Relativistic Atomic Structure and Spectral Data Calculations for O-Like Tungsten Ion — Supplement

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topics: atomic data, plasma spectroscopy, transition probabilities, multipole transitions

TABLE SI

Possible electronic configurations of ground state complex ($n = 2$) and higher excited states ($n = 3, 4, 5, 6$) in W^{66+} .

Complex	Electronic configurations
$n = 2$	$2s^2 2p^4, 2s^1 2p^5, 2p^6$
$n = 3$	$2s^2 2p^3 3s, 2s^2 2p^3 3p, 2s^2 2p^3 3d, 2s 2p^4 3s, 2s 2p^4 3p, 2s 2p^4 3d, 2p^5 3s, 2p^5 3p, 2p^5 3d$
$n = 4$	$2s^2 2p^3 4s, 2s^2 2p^3 4p, 2s^2 2p^3 4d, 2s 2p^4 4s, 2s 2p^4 4p, 2s 2p^4 4d, 2s 2p^4 4f, 2s^2 2p^2 4s^2, 2s^2 2p^2 4p^2, 2s^2 2p^2 4d^2, 2s^2 2p^2 4f^2, 2s^2 2p^1 4p^3, 2s^2 2p^1 4d^3, 2s^2 2p^1 4f^3, 2s^2 4p^4, 2s^2 4d^4, 2s^2 4f^4, 2p^5 3s, 2p^5 4p, 2p^5 4d, 2p^5 3f$
$n = 5$	$2s^2 2p^3 5s, 2s^2 2p^3 5p, 2s^2 2p^3 5d, 2s^2 2p^3 5f, 2s^2 2p^3 5g, 2s 2p^4 5s, 2s 2p^4 5p, 2s 2p^4 5d, 2s 2p^4 5f, 2s 2p^4 5g, 2s^2 2p^2 5s^2, 2s^2 2p^2 5p^2, 2s^2 2p^2 5d^2, 2s^2 2p^2 5f^2, 2s^2 2p^2 5g^2, 2s^2 2p^1 5p^3, 2s^2 2p^1 5d^3, 2s^2 2p^1 5f^3, 2s^2 2p^1 5g^3, 2s^2 5p^4, 2s^2 5d^4, 2s^2 5f^4, 2s^2 5g^4, 2s 5p^5, 2s 5d^5, 2s 5f^5, 2s 5g^5, 2p^5 5s, 2p^5 5p, 2p^5 5d, 2p^5 5f, 2p^5 5g$
$n = 6$	$2s^2 2p^3 6s, 2s^2 2p^3 6p, 2s^2 2p^3 6d, 2s^2 2p^3 6f, 2s^2 2p^3 6g, 2s^2 2p^3 6h, 2s 2p^4 6s, 2s 2p^4 6p, 2s 2p^4 6d, 2s 2p^4 6f, 2s 2p^4 6g, 2s 2p^4 6h, 2s^2 2p^2 6s^2, 2s^2 2p^2 6p^2, 2s^2 2p^2 6d^2, 2s^2 2p^2 6f^2, 2s^2 2p^2 6g^2, 2s^2 2p^2 6h^2, 2s^2 2p^1 6p^3, 2s^2 2p^1 6d^3, 2s^2 2p^1 6f^3, 2s^2 2p^1 6g^3, 2s^2 2p^1 6h^3, 2s^2 6p^4, 2s^2 6d^4, 2s^2 6f^4, 2s^2 6g^4, 2s 6p^5, 2s 6d^5, 2s 6f^5, 2s 6g^5, 2s 6h^5, 2p^5 6s, 2p^5 6p, 2p^5 6d, 2p^5 6f, 2p^5 6g, 2p^5 6h$

Strong electric dipole transitions (E1) atomic data for W^{66+} calculated by MR-MBPT method.

TABLE SII

Upper state	J_{up}	Lower state	J_{low}	ΔE [eV]	gf_{ij}	A_r [s^{-1}]	λ [$\text{\AA}$]
$2p_{1/2} 2p_{3/2}^2 6d_{3/2}$	1	$2p_{3/2}^2$	0	15964.19	4.78×10^{-2}	$1.76 \times 10^{+14}$	0.7766
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3 5d_{5/2}$	1	$2s_{1/2} 2p_{1/2}$	1	15199.64	1.18×10^{-1}	$3.23 \times 10^{+14}$	0.8157
$2p_{1/2} 2p_{3/2}^2 5d_{3/2}$	1	$2p_{3/2}^2$	0	15177.62	9.72×10^{-2}	$3.25 \times 10^{+14}$	0.8169
$2s_{1/2} 2p_{3/2}^2 4p_{3/2}$	1	$2p_{3/2}^2$	0	14108.07	8.61×10^{-2}	$2.48 \times 10^{+14}$	0.8788
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3 4p_{3/2}$	1	$2p_{1/2} 2p_{3/2}^3$	2	14105.83	8.55×10^{-2}	$2.46 \times 10^{+14}$	0.8789
$2s_{1/2} 2p_{3/2}^2 4p_{3/2}$	1	$2p_{3/2}^2$	2	14062.58	8.18×10^{-2}	$2.34 \times 10^{+14}$	0.8816
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3$	1	$2s_{1/2} 2p_{3/2}^3$	1	13807.12	4.28×10^{-1}	$7.06 \times 10^{+14}$	0.8979
$2s_{1/2} 2p_{3/2}^2 3p_{1/2}$	1	$2p_{3/2}^2$	0	13782.22	3.46×10^{-1}	$5.57 \times 10^{+14}$	0.8996
$2p_{1/2} 2p_{3/2}^2 4d_{3/2}$	1	$2p_{3/2}^2$	2	13760.43	2.38×10^{-1}	$6.53 \times 10^{+14}$	0.901
$2p_{1/2} 4d_{3/2}$	1	$2p_{3/2}^4$	0	13759.19	2.47×10^{-1}	$6.72 \times 10^{+14}$	0.9011
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3 4d_{3/2}$	0	$2s_{1/2} 2p_{3/2}^3$	1	13751.31	8.09×10^{-2}	$6.64 \times 10^{+14}$	0.9016
$2s_{1/2} 2p_{3/2}^2 3p_{1/2}$	1	$2p_{3/2}^2$	2	12426.08	3.86×10^{-1}	$6.29 \times 10^{+14}$	0.9977
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3$	1	$2s_{1/2} 2p_{1/2}$	0	12419.41	8.19×10^{-1}	$1.04 \times 10^{+15}$	0.9983
$2p_{3/2}^3 3d_{3/2}$	0	$2p_{1/2} 2p_{3/2}^3$	1	12413.97	2.62×10^{-1}	$1.31 \times 10^{+15}$	0.9987

TABLE SII cont.

Upper state	J_{up}	Lower state	J_{low}	ΔE [eV]	gf_{ij}	A_r [s^{-1}]	λ [$\text{\AA}$]
$2p_{3/2}^3 3d_{3/2}$	1	$2p_{1/2} 2p_{3/2}^3$	1	12412.85	6.50×10^{-1}	$1.09 \times 10^{+15}$	0.9988
$2p_{3/2}^3 4d_{3/2}$	3	$2p_{1/2} 2p_{3/2}^3$	2	12353.66	4.44×10^{-1}	$5.25 \times 10^{+14}$	1.0036
$2p_{3/2}^3 4d_{5/2}$	1	$2p_{3/2}^4$	0	12338.45	4.66×10^{-1}	$1.04 \times 10^{+15}$	1.0048
$2p_{1/2} 2p_{3/2}^2 4d_{5/2}$	2	$2p_{1/2} 2p_{3/2}^3$	1	11015.47	4.55×10^{-1}	$6.08 \times 10^{+14}$	1.1255
$2s_{1/2} 3p_{3/2}$	1	$2p_{3/2}^4$	0	10947.8	2.87×10^{-1}	$5.01 \times 10^{+14}$	1.1325
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3 4d_{3/2}$	1	$2s_{1/2} 2p_{3/2}^3$	2	10903.64	2.47×10^{-1}	$6.77 \times 10^{+14}$	1.1371
$2p_{3/2}^3 3p_{1/2}$	1	$2s_{1/2} 2p_{3/2}^3$	2	10751.29	6.48×10^{-1}	$1.06 \times 10^{+15}$	1.1532
$2p_{1/2} 2p_{3/2}^2 6f_{9/2}$	1	$2p_{3/2}^4$	0	10746.4	4.68×10^{-1}	$1.03 \times 10^{+15}$	1.1537
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3$	1	$2s_{1/2} 2p_{3/2}^3$	1	10741.89	6.67×10^{-1}	$1.11 \times 10^{+15}$	1.1542
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3$	3	$2s_{1/2} 2p_{3/2}^3$	2	10733.22	1.76×10^0	$1.25 \times 10^{+15}$	1.1551
$2s_{1/2} 3d_{3/2}$	2	$2s_{1/2} 2p_{1/2}$	1	10715.51	1.45×10^0	$1.45 \times 10^{+15}$	1.157
$2p_{3/2}^3 3d_{3/2}$	3	$2p_{1/2} 2p_{3/2}^3$	2	10712.94	1.91×10^0	$1.37 \times 10^{+15}$	1.1573
$2p_{1/2} 2p_{3/2}^2 3d_{3/2}$	1	$2p_{3/2}^2$	2	10712.1	9.45×10^{-1}	$1.57 \times 10^{+15}$	1.1574
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3$	2	$2s_{1/2} 2p_{3/2}^3$	2	10711.46	1.44×10^0	$1.43 \times 10^{+15}$	1.1575
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3$	1	$2s_{1/2} 2p_{1/2}$	1	10695.96	1.43×10^0	$1.81 \times 10^{+15}$	1.1591
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3$	2	$2s_{1/2} 2p_{3/2}^3$	1	10691.64	1.59×10^0	$1.57 \times 10^{+15}$	1.1596
$2p_{1/2} 2p_{3/2}^2 3d_{3/2}$	2	$2p_{3/2}^2$	2	10683.84	1.53×10^0	$1.53 \times 10^{+15}$	1.1604
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3$	0	$2s_{1/2} 2p_{3/2}^3$	1	10681.94	3.61×10^{-1}	$1.79 \times 10^{+15}$	1.1607
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3$	2	$2p_{1/2} 2p_{3/2}^3$	1	10658.73	1.60×10^{-1}	$1.65 \times 10^{+14}$	1.1632
$2p_{3/2} 3d_{5/2}$	1	$2p_{3/2}^2$	0	10649.85	1.14×10^0	$1.45 \times 10^{+15}$	1.1641
$2p_{1/2} 2p_{3/2}^2 3d_{5/2}$	0	$2p_{1/2} 2p_{3/2}^3$	1	10621.51	2.10×10^{-1}	$8.05 \times 10^{+14}$	1.1673
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3$	1	$2s_{1/2} 2p_{1/2}$	0	10612.68	5.94×10^{-1}	$7.51 \times 10^{+14}$	1.1682
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3$	1	$2s_{1/2} 2p_{1/2}$	0	10504.75	7.31×10^{-1}	$9.46 \times 10^{+14}$	1.1802
$2s_{1/2} 2p_{3/2}^2 3d_{5/2}$	1	$2s_{1/2} 2p_{3/2}^3$	1	9457.2	1.28×10^0	$1.62 \times 10^{+15}$	1.311
$2p_{1/2} 2p_{3/2}^2 3d_{3/2}$	3	$2p_{3/2}^2$	2	9442.09	2.13×10^0	$1.52 \times 10^{+15}$	1.3131
$2p_{3/2}^3 3d_{5/2}$	1	$2p_{3/2}^4$	0	9435.53	2.38×10^0	$3.01 \times 10^{+15}$	1.314
$2s_{1/2} 2p_{3/2}^2 3d_{5/2}$	2	$2s_{1/2} 2p_{3/2}^3$	2	9435.41	2.44×10^0	$1.86 \times 10^{+15}$	1.314
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3$	1	$2s_{1/2} 2p_{1/2}$	1	9424.98	9.70×10^{-1}	$1.24 \times 10^{+15}$	1.3154
$2p_{1/2} 2p_{3/2}^2 3d_{5/2}$	3	$2p_{1/2} 2p_{3/2}^3$	2	9420.26	2.89×10^0	$1.59 \times 10^{+15}$	1.3161
$2s_{1/2} 2p_{3/2}^2 3d_{5/2}$	2	$2s_{1/2} 2p_{3/2}^3$	1	9413.68	3.20×10^0	$2.44 \times 10^{+15}$	1.317
$2s_{1/2} 2p_{3/2}^2 3d_{5/2}$	3	$2s_{1/2} 2p_{3/2}^3$	2	9412.27	2.45×10^0	$1.35 \times 10^{+15}$	1.3172
$2p_{1/2} 2p_{3/2}^2 3d_{5/2}$	2	$2p_{1/2} 2p_{3/2}^3$	2	9409.66	2.48×10^0	$1.90 \times 10^{+15}$	1.3176
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3$	2	$2s_{1/2} 2p_{1/2}$	1	9378.3	3.02×10^0	$2.33 \times 10^{+15}$	1.322
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3$	0	$2s_{1/2} 2p_{1/2}$	1	9372.29	8.11×10^{-1}	$3.09 \times 10^{+15}$	1.3228
$2p_{1/2} 2p_{3/2}^2 3d_{5/2}$	1	$2p_{1/2} 2p_{3/2}^3$	1	9365.21	1.04×10^0	$1.33 \times 10^{+15}$	1.3238
$2p_{3/2}^3 3d_{5/2}$	1	$2p_{3/2}^4$	0	9364.03	2.43×10^0	$3.13 \times 10^{+15}$	1.324
$2p_{1/2} 3d_{3/2}$	1	$2p_{3/2}^4$	0	9362.74	1.16×10^0	$1.90 \times 10^{+15}$	1.3242
$2p_{3/2} 3d_{5/2}$	2	$2p_{3/2}^2$	2	9360.85	1.36×10^0	$1.04 \times 10^{+15}$	1.3245
$2p_{1/2} 2p_{3/2}^2 3d_{5/2}$	2	$2p_{1/2} 2p_{3/2}^3$	1	9352.89	2.30×10^0	$1.77 \times 10^{+15}$	1.3256
$2s_{1/2} 2p_{3/2}^2 3d_{5/2}$	3	$2s_{1/2} 2p_{3/2}^3$	2	9349.95	2.30×10^0	$1.25 \times 10^{+15}$	1.326
$2p_{3/2}^3 5d_{5/2}$	1	$2p_{3/2}^4$	0	8650.1	1.74×10^{-1}	$4.82 \times 10^{+14}$	1.4333
$2p_{1/2} 3p_{1/2}$	1	$2s_{1/2} 2p_{1/2}$	1	8638.62	3.15×10^{-1}	$5.09 \times 10^{+14}$	1.4352
$2s_{1/2} 2p_{1/2} 2p_{3/2}^3 3s_{1/2}$	2	$2s_{1/2} 2p_{3/2}^3$	2	8597.05	2.40×10^{-1}	$3.95 \times 10^{+14}$	1.4421
$2s_{1/2} 2p_{3/2}^2 3d_{5/2}$	0	$2s_{1/2} 2p_{3/2}^3$	1	8596.3	3.23×10^{-1}	$1.21 \times 10^{+15}$	1.4422

TABLE SIII

Forbidden transitions (E2, M1, and M2) atomic data parameters for strong lines calculated by using MR-MBPT method

Upper state	J_{up}	Lower state	J_{low}	ΔE [eV]	gf_{ij}	A_r [s^{-1}]	λ [$\text{\AA}$]
E2 transitions							
$2p_{1/2}2p_{3/2}^23s_{1/2}$	4	$2p_{1/2}^22p_{3/2}^2$	2	13835.45	5.22×10^{-3}	$4.82 \times 10^{+12}$	0.896
$2p_{3/2}4f_{7/2}$	4	$2p_{1/2}^22p_{3/2}^2$	2	12457.44	1.01×10^{-2}	$7.59 \times 10^{+12}$	0.995
$2p_{3/2}^34f_{7/2}$	2	$2p_{3/2}^4$	0	12368.94	6.22×10^{-3}	$8.25 \times 10^{+12}$	1.002
$2s_{1/2}2p_{1/2}2p_{3/2}^33d_{5/2}$	3	$2p_{1/2}2p_{3/2}^3$	1	11247.55	9.70×10^{-3}	$7.60 \times 10^{+12}$	1.102
$2s_{1/2}2p_{3/2}^23d_{5/2}$	4	$2p_{1/2}^22p_{3/2}^2$	2	11236.6	1.41×10^{-2}	$8.58 \times 10^{+12}$	1.103
$2p_{3/2}^33d_{5/2}$	4	$2s_{1/2}2p_{3/2}^3$	2	11233.17	1.48×10^{-2}	$8.99 \times 10^{+12}$	1.104
$2s_{1/2}3d_{5/2}$	2	$2p_{3/2}^4$	0	11218.25	1.17×10^{-2}	$1.28 \times 10^{+13}$	1.105
$2p_{1/2}3d_{5/2}$	3	$2s_{1/2}2p_{1/2}$	1	11207.83	1.17×10^{-2}	$9.09 \times 10^{+12}$	1.106
$2s_{1/2}2p_{1/2}2p_{3/2}^33d_{5/2}$	2	$2p_{1/2}2p_{3/2}^3$	2	11185.31	1.27×10^{-2}	$1.38 \times 10^{+13}$	1.108
$2s_{1/2}2p_{1/2}2p_{3/2}^33d_{5/2}$	3	$2p_{1/2}2p_{3/2}^3$	2	11171.36	9.63×10^{-3}	$7.45 \times 10^{+12}$	1.11
$2s_{1/2}2p_{3/2}^23d_{5/2}$	3	$2p_{1/2}^22p_{3/2}^2$	2	11160.99	1.52×10^{-2}	$1.17 \times 10^{+13}$	1.111
$2s_{1/2}2p_{1/2}2p_{3/2}^33d_{3/2}$	2	$2p_{1/2}2p_{3/2}^3$	1	11160.64	8.07×10^{-3}	$8.72 \times 10^{+12}$	1.111
M1 transitions							
$2p_{1/2}2p_{3/2}^25p_{1/2}$	0	$2p_{1/2}2p_{3/2}^3$	1	13752.05	1.86×10^{-6}	$1.53 \times 10^{+10}$	0.902
$2p_{1/2}2p_{3/2}^24p_{1/2}$	2	$2p_{1/2}2p_{3/2}^3$	2	12157.09	1.33×10^{-5}	$1.70 \times 10^{+10}$	1.02
$2s_{1/2}2p_{1/2}2p_{3/2}^34p_{1/2}$	2	$2s_{1/2}2p_{1/2}$	1	12099.65	1.22×10^{-5}	$1.55 \times 10^{+10}$	1.025
$2s_{1/2}2p_{3/2}^24p_{1/2}$	2	$2s_{1/2}2p_{3/2}^3$	2	12084.48	1.80×10^{-5}	$2.28 \times 10^{+10}$	1.026
$2p_{3/2}^33p_{3/2}$	3	$2p_{1/2}2p_{3/2}^3$	2	10591.33	3.00×10^{-5}	$2.09 \times 10^{+10}$	1.171
$2s_{1/2}3p_{3/2}$	2	$2s_{1/2}2p_{1/2}$	1	10567.38	2.04×10^{-5}	$1.98 \times 10^{+10}$	1.173
$2s_{1/2}2p_{1/2}2p_{3/2}^33p_{3/2}$	2	$2s_{1/2}2p_{3/2}^3$	2	10557.53	2.28×10^{-5}	$2.21 \times 10^{+10}$	1.174
$2s_{1/2}2p_{1/2}2p_{3/2}^33p_{3/2}$	3	$2s_{1/2}2p_{3/2}^3$	2	10503.09	2.49×10^{-5}	$1.70 \times 10^{+10}$	1.18
$2s_{1/2}2p_{3/2}^23p_{3/2}$	1	$2s_{1/2}2p_{3/2}^3$	2	9106.67	1.36×10^{-5}	$1.63 \times 10^{+10}$	1.361
$2p_{3/2}^33p_{1/2}$	1	$2p_{3/2}^4$	0	8782.21	3.07×10^{-5}	$3.42 \times 10^{+10}$	1.412
$2p_{1/2}2p_{3/2}^23p_{1/2}$	1	$2p_{1/2}2p_{3/2}^3$	1	8742.88	3.83×10^{-5}	$4.24 \times 10^{+10}$	1.418
$2p_{1/2}2p_{3/2}^23p_{1/2}$	2	$2p_{1/2}2p_{3/2}^3$	2	8732.21	3.96×10^{-5}	$2.62 \times 10^{+10}$	1.42
$2s_{1/2}2p_{3/2}^23p_{1/2}$	1	$2s_{1/2}2p_{3/2}^3$	1	8717.98	3.95×10^{-5}	$4.34 \times 10^{+10}$	1.422
$2s_{1/2}2p_{3/2}^23p_{1/2}$	2	$2s_{1/2}2p_{3/2}^3$	2	8695.32	6.19×10^{-5}	$4.06 \times 10^{+10}$	1.426
$2p_{3/2}^33p_{1/2}$	1	$2p_{3/2}^4$	0	8680.17	2.84×10^{-5}	$3.10 \times 10^{+10}$	1.428
M2 transitions							
$2s_{1/2}2p_{3/2}^25d_{5/2}$	2	$2s_{1/2}2p_{3/2}^3$	2	13766.32	1.93×10^{-5}	$5.28 \times 10^{+10}$	0.901
$2p_{3/2}^24d_{5/2}$	4	$2p_{1/2}^22p_{3/2}^2$	4	9397.458	1.68×10^{-4}	$1.29 \times 10^{+11}$	1.319
$2p_{3/2}^33d_{5/2}$	4	$2p_{3/2}^4$	0	9393.341	1.80×10^{-4}	$1.38 \times 10^{+11}$	1.32
$2p_{3/2}^25d_{5/2}$	4	$2p_{3/2}^4$	0	9393.341	1.88×10^{-4}	$1.44 \times 10^{+11}$	1.32
$2p_{1/2}2p_{3/2}^23d_{5/2}$	8	$2p_{1/2}2p_{3/2}^3$	4	9372.913	2.62×10^{-4}	$1.11 \times 10^{+11}$	1.323
$2p_{1/2}2p_{3/2}^24f_{5/2}$	8	$2p_{1/2}2p_{3/2}^3$	4	9372.913	2.75×10^{-4}	$1.16 \times 10^{+11}$	1.323
$2s_{1/2}2p_{3/2}^24p_{1/2}$	2	$2s_{1/2}2p_{3/2}^3$	2	9362.741	1.05×10^{-4}	$1.34 \times 10^{+11}$	1.324
$2p_{1/2}2p_{3/2}^24f_{7/2}$	2	$2s_{1/2}2p_{3/2}^3$	4	9351.663	1.09×10^{-4}	$1.38 \times 10^{+11}$	1.326
$2p_{3/2}^34d_{5/2}$	6	$2s_{1/2}2p_{1/2}$	2	9331.514	1.75×10^{-4}	$9.45 \times 10^{+10}$	1.329
$2p_{1/2}2p_{3/2}^24f_{7/2}$	8	$2s_{1/2}2p_{3/2}^3$	4	9313.58	2.74×10^{-4}	$1.15 \times 10^{+11}$	1.331
$2s_{1/2}2p_{1/2}2p_{3/2}^34s_{1/2}$	4	$2s_{1/2}2p_{1/2}$	0	9308.233	1.88×10^{-4}	$1.41 \times 10^{+11}$	1.332