	0.0041	0.1341E+11
14	78.140	2	2306.266	3	44.881	0.0116	0.3849E+11
15	51.199	2	2279.666	1	44.874	0.0021	0.6966E+10
16	82.447	4	2312.910	4	44.834	0.0027	0.9013E+10
17	23.891	3	2264.474	3	44.631	0.0022	0.7362E+10
18	51.199	2	2292.110	2	44.625	0.0022	0.7428E+10
19	78.140	2	2321.706	3	44.572	0.0093	0.3136E+11
20	0.211	4	2244.096	4	44.566	0.0168	0.5647E+11
21	51.199	2	2296.720	3	44.533	0.0412	0.1386E+12
22	176.808	0	2423.345	1	44.513	0.0052	0.1739E+11
23	82.447	4	2329.453	5	44.504	0.0039	0.1317E+11
24	78.140	2	2326.368	1	44.479	0.0031	0.1038E+11
25	70.034	1	2318.266	2	44.479	0.0162	0.5462E+11
26	0.211	4	2248.462	5	44.479	0.0057	0.1929E+11
27	70.034	1	2319.974	2	44.446	0.0096	0.3232E+11
28	82.447	4	2332.630	3	44.441	0.0123	0.4159E+11
29	23.891	3	2274.208	2	44.438	0.0115	0.3880E+11
30	78.140	2	2328.635	3	44.435	0.0159	0.5362E+11
31	27.000	2	2279.666	1	44.392	0.0050	0.1686E+11
32	23.891	3	2277.940	3	44.365	0.0292	0.9899E+11
33	78.140	2	2332.630	3	44.356	0.0100	0.3397E+11
34	51.199	2	2306.266	3	44.345	0.0425	0.1442E+12
35	78.140	2	2333.209	1	44.345	0.0071	0.2400E+11
36	70.034	1	2326.368	1	44.320	0.0118	0.3996E+11
37	27.000	2	2283.997	2	44.307	0.0170	0.5763E+11
38	68.297	0	2326.368	1	44.286	0.0209	0.7115E+11
39	70.034	1	2329.388	2	44.260	0.0131	0.4450E+11
40	23.891	3	2283.997	2	44.246	0.0135	0.4603E+11

TABLE 8 (Continued).

41	51.199	2	2311.804	1	44.236	0.0203	0.6924E+11
42	78.140	2	2339.617	2	44.219	0.0096	0.3268E+11
43	70.034	1	2333.209	1	44.186	0.0033	0.1116E+11
44	78.140	2	2341.843	3	44.175	0.0152	0.5187E+11
45	0.211	4	2264.474	3	44.164	0.0126	0.4293E+11
46	68.297	0	2333.209	1	44.152	0.0224	0.7674E+11
47	82.447	4	2347.655	3	44.146	0.0034	0.1150E+11
48	82.447	4	2348.257	4	44.134	0.0021	0.7336E+10
49	70.034	1	2336.443	2	44.123	0.0212	0.7253E+11
50	82.447	4	2349.052	3	44.119	0.0190	0.6522E+11
51	51.199	2	2318.266	2	44.110	0.0282	0.9663E+11
52	51.199	2	2319.170	3	44.092	0.0216	0.7417E+11
53	23.891	3	2292.110	2	44.087	0.0062	0.2136E+11
54	23.891	3	2292.306	4	44.084	0.0030	0.1019E+11
55	51.199	2	2319.974	2	44.077	0.0071	0.2443E+11
56	27.000	2	2295.965	1	44.073	0.0077	0.2643E+11
57	0.211	4	2269.750	4	44.062	0.0321	0.1104E+12
58	70.034	1	2339.617	2	44.061	0.0461	0.1583E+12
59	27.000	2	2296.720	3	44.058	0.0203	0.6980E+11
60	70.034	1	2340.005	0	44.053	0.0084	0.2876E+11
61	70.034	1	2340.448	1	44.045	0.0307	0.1056E+12
62	51.199	2	2321.706	3	44.043	0.0575	0.1978E+12
63	78.140	2	2349.052	3	44.035	0.0237	0.8158E+11
64	82.447	4	2353.813	4	44.026	0.0340	0.1170E+12
65	82.447	4	2354.452	5	44.014	0.0921	0.3169E+12
66	68.297	0	2340.448	1	44.011	0.0210	0.7234E+11
67	23.891	3	2296.720	3	43.998	0.0025	0.8446E+10
68	82.447	4	2358.931	3	43.927	0.0072	0.2477E+11
69	78.140	2	2355.830	2	43.904	0.0038	0.1310E+11
70	78.140	2	2357.151	1	43.879	0.0072	0.2479E+11
71	70.034	1	2349.147	2	43.877	0.0720	0.2494E+12
72	27.000	2	2306.266	3	43.874	0.0494	0.1712E+12
73	23.891	3	2303.516	4	43.867	0.0095	0.3277E+11
74	82.447	4	2363.161	3	43.846	0.0032	0.1119E+11
75	78.140	2	2358.931	3	43.844	0.0030	0.1051E+11
76	82.447	4	2363.844	4	43.833	0.0939	0.3260E+12
77	51.199	2	2333.209	1	43.821	0.0108	0.3747E+11
78	23.891	3	2306.266	3	43.814	0.0721	0.2506E+12
79	176.808	0	2459.206	1	43.814	0.0525	0.1825E+12
80	78.140	2	2361.495	1	43.795	0.0061	0.2135E+11
81	0.211	4	2283.989	5	43.787	0.0410	0.1428E+12
82	82.447	4	2366.900	5	43.774	0.0853	0.2971E+12
83	27.000	2	2311.804	1	43.767	0.0047	0.1644E+11
84	51.199	2	2336.443	2	43.759	0.0056	0.1948E+11
85	70.034	1	2355.509	1	43.755	0.0213	0.7422E+11
86	70.034	1	2357.151	1	43.723	0.0590	0.2058E+12
87	68.297	0	2355.509	1	43.721	0.0142	0.4961E+11
88	51.199	2	2339.617	2	43.698	0.0647	0.2261E+12
89	23.891	3	2312.910	4	43.687	0.0350	0.1224E+12
90	51.199	2	2340.448	1	43.682	0.0050	0.1737E+11

TABLE 8 (Continued).

91	51.199	2	2341.843	3	43.656	0.0037	0.1286E+11
92	27.000	2	2318.266	2	43.644	0.0227	0.7948E+11
93	70.034	1	2361.495	1	43.640	0.0860	0.3010E+12
94	0.211	4	2292.306	4	43.628	0.2054	0.7198E+12
95	78.140	2	2370.846	3	43.617	0.0022	0.7877E+10
96	27.000	2	2319.974	2	43.611	0.0261	0.9161E+11
97	68.297	0	2361.495	1	43.607	0.0269	0.9421E+11
98	78.140	2	2371.845	1	43.598	0.0285	0.9998E+11
99	23.891	3	2318.266	2	43.585	0.0287	0.1009E+12
100	27.000	2	2321.706	3	43.579	0.0035	0.1237E+11
101	70.034	1	2364.801	2	43.577	0.0040	0.1416E+11
102	78.140	2	2372.947	1	43.577	0.0051	0.1792E+11
103	23.891	3	2319.170	3	43.568	0.0454	0.1597E+12
104	23.891	3	2319.974	2	43.552	0.0078	0.2740E+11
105	51.199	2	2347.655	3	43.545	0.0030	0.1062E+11
106	0.211	4	2296.720	3	43.544	0.1618	0.5692E+12
107	70.034	1	2367.019	2	43.535	0.0023	0.8162E+10
108	82.447	4	2379.581	4	43.533	0.0137	0.4810E+11
109	23.891	3	2321.243	4	43.528	0.0102	0.3599E+11
110	70.034	1	2367.718	2	43.522	0.0069	0.2436E+11
111	78.140	2	2375.938	3	43.520	0.0157	0.5523E+11
112	23.891	3	2321.706	3	43.520	0.0355	0.1250E+12
113	51.199	2	2349.147	2	43.517	0.0283	0.9956E+11
114	82.447	4	2380.953	5	43.507	0.1647	0.5805E+12
115	78.140	2	2377.334	2	43.494	0.0048	0.1683E+11
116	27.000	2	2326.368	1	43.490	0.0567	0.2001E+12
117	82.447	4	2383.478	4	43.459	1.2688	0.4481E+13
118	23.891	3	2325.620	4	43.446	0.0029	0.1039E+11
119	70.034	1	2371.845	1	43.444	0.0071	0.2527E+11
120	27.000	2	2329.388	2	43.433	0.1280	0.4527E+12
121	82.447	4	2384.844	3	43.433	0.1348	0.4765E+12
122	68.297	0	2371.845	1	43.411	0.0128	0.4544E+11
123	51.199	2	2355.509	1	43.397	0.0482	0.1708E+12
124	68.297	0	2372.947	1	43.391	0.0550	0.1950E+12
125	78.140	2	2382.829	2	43.390	0.0952	0.3374E+12
126	23.891	3	2328.635	3	43.389	0.0078	0.2761E+11
127	23.891	3	2329.388	2	43.375	0.1019	0.3613E+12
128	27.000	2	2332.630	3	43.372	0.1782	0.6319E+12
129	51.199	2	2357.151	1	43.366	0.0551	0.1954E+12
130	0.211	4	2306.266	3	43.364	0.1067	0.3786E+12
131	27.000	2	2333.209	1	43.361	0.0785	0.2784E+12
132	78.140	2	2384.844	3	43.352	0.2408	0.8544E+12
133	70.034	1	2377.334	2	43.341	0.0215	0.7632E+11
134	0.211	4	2307.719	5	43.337	0.0050	0.1793E+11
135	23.891	3	2332.630	3	43.314	0.0620	0.2205E+12
136	78.140	2	2387.382	1	43.304	0.0605	0.2150E+12
137	27.000	2	2336.443	2	43.300	0.0053	0.1877E+11
138	0.211	4	2309.730	5	43.299	0.0423	0.1505E+12
139	51.199	2	2361.495	1	43.284	0.0275	0.9775E+11
140	176.808	0	2487.833	1	43.271	0.0618	0.2200E+12

TABLE 8 (Continued).

141	27.000	2	2339.617	2	43.241	0.0040	0.1425E+11
142	0.211	4	2312.910	4	43.240	0.6250	0.2230E+13
143	78.140	2	2390.960	2	43.237	0.0467	0.1666E+12
144	78.140	2	2391.219	1	43.232	0.0161	0.5736E+11
145	27.000	2	2340.448	1	43.226	0.0287	0.1026E+12
146	51.199	2	2364.801	2	43.223	0.0314	0.1121E+12
147	78.140	2	2392.587	3	43.207	0.0755	0.2696E+12
148	23.891	3	2339.617	2	43.183	0.1012	0.3620E+12
149	51.199	2	2367.019	2	43.181	0.0194	0.6927E+11
150	51.199	2	2367.718	2	43.168	0.0405	0.1450E+12
151	70.034	1	2387.382	1	43.153	0.0059	0.2113E+11
152	23.891	3	2341.843	3	43.142	0.2049	0.7342E+12
153	0.211	4	2319.170	3	43.123	0.1553	0.5569E+12
154	82.447	4	2401.427	4	43.122	0.0084	0.3015E+11
155	68.297	0	2387.382	1	43.120	0.0256	0.9198E+11
156	51.199	2	2370.846	3	43.110	0.1065	0.3822E+12
157	78.140	2	2397.792	2	43.110	0.1781	0.6391E+12
158	78.140	2	2398.618	3	43.095	0.0274	0.9847E+11
159	51.199	2	2371.845	1	43.091	0.1476	0.5302E+12
160	27.000	2	2347.655	3	43.091	0.0289	0.1037E+12
161	70.034	1	2390.960	2	43.086	0.0198	0.7127E+11
162	0.211	4	2321.243	4	43.084	0.0732	0.2629E+12
163	23.891	3	2344.932	4	43.084	0.0030	0.1079E+11
164	0.211	4	2321.706	3	43.076	0.0234	0.8428E+11
165	70.034	1	2391.663	0	43.073	0.0340	0.1222E+12
166	51.199	2	2372.947	1	43.071	0.0076	0.2721E+11
167	27.000	2	2349.052	3	43.065	0.2340	0.8417E+12
168	27.000	2	2349.147	2	43.064	0.0177	0.6371E+11
169	78.140	2	2401.480	1	43.041	0.2216	0.7978E+12
170	82.447	4	2405.903	5	43.039	0.2817	0.1014E+13
171	23.891	3	2347.655	3	43.034	0.1050	0.3780E+12
172	23.891	3	2348.257	4	43.022	0.0384	0.1383E+12
173	51.199	2	2375.938	3	43.016	0.0997	0.3595E+12
174	23.891	3	2349.052	3	43.008	0.0878	0.3167E+12
175	23.891	3	2349.147	2	43.006	0.0829	0.2989E+12
176	0.211	4	2325.620	4	43.003	0.0698	0.2516E+12
177	176.808	0	2502.765	1	42.993	0.1858	0.6703E+12
178	51.199	2	2377.334	2	42.990	0.1045	0.3772E+12
179	70.034	1	2397.792	2	42.960	0.0211	0.7639E+11
180	0.211	4	2328.635	3	42.947	0.0740	0.2675E+12
181	27.000	2	2355.509	1	42.946	0.1708	0.6178E+12
182	27.000	2	2355.830	2	42.940	0.0463	0.1674E+12
183	0.211	4	2329.453	5	42.932	0.6481	0.2345E+13
184	23.891	3	2353.813	4	42.920	0.5690	0.2060E+13
185	27.000	2	2357.151	1	42.916	0.0114	0.4137E+11
186	70.034	1	2401.480	1	42.892	0.0210	0.7604E+11
187	51.199	2	2382.829	2	42.888	0.1623	0.5885E+12
188	27.000	2	2358.931	3	42.883	0.0190	0.6883E+11
189	23.891	3	2355.830	2	42.883	0.1176	0.4265E+12
190	0.211	4	2332.630	3	42.874	0.0472	0.1714E+12

TABLE 8 (Continued).

241	0.211	4	2363.844	4	42.308	0.0304	0.1132E+12
242	27.000	2	2390.960	2	42.302	0.0025	0.9403E+10
243	27.000	2	2391.219	1	42.297	0.0470	0.1752E+12
244	27.000	2	2392.587	3	42.273	0.0276	0.1030E+12
245	78.140	2	2444.152	3	42.265	0.1094	0.4085E+12
246	0.211	4	2366.900	5	42.253	0.0078	0.2921E+11
247	23.891	3	2390.960	2	42.246	0.0210	0.7859E+11
248	51.199	2	2418.500	2	42.242	0.0364	0.1361E+12
249	23.891	3	2392.587	3	42.217	0.0242	0.9069E+11
250	51.199	2	2419.937	3	42.217	0.0217	0.8121E+11
251	0.211	4	2370.846	3	42.183	0.0136	0.5100E+11
252	27.000	2	2397.792	2	42.180	0.0037	0.1400E+11
253	51.199	2	2423.345	1	42.156	0.0272	0.1020E+12
254	23.891	3	2397.792	2	42.125	0.0199	0.7498E+11
255	23.891	3	2398.618	3	42.110	0.0102	0.3846E+11
256	78.140	2	2453.651	2	42.096	0.0114	0.4293E+11
257	0.211	4	2375.938	3	42.092	0.0164	0.6188E+11
258	23.891	3	2401.427	4	42.060	0.0322	0.1215E+12
259	51.199	2	2429.117	2	42.054	0.0135	0.5083E+11
260	78.140	2	2456.810	2	42.040	0.0667	0.2519E+12
261	0.211	4	2379.581	4	42.028	0.0371	0.1401E+12
262	0.211	4	2380.953	5	42.004	0.0344	0.1300E+12
263	78.140	2	2459.206	1	41.998	0.0107	0.4048E+11
264	82.447	4	2465.724	3	41.959	0.0487	0.1844E+12
265	70.034	1	2456.810	2	41.898	0.0766	0.2910E+12
266	70.034	1	2459.206	1	41.855	0.0081	0.3097E+11
267	68.297	0	2459.206	1	41.825	0.0253	0.9664E+11
268	27.000	2	2418.500	2	41.815	0.0042	0.1620E+11
269	0.211	4	2392.587	3	41.799	0.0116	0.4416E+11
270	27.000	2	2419.937	3	41.790	0.0279	0.1066E+12
271	51.199	2	2444.152	3	41.789	0.0052	0.1998E+11
272	23.891	3	2418.500	2	41.760	0.0254	0.9730E+11
273	23.891	3	2419.937	3	41.735	0.0030	0.1158E+11
274	27.000	2	2423.345	1	41.730	0.0296	0.1134E+12
275	0.211	4	2398.618	3	41.694	0.0170	0.6508E+11
276	23.891	3	2422.385	4	41.693	0.0064	0.2455E+11
277	51.199	2	2453.651	2	41.624	0.0091	0.3504E+11
278	23.891	3	2429.117	2	41.576	0.0154	0.5950E+11
279	51.199	2	2456.810	2	41.569	0.0407	0.1569E+12
280	0.211	4	2405.903	5	41.568	0.0048	0.1856E+11
281	70.034	1	2477.737	0	41.533	0.0313	0.1209E+12
282	23.891	3	2431.861	4	41.529	0.0070	0.2694E+11
283	51.199	2	2459.206	1	41.528	0.0043	0.1664E+11
284	82.447	4	2491.362	3	41.512	0.1535	0.5940E+12
285	78.140	2	2487.833	1	41.499	0.0030	0.1174E+11
286	82.447	4	2494.116	4	41.465	0.0066	0.2552E+11
287	78.140	2	2491.362	3	41.438	0.0077	0.2999E+11
288	27.000	2	2444.152	3	41.371	0.0043	0.1657E+11
289	70.034	1	2487.833	1	41.360	0.0181	0.7064E+11
290	68.297	0	2487.833	1	41.330	0.0111	0.4320E+11

TABLE 8 (Continued).

191	68.297	0	2401.480	1	42.860	0.0068	0.2451E+11
192	27.000	2	2361.495	1	42.836	0.0156	0.5682E+11
193	23.891	3	2358.931	3	42.826	0.0250	0.9099E+11
194	27.000	2	2363.161	3	42.805	0.0220	0.8013E+11
195	51.199	2	2387.382	1	42.805	0.0456	0.1659E+12
196	70.034	1	2406.731	2	42.795	0.0554	0.2019E+12
197	82.447	4	2419.937	3	42.781	0.0457	0.1665E+12
198	27.000	2	2364.801	2	42.775	0.2680	0.9770E+12
199	78.140	2	2416.975	1	42.756	0.0722	0.2634E+12
200	82.447	4	2421.570	3	42.751	0.1456	0.5314E+12
201	23.891	3	2363.161	3	42.748	0.1864	0.6802E+12
202	82.447	4	2422.385	4	42.736	0.0454	0.1657E+12
203	27.000	2	2367.019	2	42.735	0.0465	0.1699E+12
204	78.140	2	2418.500	2	42.728	0.0362	0.1321E+12
205	23.891	3	2364.801	2	42.718	0.0351	0.1283E+12
206	51.199	2	2392.587	3	42.710	0.0082	0.2984E+11
207	0.211	4	2341.843	3	42.705	0.0116	0.4251E+11
208	78.140	2	2419.937	3	42.702	0.0835	0.3055E+12
209	23.891	3	2367.019	2	42.678	0.0262	0.9608E+11
210	78.140	2	2421.570	3	42.673	0.0384	0.1408E+12
211	23.891	3	2367.718	2	42.665	0.0642	0.2353E+12
212	27.000	2	2370.846	3	42.665	0.0072	0.2630E+11
213	0.211	4	2344.932	4	42.649	0.0168	0.6168E+11
214	27.000	2	2371.845	1	42.647	0.0046	0.1692E+11
215	78.140	2	2423.345	1	42.640	0.0209	0.7670E+11
216	70.034	1	2416.975	1	42.609	0.1034	0.3799E+12
217	23.891	3	2370.846	3	42.608	0.0092	0.3378E+11
218	51.199	2	2398.618	3	42.600	0.2634	0.9680E+12
219	0.211	4	2347.655	3	42.600	0.2057	0.7561E+12
220	0.211	4	2348.046	5	42.592	0.0328	0.1207E+12
221	0.211	4	2348.257	4	42.589	0.0805	0.2962E+12
222	70.034	1	2418.500	2	42.581	0.0530	0.1948E+12
223	0.211	4	2349.052	3	42.574	0.0029	0.1078E+11
224	27.000	2	2375.938	3	42.572	0.0127	0.4679E+11
225	70.034	1	2419.096	0	42.570	0.0282	0.1036E+12
226	51.199	2	2401.480	1	42.548	0.0155	0.5715E+11
227	27.000	2	2377.334	2	42.547	0.0132	0.4874E+11
228	78.140	2	2429.117	2	42.536	0.0830	0.3058E+12
229	23.891	3	2375.938	3	42.516	0.0085	0.3139E+11
230	70.034	1	2423.345	1	42.493	0.0148	0.5478E+11
231	0.211	4	2354.452	5	42.477	0.0487	0.1801E+12
232	68.297	0	2423.345	1	42.462	0.0928	0.3433E+12
233	23.891	3	2379.581	4	42.450	0.0151	0.5602E+11
234	27.000	2	2382.829	2	42.448	0.0113	0.4197E+11
235	0.211	4	2358.931	3	42.396	0.1583	0.5875E+12
236	23.891	3	2382.829	2	42.392	0.0476	0.1768E+12
237	70.034	1	2429.117	2	42.389	0.0797	0.2957E+12
238	23.891	3	2383.478	4	42.380	0.0150	0.5579E+11
239	82.447	4	2444.152	3	42.342	0.4088	0.1521E+13
240	0.211	4	2363.161	3	42.320	0.0052	0.1954E+11

TABLE 8 (Continued).

291	0.211	4	2419.937	3	41.327	0.0116	0.4533E+11
292	78.140	2	2500.088	2	41.289	0.0119	0.4668E+11
293	78.140	2	2502.765	1	41.243	0.0040	0.1560E+11
294	27.000	2	2453.651	2	41.209	0.0031	0.1199E+11
295	70.034	1	2500.088	2	41.151	0.0027	0.1044E+11
296	0.211	4	2430.416	5	41.149	0.0041	0.1626E+11
297	0.211	4	2431.861	4	41.124	0.0072	0.2840E+11
298	78.140	2	2509.906	2	41.122	0.0030	0.1164E+11
299	27.000	2	2459.206	1	41.115	0.0025	0.9839E+10
300	82.447	4	2515.820	3	41.095	0.0219	0.8660E+11
301	68.297	0	2502.765	1	41.077	0.0026	0.1041E+11
302	51.199	2	2487.833	1	41.040	0.0152	0.6012E+11
303	78.140	2	2515.820	3	41.023	0.0052	0.2067E+11
304	70.034	1	2509.906	2	40.986	0.0046	0.1825E+11
305	23.891	3	2465.724	3	40.953	0.0095	0.3772E+11
306	51.199	2	2500.088	2	40.835	0.0025	0.9846E+10
307	51.199	2	2502.765	1	40.790	0.0062	0.2498E+11
308	51.199	2	2509.906	2	40.672	0.0035	0.1400E+11
309	51.199	2	2515.820	3	40.574	0.0075	0.3051E+11
310	27.000	2	2502.765	1	40.392	0.0039	0.1601E+11
311	23.891	3	2500.088	2	40.385	0.0161	0.6577E+11
312	27.000	2	2509.906	2	40.275	0.0045	0.1861E+11
313	0.211	4	2494.116	4	40.098	0.0096	0.3990E+11
314	0.211	4	2515.820	3	39.752	0.0132	0.5570E+11

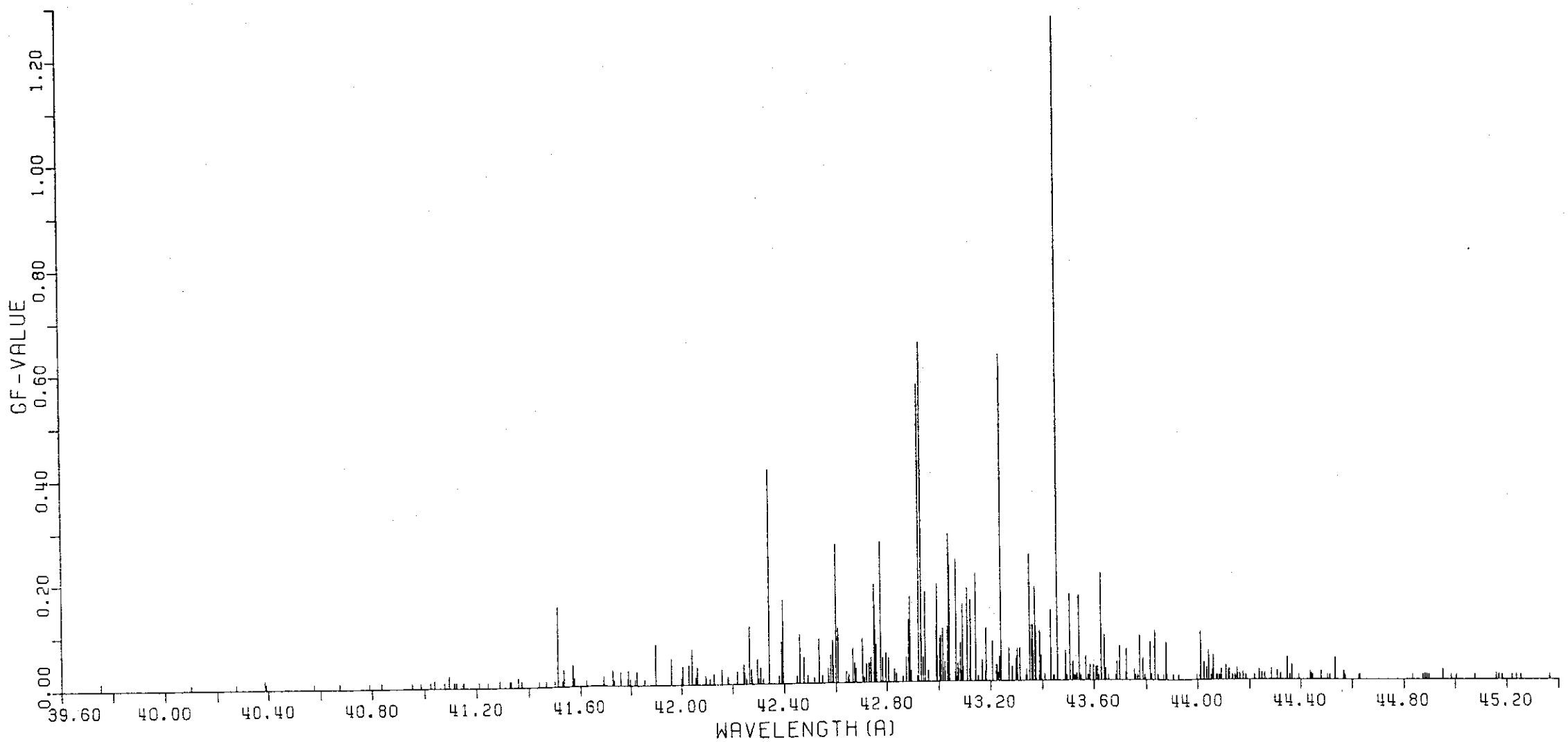

Fig. 6 Calculated spectrum for $3d^8$-$3d^7 4p$ transition array in Mo XVII.

TABLE 9 Calculated wavelengths, weighted oscillator strengths and weighted transition probabilities for $3d^8$ - $3d^74f$ transition array in Mo XVII.

Line No	$3d^8$ Conf Term	J	$3d^74f$ Conf Term	J	WL(A)	gf	gA(sec^{-1})
1	176.808	0.0	3210.496	1.0	32.963	0.0518	0.3182E+12
2	176.808	0.0	3238.518	1.0	32.661	0.0602	0.3767E+12
3	78.140	2.0	3140.662	1.0	32.653	0.0294	0.1839E+12
4	51.199	2.0	3113.973	2.0	32.650	0.0317	0.1986E+12
5	51.199	2.0	3122.011	1.0	32.565	0.0375	0.2359E+12
6	51.199	2.0	3122.228	2.0	32.562	0.0329	0.2067E+12
7	78.140	2.0	3156.779	2.0	32.482	0.0634	0.4009E+12
8	51.199	2.0	3131.876	2.0	32.460	0.0311	0.1970E+12
9	70.034	1.0	3150.763	0.0	32.460	0.0380	0.2407E+12
10	51.199	2.0	3132.265	2.0	32.456	0.0264	0.1670E+12
11	78.140	2.0	3164.680	2.0	32.399	0.0308	0.1959E+12
12	70.034	1.0	3156.779	2.0	32.397	0.0478	0.3039E+12
13	27.000	2.0	3113.973	2.0	32.394	0.0372	0.2361E+12
14	70.034	1.0	3157.076	0.0	32.393	0.0775	0.4924E+12
15	51.199	2.0	3140.662	1.0	32.368	0.0404	0.2569E+12
16	82.447	4.0	3172.069	5.0	32.366	0.0355	0.2258E+12
17	82.447	4.0	3172.916	3.0	32.358	0.0452	0.2881E+12
18	70.034	1.0	3161.322	2.0	32.349	0.0420	0.2675E+12
19	70.034	1.0	3163.021	1.0	32.331	0.1133	0.7227E+12
20	51.199	2.0	3144.646	3.0	32.326	0.0649	0.4143E+12
21	51.199	2.0	3145.992	2.0	32.312	0.0903	0.5767E+12
22	176.808	0.0	3271.922	1.0	32.309	0.0346	0.2209E+12
23	82.447	4.0	3177.799	4.0	32.307	0.0277	0.1772E+12
24	78.140	2.0	3174.909	2.0	32.292	0.0450	0.2877E+12
25	82.447	4.0	3180.092	4.0	32.283	0.0321	0.2052E+12
26	78.140	2.0	3176.016	3.0	32.280	0.0462	0.2960E+12
27	51.199	2.0	3150.084	1.0	32.270	0.1612	0.1033E+13
28	82.447	4.0	3181.680	5.0	32.266	0.0634	0.4061E+12
29	78.140	2.0	3177.969	1.0	32.260	0.0982	0.6294E+12
30	82.447	4.0	3184.334	3.0	32.238	0.0641	0.4115E+12
31	51.199	2.0	3153.506	2.0	32.234	0.0473	0.3036E+12
32	70.034	1.0	3172.718	2.0	32.230	0.0788	0.5059E+12
33	68.297	0.0	3171.802	1.0	32.222	0.0851	0.5467E+12
34	51.199	2.0	3154.846	1.0	32.220	0.0966	0.6207E+12
35	27.000	2.0	3131.876	2.0	32.207	0.0481	0.3094E+12
36	51.199	2.0	3156.666	3.0	32.201	0.1167	0.7505E+12
37	51.199	2.0	3156.779	2.0	32.200	0.0586	0.3771E+12
38	23.891	3.0	3130.702	3.0	32.187	0.1071	0.6892E+12
39	23.891	3.0	3130.983	4.0	32.184	0.0467	0.3007E+12
40	70.034	1.0	3177.969	1.0	32.176	0.0861	0.5547E+12
41	23.891	3.0	3131.876	2.0	32.175	0.0741	0.4776E+12
42	70.034	1.0	3178.320	2.0	32.172	0.0562	0.3621E+12

43	23.891	3.0	3133.477	4.0	32.159	0.1635	0.1054E+13
44	68.297	0.0	3177.969	1.0	32.158	0.0748	0.4827E+12
45	51.199	2.0	3163.021	1.0	32.136	0.0343	0.2214E+12
46	27.000	2.0	3139.023	1.0	32.133	0.0271	0.1754E+12
47	51.199	2.0	3164.680	2.0	32.118	0.1425	0.9214E+12
48	0.211	4.0	3113.760	3.0	32.118	0.1681	0.1087E+13
49	27.000	2.0	3140.662	1.0	32.117	0.0864	0.5586E+12
50	0.211	4.0	3114.622	5.0	32.109	0.2451	0.1586E+13
51	82.447	4.0	3197.415	4.0	32.103	0.0528	0.3419E+12
52	0.211	4.0	3115.880	4.0	32.096	0.1816	0.1176E+13
53	23.891	3.0	3139.854	3.0	32.093	0.0690	0.4466E+12
54	82.447	4.0	3198.627	4.0	32.091	0.0586	0.3795E+12
55	70.034	1.0	3186.819	1.0	32.084	0.1122	0.7271E+12
56	23.891	3.0	3141.465	4.0	32.076	0.0276	0.1787E+12
57	27.000	2.0	3144.646	3.0	32.075	0.1338	0.8671E+12
58	68.297	0.0	3186.819	1.0	32.066	0.2330	0.1511E+13
59	27.000	2.0	3145.992	2.0	32.062	0.0960	0.6227E+12
60	70.034	1.0	3189.716	2.0	32.055	0.0768	0.4987E+12
61	68.297	0.0	3188.013	1.0	32.054	0.1150	0.7468E+12
62	82.447	4.0	3202.321	5.0	32.053	0.0942	0.6113E+12
63	78.140	2.0	3198.094	3.0	32.052	0.0570	0.3699E+12
64	23.891	3.0	3144.646	3.0	32.044	0.1713	0.1113E+13
65	23.891	3.0	3145.992	2.0	32.030	0.0577	0.3750E+12
66	70.034	1.0	3192.524	2.0	32.026	0.1340	0.8712E+12
67	70.034	1.0	3192.750	1.0	32.023	0.0441	0.2867E+12
68	27.000	2.0	3149.727	3.0	32.023	0.1235	0.8034E+12
69	0.211	4.0	3123.015	3.0	32.022	0.0967	0.6290E+12
70	0.211	4.0	3123.849	5.0	32.014	0.0335	0.2177E+12
71	51.199	2.0	3174.909	2.0	32.013	0.0684	0.4451E+12
72	23.891	3.0	3147.833	4.0	32.011	0.3822	0.2488E+13
73	51.199	2.0	3176.016	3.0	32.002	0.0608	0.3958E+12
74	51.199	2.0	3177.969	1.0	31.982	0.0631	0.4118E+12
75	82.447	4.0	3209.229	5.0	31.982	0.2124	0.1385E+13
76	78.140	2.0	3205.304	3.0	31.978	0.0929	0.6061E+12
77	0.211	4.0	3128.394	4.0	31.967	0.3222	0.2103E+13
78	82.447	4.0	3210.655	4.0	31.967	0.0800	0.5224E+12
79	70.034	1.0	3198.780	2.0	31.962	0.1499	0.9786E+12
80	82.447	4.0	3211.250	3.0	31.961	0.0690	0.4505E+12
81	0.211	4.0	3129.033	5.0	31.961	0.2343	0.1530E+13
82	27.000	2.0	3156.666	3.0	31.952	0.2403	0.1570E+13
83	27.000	2.0	3156.779	2.0	31.951	0.0754	0.4926E+12
84	82.447	4.0	3212.528	3.0	31.948	0.1539	0.1006E+13
85	0.211	4.0	3130.702	3.0	31.944	0.0942	0.6159E+12
86	0.211	4.0	3130.983	4.0	31.941	0.1940	0.1268E+13
87	51.199	2.0	3183.299	3.0	31.927	0.0502	0.3284E+12
88	78.140	2.0	3211.225	2.0	31.917	0.0270	0.1768E+12
89	78.140	2.0	3211.250	3.0	31.917	0.0467	0.3057E+12
90	51.199	2.0	3184.334	3.0	31.917	0.0328	0.2146E+12
91	0.211	4.0	3133.477	4.0	31.916	0.1175	0.7694E+12
92	27.000	2.0	3161.322	2.0	31.905	0.0275	0.1802E+12
93	27.000	2.0	3163.021	1.0	31.888	0.0602	0.3947E+12

94	51.199	2.0	3188.013	1.0	31.879	0.0538	0.3529E+12
95	27.000	2.0	3164.680	2.0	31.871	0.1385	0.9093E+12
96	78.140	2.0	3216.363	1.0	31.865	0.0408	0.2682E+12
97	51.199	2.0	3189.716	2.0	31.862	0.1166	0.7661E+12
98	23.891	3.0	3163.052	4.0	31.856	0.0320	0.2103E+12
99	0.211	4.0	3139.978	4.0	31.849	0.1127	0.7410E+12
100	78.140	2.0	3219.017	2.0	31.838	0.1314	0.8648E+12
101	82.447	4.0	3223.477	3.0	31.837	0.0922	0.6066E+12
102	0.211	4.0	3141.465	4.0	31.834	0.0334	0.2199E+12
103	51.199	2.0	3192.524	2.0	31.834	0.0979	0.6447E+12
104	82.447	4.0	3224.179	4.0	31.830	0.0445	0.2928E+12
105	51.199	2.0	3193.921	3.0	31.820	0.1802	0.1187E+13
106	78.140	2.0	3221.273	2.0	31.815	0.2050	0.1351E+13
107	82.447	4.0	3225.773	5.0	31.813	0.0686	0.4521E+12
108	23.891	3.0	3167.914	4.0	31.806	0.0402	0.2648E+12
109	78.140	2.0	3223.477	3.0	31.793	0.0656	0.4329E+12
110	70.034	1.0	3215.655	0.0	31.790	0.1237	0.8163E+12
111	0.211	4.0	3146.011	5.0	31.788	0.5218	0.3444E+13
112	23.891	3.0	3169.868	3.0	31.787	0.0348	0.2299E+12
113	70.034	1.0	3216.363	1.0	31.783	0.2230	0.1472E+13
114	82.447	4.0	3229.318	5.0	31.778	0.3005	0.1985E+13
115	82.447	4.0	3230.102	3.0	31.770	0.9542	0.6305E+13
116	70.034	1.0	3219.017	2.0	31.756	0.0418	0.2764E+12
117	23.891	3.0	3172.916	3.0	31.756	0.0477	0.3157E+12
118	82.447	4.0	3231.623	4.0	31.754	0.0364	0.2410E+12
119	51.199	2.0	3200.874	3.0	31.749	0.3210	0.2124E+13
120	0.211	4.0	3150.421	5.0	31.744	0.4940	0.3270E+13
121	23.891	3.0	3174.909	2.0	31.736	0.0576	0.3818E+12
122	78.140	2.0	3229.363	2.0	31.734	0.0581	0.3850E+12
123	70.034	1.0	3221.273	2.0	31.734	0.0604	0.4001E+12
124	27.000	2.0	3178.320	2.0	31.733	0.0476	0.3154E+12
125	23.891	3.0	3176.016	3.0	31.725	0.1557	0.1032E+13
126	23.891	3.0	3176.111	4.0	31.724	0.1272	0.8433E+12
127	82.447	4.0	3235.642	5.0	31.714	0.2423	0.1607E+13
128	0.211	4.0	3153.806	4.0	31.710	0.0270	0.1790E+12
129	82.447	4.0	3236.251	3.0	31.708	0.4378	0.2904E+13
130	23.891	3.0	3177.799	4.0	31.707	0.1392	0.9234E+12
131	51.199	2.0	3205.304	3.0	31.705	0.0455	0.3017E+12
132	23.891	3.0	3178.320	2.0	31.701	0.0463	0.3070E+12
133	27.000	2.0	3182.310	2.0	31.693	0.0466	0.3093E+12
134	23.891	3.0	3180.092	4.0	31.684	0.0859	0.5705E+12
135	27.000	2.0	3183.299	3.0	31.683	0.1475	0.9803E+12
136	82.447	4.0	3239.563	4.0	31.674	0.1110	0.7381E+12
137	82.447	4.0	3240.184	3.0	31.668	0.4603	0.3062E+13
138	78.140	2.0	3236.251	3.0	31.665	0.1033	0.6872E+12
139	23.891	3.0	3182.310	2.0	31.661	0.2087	0.1388E+13
140	82.447	4.0	3241.177	4.0	31.658	0.4415	0.2938E+13
141	27.000	2.0	3186.273	3.0	31.653	0.0482	0.3212E+12
142	70.034	1.0	3229.355	1.0	31.652	0.0461	0.3069E+12
143	23.891	3.0	3183.299	3.0	31.652	0.1077	0.7171E+12
144	51.199	2.0	3211.225	2.0	31.645	0.1221	0.8131E+12

145	51.199	2.0	3211.250	3.0	31.645	0.1090	0.7263E+12
146	78.140	2.0	3238.518	1.0	31.642	0.2928	0.1951E+13
147	23.891	3.0	3184.334	3.0	31.641	0.1677	0.1117E+13
148	0.211	4.0	3161.338	5.0	31.634	0.0301	0.2009E+12
149	51.199	2.0	3212.528	3.0	31.632	0.0662	0.4416E+12
150	78.140	2.0	3240.184	3.0	31.625	0.0481	0.3206E+12
151	82.447	4.0	3245.194	3.0	31.618	2.2149	0.1478E+14
152	82.447	4.0	3245.435	5.0	31.616	1.0804	0.7209E+13
153	23.891	3.0	3187.477	4.0	31.610	0.1098	0.7327E+12
154	51.199	2.0	3216.363	1.0	31.594	0.0690	0.4613E+12
155	82.447	4.0	3247.996	5.0	31.590	0.0576	0.3851E+12
156	23.891	3.0	3189.716	2.0	31.587	0.0304	0.2034E+12
157	82.447	4.0	3248.393	4.0	31.586	0.7427	0.4965E+13
158	23.891	3.0	3190.106	4.0	31.583	0.0883	0.5905E+12
159	23.891	3.0	3190.602	3.0	31.579	0.0337	0.2257E+12
160	27.000	2.0	3193.921	3.0	31.576	0.0526	0.3516E+12
161	78.140	2.0	3245.194	3.0	31.575	0.1391	0.9303E+12
162	78.140	2.0	3245.303	2.0	31.574	0.2318	0.1551E+13
163	82.447	4.0	3249.857	3.0	31.572	0.5349	0.3579E+13
164	51.199	2.0	3219.017	2.0	31.567	0.0417	0.2788E+12
165	70.034	1.0	3238.518	1.0	31.561	0.0586	0.3924E+12
166	23.891	3.0	3192.524	2.0	31.559	0.1258	0.8424E+12
167	0.211	4.0	3169.313	5.0	31.555	0.0456	0.3057E+12
168	0.211	4.0	3169.868	3.0	31.549	0.1710	0.1146E+13
169	78.140	2.0	3248.232	2.0	31.545	0.0625	0.4190E+12
170	68.297	0.0	3238.518	1.0	31.544	0.1786	0.1197E+13
171	82.447	4.0	3252.741	4.0	31.543	0.4340	0.2909E+13
172	78.140	2.0	3248.703	1.0	31.540	0.0723	0.4850E+12
173	27.000	2.0	3198.094	3.0	31.535	0.1422	0.9539E+12
174	78.140	2.0	3249.857	3.0	31.529	0.0508	0.3406E+12
175	51.199	2.0	3223.477	3.0	31.523	0.1622	0.1089E+13
176	0.211	4.0	3172.916	3.0	31.519	0.1403	0.9420E+12
177	82.447	4.0	3255.909	3.0	31.511	0.1322	0.8877E+12
178	27.000	2.0	3200.812	2.0	31.508	0.0702	0.4714E+12
179	23.891	3.0	3198.094	3.0	31.504	0.0335	0.2251E+12
180	23.891	3.0	3198.627	4.0	31.499	0.1418	0.9529E+12
181	82.447	4.0	3257.792	4.0	31.493	0.0405	0.2725E+12
182	78.140	2.0	3253.580	2.0	31.492	0.0488	0.3284E+12
183	0.211	4.0	3176.016	3.0	31.488	0.0574	0.3859E+12
184	82.447	4.0	3258.271	5.0	31.488	0.0747	0.5028E+12
185	0.211	4.0	3176.111	4.0	31.487	0.2226	0.1498E+13
186	0.211	4.0	3176.611	5.0	31.482	0.0379	0.2553E+12
187	82.447	4.0	3259.559	3.0	31.475	0.5875	0.3955E+13
188	0.211	4.0	3177.799	4.0	31.470	0.0299	0.2013E+12
189	51.199	2.0	3229.355	1.0	31.465	0.1016	0.6846E+12
190	51.199	2.0	3229.363	2.0	31.465	0.3766	0.2537E+13
191	70.034	1.0	3248.232	2.0	31.464	0.1092	0.7360E+12
192	27.000	2.0	3205.304	3.0	31.463	0.0788	0.5311E+12
193	51.199	2.0	3230.102	3.0	31.457	0.2060	0.1388E+13
194	78.140	2.0	3257.624	1.0	31.452	0.8499	0.5731E+13
195	0.211	4.0	3180.092	4.0	31.448	0.1204	0.8118E+12

196	68.297	0.0	3248.703	1.0	31.443	0.2084	0.1406E+13
197	0.211	4.0	3181.680	5.0	31.432	0.5402	0.3647E+13
198	27.000	2.0	3210.282	3.0	31.414	0.1479	0.9997E+12
199	27.000	2.0	3210.496	1.0	31.412	0.1242	0.8398E+12
200	0.211	4.0	3184.334	3.0	31.406	0.0441	0.2984E+12
201	27.000	2.0	3211.225	2.0	31.405	0.1748	0.1182E+13
202	27.000	2.0	3211.250	3.0	31.405	0.0867	0.5862E+12
203	78.140	2.0	3263.014	1.0	31.398	0.0794	0.5373E+12
204	51.199	2.0	3236.251	3.0	31.397	0.2642	0.1787E+13
205	27.000	2.0	3212.528	3.0	31.392	0.3060	0.2071E+13
206	82.447	4.0	3268.854	3.0	31.383	0.2406	0.1629E+13
207	51.199	2.0	3238.518	1.0	31.374	0.2826	0.1915E+13
208	23.891	3.0	3211.225	2.0	31.374	0.0327	0.2219E+12
209	23.891	3.0	3212.528	3.0	31.361	0.3498	0.2372E+13
210	51.199	2.0	3240.184	3.0	31.358	0.0864	0.5859E+12
211	27.000	2.0	3216.363	1.0	31.354	0.2546	0.1727E+13
212	0.211	4.0	3190.106	4.0	31.349	0.0586	0.3975E+12
213	0.211	4.0	3190.602	3.0	31.344	0.0916	0.6216E+12
214	70.034	1.0	3260.699	0.0	31.341	0.3733	0.2535E+13
215	78.140	2.0	3268.854	3.0	31.341	0.3177	0.2158E+13
216	27.000	2.0	3219.017	2.0	31.328	0.4861	0.3304E+13
217	0.211	4.0	3193.006	4.0	31.321	0.0931	0.6329E+12
218	70.034	1.0	3263.014	1.0	31.319	0.8192	0.5570E+13
219	78.140	2.0	3271.922	1.0	31.311	0.0378	0.2572E+12
220	51.199	2.0	3245.303	2.0	31.308	0.1991	0.1355E+13
221	27.000	2.0	3221.273	2.0	31.306	0.1332	0.9062E+12
222	23.891	3.0	3218.353	4.0	31.304	0.2049	0.1395E+13
223	176.808	0.0	3371.502	1.0	31.302	4.1012	0.2792E+14
224	68.297	0.0	3263.014	1.0	31.302	0.5084	0.3461E+13
225	70.034	1.0	3264.770	2.0	31.301	2.9743	0.2025E+14
226	23.891	3.0	3219.017	2.0	31.298	0.4141	0.2820E+13
227	27.000	2.0	3223.477	3.0	31.284	0.4650	0.3169E+13
228	78.140	2.0	3274.774	2.0	31.283	3.7838	0.2579E+14
229	51.199	2.0	3248.232	2.0	31.279	0.4155	0.2832E+13
230	23.891	3.0	3221.273	2.0	31.276	0.7343	0.5007E+13
231	51.199	2.0	3248.703	1.0	31.274	0.0938	0.6399E+12
232	51.199	2.0	3249.857	3.0	31.263	0.2442	0.1667E+13
233	70.034	1.0	3268.749	2.0	31.263	0.9274	0.6329E+13
234	23.891	3.0	3223.477	3.0	31.254	0.1890	0.1290E+13
235	82.447	4.0	3282.184	4.0	31.253	9.2407	0.6310E+14
236	23.891	3.0	3224.179	4.0	31.247	0.2598	0.1774E+13
237	0.211	4.0	3200.845	5.0	31.244	0.2588	0.1768E+13
238	0.211	4.0	3200.874	3.0	31.244	0.0470	0.3209E+12
239	70.034	1.0	3271.922	1.0	31.232	0.7337	0.5017E+13
240	27.000	2.0	3229.355	1.0	31.227	2.2607	0.1546E+14
241	27.000	2.0	3229.363	2.0	31.227	1.1299	0.7729E+13
242	51.199	2.0	3253.580	2.0	31.227	0.0738	0.5050E+12
243	82.447	4.0	3285.499	5.0	31.220	6.5130	0.4457E+14
244	27.000	2.0	3230.102	3.0	31.220	0.1468	0.1005E+13
245	68.297	0.0	3271.922	1.0	31.215	0.9974	0.6827E+13
246	0.211	4.0	3204.466	4.0	31.208	0.0723	0.4952E+12

247	51.199	2.0	3255.909	3.0	31.204	0.2874	0.1969E+13
248	0.211	4.0	3205.304	3.0	31.200	0.6550	0.4488E+13
249	23.891	3.0	3229.363	2.0	31.197	0.6108	0.4186E+13
250	23.891	3.0	3230.102	3.0	31.189	3.5676	0.2446E+14
251	51.199	2.0	3257.624	1.0	31.187	1.4816	0.1016E+14
252	82.447	4.0	3289.149	3.0	31.185	0.0737	0.5057E+12
253	27.000	2.0	3233.804	2.0	31.184	1.1748	0.8058E+13
254	78.140	2.0	3285.596	1.0	31.177	1.9505	0.1338E+14
255	23.891	3.0	3231.623	4.0	31.175	0.4656	0.3195E+13
256	51.199	2.0	3259.559	3.0	31.169	0.7820	0.5369E+13
257	27.000	2.0	3236.251	3.0	31.160	0.4132	0.2838E+13
258	23.891	3.0	3233.804	2.0	31.153	2.3746	0.1632E+14
259	0.211	4.0	3210.282	3.0	31.152	0.6434	0.4422E+13
260	0.211	4.0	3210.655	4.0	31.148	0.1121	0.7709E+12
261	78.140	2.0	3289.149	3.0	31.143	6.9513	0.4780E+14
262	0.211	4.0	3211.250	3.0	31.143	2.3701	0.1630E+14
263	27.000	2.0	3238.518	1.0	31.138	0.0400	0.2753E+12
264	51.199	2.0	3263.014	1.0	31.135	0.0374	0.2575E+12
265	0.211	4.0	3212.528	3.0	31.130	1.9309	0.1329E+14
266	27.000	2.0	3240.184	3.0	31.122	0.7839	0.5398E+13
267	51.199	2.0	3264.770	2.0	31.118	1.1070	0.7625E+13
268	0.211	4.0	3214.996	4.0	31.106	0.1348	0.9291E+12
269	70.034	1.0	3285.596	1.0	31.099	0.3854	0.2658E+13
270	23.891	3.0	3239.563	4.0	31.098	3.4569	0.2384E+14
271	23.891	3.0	3240.184	3.0	31.092	0.3334	0.2300E+13
272	68.297	0.0	3285.596	1.0	31.082	0.1166	0.8049E+12
273	51.199	2.0	3268.749	2.0	31.080	2.9555	0.2041E+14
274	51.199	2.0	3268.854	3.0	31.079	5.0655	0.3498E+14
275	0.211	4.0	3218.353	4.0	31.074	9.8613	0.6812E+14
276	27.000	2.0	3245.194	3.0	31.073	0.1705	0.1178E+13
277	27.000	2.0	3245.303	2.0	31.072	0.6477	0.4474E+13
278	82.447	4.0	3302.924	4.0	31.051	0.0454	0.3143E+12
279	51.199	2.0	3271.922	1.0	31.049	0.0406	0.2808E+12
280	27.000	2.0	3248.232	2.0	31.044	0.1878	0.1300E+13
281	23.891	3.0	3245.194	3.0	31.043	1.4460	0.1001E+14
282	27.000	2.0	3248.703	1.0	31.039	0.3156	0.2185E+13
283	27.000	2.0	3249.857	3.0	31.028	1.0506	0.7278E+13
284	0.211	4.0	3223.477	3.0	31.024	0.4570	0.3167E+13
285	82.447	4.0	3305.852	5.0	31.023	0.1110	0.7692E+12
286	23.891	3.0	3248.232	2.0	31.014	0.1804	0.1251E+13
287	23.891	3.0	3248.393	4.0	31.013	1.2225	0.8478E+13
288	78.140	2.0	3302.907	2.0	31.010	0.8748	0.6068E+13
289	0.211	4.0	3225.773	5.0	31.002	10.5623	0.7330E+14
290	23.891	3.0	3249.857	3.0	30.998	1.8094	0.1256E+14
291	27.000	2.0	3253.580	2.0	30.993	1.9023	0.1321E+14
292	23.891	3.0	3252.741	4.0	30.971	2.6874	0.1869E+14
293	27.000	2.0	3255.909	3.0	30.970	4.6632	0.3243E+14
294	0.211	4.0	3229.318	5.0	30.968	3.2017	0.2227E+14
295	23.891	3.0	3253.580	2.0	30.963	0.2967	0.2064E+13
296	0.211	4.0	3230.102	3.0	30.961	0.2606	0.1813E+13
297	27.000	2.0	3257.624	1.0	30.954	0.0358	0.2489E+12

298	78.140	2.0	3308.882	1.0	30.953	0.1729	0.1204E+13
299	0.211	4.0	3231.623	4.0	30.946	0.1094	0.7617E+12
300	23.891	3.0	3255.909	3.0	30.940	0.4958	0.3454E+13
301	27.000	2.0	3259.559	3.0	30.935	1.5518	0.1082E+14
302	70.034	1.0	3302.907	2.0	30.932	0.5049	0.3520E+13
303	78.140	2.0	3311.704	2.0	30.926	0.3165	0.2207E+13
304	23.891	3.0	3257.792	4.0	30.922	4.5586	0.3180E+14
305	51.199	2.0	3285.596	1.0	30.918	0.9778	0.6823E+13
306	23.891	3.0	3259.559	3.0	30.906	0.0765	0.5341E+12
307	0.211	4.0	3236.251	3.0	30.902	0.1002	0.6999E+12
308	82.447	4.0	3320.120	4.0	30.886	0.4762	0.3329E+13
309	51.199	2.0	3289.149	3.0	30.884	1.2349	0.8635E+13
310	70.034	1.0	3308.882	1.0	30.875	0.5808	0.4064E+13
311	78.140	2.0	3317.286	3.0	30.872	0.1355	0.9483E+12
312	0.211	4.0	3239.563	4.0	30.870	0.0466	0.3261E+12
313	68.297	0.0	3308.882	1.0	30.859	0.8533	0.5977E+13
314	23.891	3.0	3264.770	2.0	30.856	0.1223	0.8565E+12
315	0.211	4.0	3241.177	4.0	30.855	0.4649	0.3257E+13
316	78.140	2.0	3319.558	2.0	30.851	0.1522	0.1067E+13
317	70.034	1.0	3311.846	0.0	30.847	0.6466	0.4533E+13
318	27.000	2.0	3271.922	1.0	30.817	0.0471	0.3307E+12
319	23.891	3.0	3268.854	3.0	30.817	0.2781	0.1953E+13
320	0.211	4.0	3245.435	5.0	30.814	0.6913	0.4856E+13
321	78.140	2.0	3324.610	3.0	30.803	1.2381	0.8703E+13
322	0.211	4.0	3247.996	5.0	30.790	0.9891	0.6959E+13
323	70.034	1.0	3319.558	2.0	30.774	0.2988	0.2104E+13
324	0.211	4.0	3249.857	3.0	30.773	0.1509	0.1063E+13
325	78.140	2.0	3329.516	3.0	30.756	1.8139	0.1279E+14
326	51.199	2.0	3302.907	2.0	30.753	0.2430	0.1714E+13
327	78.140	2.0	3330.171	2.0	30.750	0.4387	0.3094E+13
328	82.447	4.0	3335.504	4.0	30.740	1.5965	0.1127E+14
329	82.447	4.0	3335.590	5.0	30.740	10.5587	0.7453E+14
330	82.447	4.0	3335.907	3.0	30.737	0.0673	0.4748E+12
331	0.211	4.0	3257.792	4.0	30.698	0.3417	0.2418E+13
332	51.199	2.0	3308.882	1.0	30.697	0.0564	0.3992E+12
333	78.140	2.0	3335.907	3.0	30.696	0.1186	0.8396E+12
334	70.034	1.0	3328.054	1.0	30.693	1.0589	0.7497E+13
335	0.211	4.0	3258.271	5.0	30.693	0.4129	0.2923E+13
336	27.000	2.0	3285.596	1.0	30.688	0.0668	0.4730E+12
337	68.297	0.0	3328.054	1.0	30.677	0.8887	0.6299E+13
338	70.034	1.0	3330.171	2.0	30.674	1.8567	0.1316E+14
339	51.199	2.0	3311.704	2.0	30.670	0.1351	0.9576E+12
340	27.000	2.0	3289.149	3.0	30.655	0.2698	0.1915E+13
341	51.199	2.0	3317.286	3.0	30.618	0.6342	0.4513E+13
342	51.199	2.0	3324.610	3.0	30.549	0.3105	0.2219E+13
343	51.199	2.0	3328.054	1.0	30.517	0.0336	0.2403E+12
344	51.199	2.0	3329.516	3.0	30.503	0.8041	0.5764E+13
345	51.199	2.0	3330.171	2.0	30.497	0.3300	0.2366E+13
346	51.199	2.0	3335.907	3.0	30.444	0.0749	0.5386E+12
347	0.211	4.0	3285.499	5.0	30.439	0.0514	0.3698E+12
348	27.000	2.0	3319.558	2.0	30.372	0.1322	0.9557E+12

349	78.140	2.0	3371.502	1.0	30.364	0.0652	0.4716E+12
350	23.891	3.0	3317.286	3.0	30.364	0.0436	0.3154E+12
351	23.891	3.0	3320.120	4.0	30.338	0.4806	0.3483E+13
352	27.000	2.0	3324.610	3.0	30.325	0.4408	0.3197E+13
353	23.891	3.0	3324.610	3.0	30.296	0.0633	0.4603E+12
354	27.000	2.0	3329.516	3.0	30.280	0.0290	0.2107E+12
355	23.891	3.0	3329.516	3.0	30.251	0.0470	0.3424E+12
356	23.891	3.0	3330.297	4.0	30.244	0.2596	0.1893E+13
357	27.000	2.0	3335.907	3.0	30.221	0.1019	0.7440E+12
358	23.891	3.0	3335.504	4.0	30.197	0.2209	0.1616E+13
359	23.891	3.0	3335.907	3.0	30.193	0.0441	0.3223E+12
360	0.211	4.0	3330.297	4.0	30.029	0.0891	0.6588E+12
361	0.211	4.0	3331.970	5.0	30.014	0.4694	0.3475E+13

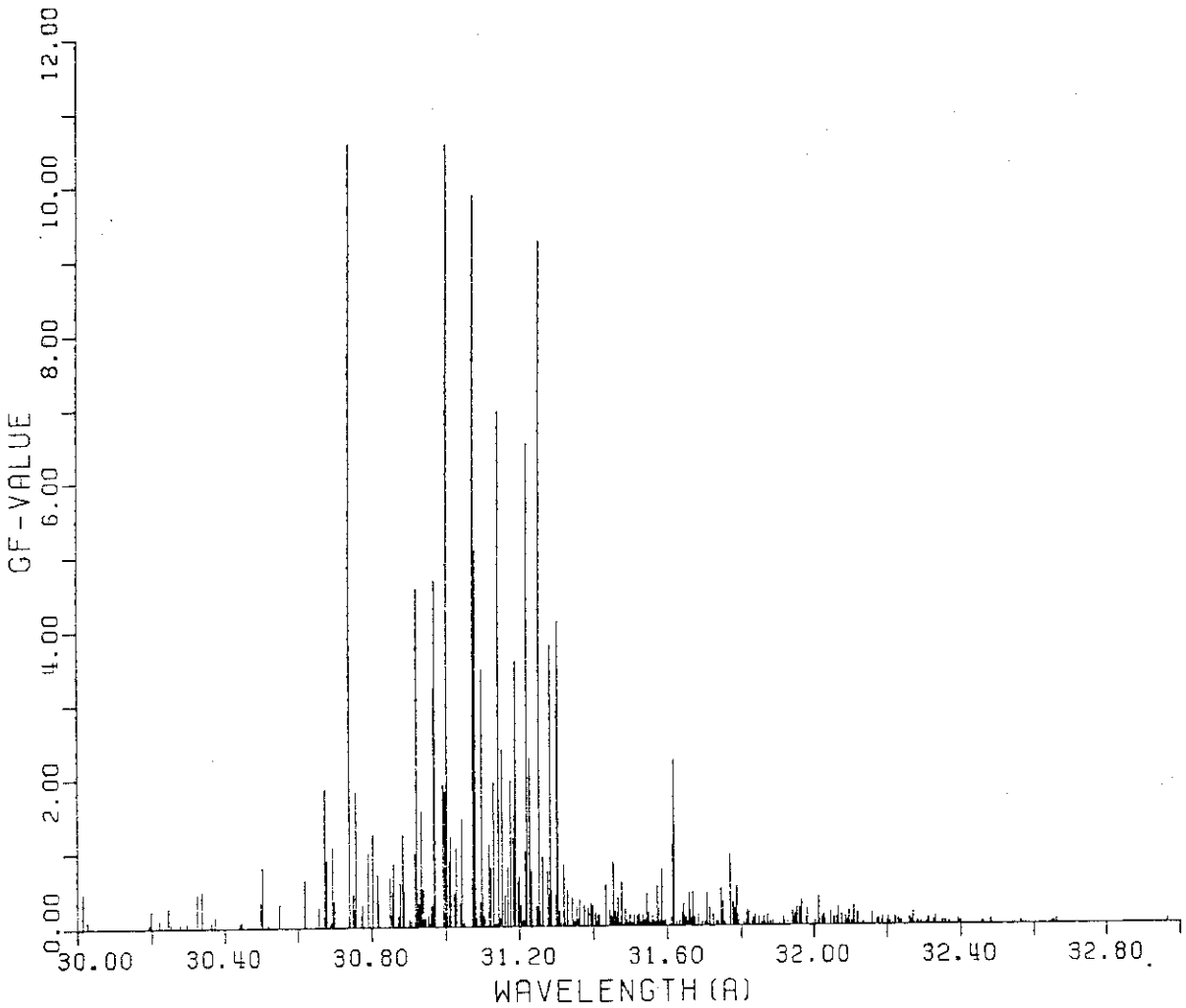

Fig. 7 Calculated spectrum for $3d^8$-$3d^7 4f$ transition array in Mo XVII.

"percentage composition" in TABLE 2 and 4. The theoretical spectrum generated from TABLE 8 is shown in FIGURE 6, which provide very helpful guidance in the analysis of the experimentally recorded spectrum. The similar one for $3d^8$-$3d^74f$ is given in FIGURE 7.

IV. DISCUSSION

The atomic structure calculation has been successfully applied to obtain the energy levels and the oscillator strengths in Mo XVII. Our calculated spectrum for the $3p^63d^8$-$3p^53d^9$ transition array is compared with the observed one[5] and shows very good agreement (FIGURE 5). This agreement means that the similar calculation for the other transition arrays in the same ion can be used as reliable guides for line identification in the observed spectrum. The similar calculation was thus extended to $3d^8$-$3d^74p$ and $3d^8$-$3d^74f$ transitions. The results are given both in numerical tables and in graphical representations. They can be useful for identification of the observed spectra. Especially, the theoretical spectra, FIGURE 6 and 7, can be very helpful guides for the identification of the observed spectra by comparing their general patterns.

Further refinement to the energy level calculation of the ground configuration will be achieved by including directly the small, but important corrections due to spin-spin, orbit-orbit and spin-other-orbit interactions. Actually, the inclusion of these contribution to the theoretical calculation proved to give the correct energy level separations of $2s^q2p^r$ and $3s^q3p^r$ configurations.[11,12] This would need to be performed after at

"percentage composition" in TABLE 2 and 4. The theoretical spectrum generated from TABLE 8 is shown in FIGURE 6, which provide very helpful guidance in the analysis of the experimentally recorded spectrum. The similar one for $3d^8$-$3d^74f$ is given in FIGURE 7.

IV. DISCUSSION

The atomic structure calculation has been successfully applied to obtain the energy levels and the oscillator strengths in Mo XVII. Our calculated spectrum for the $3p^63d^8$-$3p^53d^9$ transition array is compared with the observed one[5] and shows very good agreement (FIGURE 5). This agreement means that the similar calculation for the other transition arrays in the same ion can be used as reliable guides for line identification in the observed spectrum. The similar calculation was thus extended to $3d^8$-$3d^74p$ and $3d^8$-$3d^74f$ transitions. The results are given both in numerical tables and in graphical representations. They can be useful for identification of the observed spectra. Especially, the theoretical spectra, FIGURE 6 and 7, can be very helpful guides for the identification of the observed spectra by comparing their general patterns.

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least a few M1 transition within the ground configuration were observed.

Further refinement to the energy level calculation for $3d^74p$ and $3d^74f$ configurations will be achieved by including the effective interaction parameters, as well as the further correction to the Slater parameters used in the present work, after at least several energy levels were established.

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