Submitted to Journal of the Optical Society of America

LBL-6915
Preprint c.1

THE $3d^2$ - 3d4f TRANSITIONS IN V IV

George V. Shalimoff and John G. Conway

September 1977

Prepared for the U. S. Energy Research and Development Administration under Contract W-7405-ENG-48

THE $3d^2$ - 3d4f TRANSITIONS IN V IV

George V. Shalimoff and John G. Conway

Materials and Molecular Research Division
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

The 3d4f levels in the spectrum of triply ionized vanadium, V IV, were located by L. Iglesias.[1] She located these levels by identifying transitions from the $3d^2$ ground configuration to the 3d4p levels, then to the 3d4d levels and finally to the 3d4f levels. She also identified the transitions from the 3d4d levels to the 3d5p levels, continued up to the 3d5d levels, then back down to the 3d4f levels. Though the 3d4f levels were well established by two routes, the direct transitions from the ground state were not observed, being beyond her experimental range which stopped at 675 Å.

We have photographed the spectrum of vanadium in the region of 190 - 650 Å and the direct transitions from $3d^2$ to 3d4f have been observed. The spectrum was excited with a vacuum sliding-spark discharge between vanadium metal electrodes separated by a quartz spacer as described previously.[2] Peak discharge current was 1000 A. The spectrum was photographed on Kodak SWR plates using the 10·7 m grazing incidence spectrograph at the National Bureau of Standards in Washington, D.C. The plate factor in the region of interest is about 0.27 Å/mm. The plates were measured on a Grant comparator. Lines of yttrium IV and V, oxygen III and carbon IV were used for reference standards. The same plates were used to obtain the spectrum of vanadium V as reported previously by van Deurzen.[3]

Table I contains 19 transitions from the ground configuration, $3d^2$, to the 3d4f configuration and 3 transitions from the ground configuration to the 3d5p configuration. Column 1 in the table is our measured vacuum wavelengths. The intensities in column 2 are visual estimates on a scale of 0 to 9. Column 3 lists the wavenumber of the measured lines. The classifications of the transitions and the odd-even level values are given in columns 4 and 5 and are taken from Iglesias. The difference, Δ, between the wavenumber of the observed line and the wavenumber calculated from Iglesias' levels are given in column 6. The mean difference of column 6 is 0.6 cm^{-1}. Since a measured change of 0.001 Å at 378 Å corresponds to 0.7 cm^{-1}, we can say that the wavelengths obtained by the two methods agree to within ± 0.001 Å.

The V V wavelength list of van Deurzen shows a gap between 300 and 400 Å. The addition of our V IV lines fills this gap and provides an extensive list of accurate vanadium wavelengths suitable for reference standards throughout the vacuum wavelength region from 200 - 2000 Å.

We wish to thank W. C. Martin, J. Reader and V. Kaufman of the National Bureau of Standards and S. P. Davis of the University of California for their assistance in photographing the spectra. This work was done with support from the U.S. Energy Research and Development Administration.

REFERENCES

1. L. Iglesias, J. Research Natl. Bur. Standards, 72A(4), 295 (1968).

2. C.H.H. van Deurzen, J. G. Conway, and S. P. Davis, J. Opt. Soc. Am. 64, 498 (1974).

3. C.H.H. van Deurzen, J. Opt. Soc. Am. 67, 476 (1977).

Table I. Classified Lines in the V IV Spectrum

λ(Å)	Int.	σ(cm^{-1})	Classification[a]	Levels[a] odd	Levels[a] even	Δ[b]
378.678	3	264076.6	3d4f $^3G^o_4$ - 3d^2 $^3F_3$	264401.9 -	325.4	+ .1
378.929	4	263901.7	3d4f $^3G^o_3$ - 3d^2 $^3F_2$	263902.3 -	0	- .6
378.993	4	263857.1	3d4f $^3G^o_5$ - 3d^2 $^3F_4$	264591.9 -	734.7	- .1
379.093	4	263787.5	3d4f $^3F^o_4$ - 3d^2 $^3F_3$	264113.1 -	325.4	- .2
379.353	5	263606.7	3d4f $^3F^o_3$ - 3d^2 $^3F_2$	263608.3 -	0	-1.6
379.372	3	263593.5	3d4f $^3F^o_2$ - 3d^2 $^3F_2$	263593.0 -	0	+ .5
379.395	3	263577.5	3d4f $^3G^o_3$ - 3d^2 $^3F_3$	263902.3 -	325.4	+ .6
379.512	5	263496.3	3d4f $^3H^o_4$ - 3d^2 $^3F_3$	263822.4 -	325.4	- .7
379.613	7	263426.9	3d4f $^3H^o_5$ - 3d^2 $^3F_4$	264161.8 -	734.7	- .2
379.682	4	263378.3	3d4f $^3F^o_4$ - 3d^2 $^3F_4$	264113.1 -	734.7	- .1
380.101	0	263088.0	3d4f $^3H^o_4$ - 3d^2 $^3F_4$	263822.4 -	734.7	+ .3
380.537	0	262786.5	3d4f $^1G^o_4$ - 3d^2 $^3F_3$	263111.4 -	325.4	+ .5
391.362	0	255517.9	3d5p $^3F^o_4$ - 3d^2 $^3F_4$	256251.7 -	734.7	+ .9
392.428	3	254823.8	3d5p $^3D^o_1$ - 3d^2 $^3F_2$	254824.1 -	0	- .3
392.602	2	254710.9	3d5p $^3D^o_3$ - 3d^2 $^3F_4$	255445.5 -	734.7	+ .1
393.217	0	254312.5	3d4f $^3D^o_3$ - 3d^2 $^1D_2$	265271.6 -	10959.3	+ .2

Table I. Classified Lines in the V IV Spectrum (Continued)

λ(Å)	Int.	σ(cm^{-1})	Classification[(a)]	Levels[(a)] odd	even	Δ[(b)]
393.790	4	253942.5	3d4f $^1F^o_3$ - $3d^2$ $^1D_2$	264902.2 -	10959.3	- .4
394.441	3	253523.3	3d4f $^1D^o_2$ - $3d^2$ $^1D_2$	264482.8 -	10959.3	- .2
396.991	0	251894.9	3d4f $^3D^o_1$ - $3d^2$ ^3P_o	265019.7 -	13122.8	-2.0
397.097	3	251827.6	3d4f $^3D^o_2$ - $3d^2$ $^3P_1$	265067.4 -	13239.2	- .6
397.122	4	251811.8	3d4f $^3D^o_3$ - $3d^2$ $^3P_2$	265271.6 -	13458.3	-1.5
402.885	6	248209.8	3d4f $^1H^o_5$ - $3d^2$ $^1G_4$	266600.3 -	18391.2	+ .7

(a) Classification and value of levels are from L. Iglesias.[1]

(b) Delta is the difference between the observed wavenumber, column 3, and the calculated wavenumber using Iglesias' values in column 5. The mean of the value is 0.6 cm^{-1}.