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Analysis of the free ion spectrum of Er^{3+}(Er IV)

A Meftah[1,2], **S Ait Mammar**[1], **J-F Wyart**[2,3], **W-Ü L Tchang-Brillet**[2,4], **N Champion**[2,4], **C Blaess**[2,4], **D Deghiche**[1] and **O Lamrous**[1]

[1] Laboratoire de Physique et Chimie Quantique, Université Mouloud Mammeri, BP 17 RP, 15000 Tizi-Ouzou, Algeria
[2] LERMA, Observatoire de Paris-Meudon; PSL Research University, CNRS, UMR8112, F-92195 Meudon, France
[3] Laboratoire Aimé Cotton, CNRS UMR9188, Univ Paris-Sud, ENS Cachan, Univ Paris-Saclay, bâtiment 505, 91405 Orsay Cedex, France
[4] Sorbonne Université, UPMC Univ. Paris 6, UMR8112, LERMA, F-75005, Paris, France

E-mail: ali.meftah@obspm.fr

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Abstract

The vacuum spark spectrum of erbium is observed in the wavelength region 705–2460 Å where transitions between the low-lying configurations $4f^{11}$, $4f^{10}5d$, $4f^{10}6s$ and $4f^{10}6p$ take place. Predictions of energy levels and electric dipole transition probabilities by means of the Cowan codes served for a complete revised analysis of the spectrum. The identification of 591 spectral lines as transitions mostly between low levels of these four configurations led to the determination of 120 energy levels. Radial parameters obtained in least-squares fits of both parities are compared with *ab initio* Hartree–Fock integrals including relativistic corrections. The mean error of the fits are respectively 41 cm^{-1} for 38 known levels of the odd parity configurations $4f^{11} + 4f^{10}6p$ and 49 cm^{-1} for 82 known levels of the even configurations $4f^{10}5d + 4f^{10}6s$.

S Online supplementary data available from stacks.iop.org/jpb/49/165002/mmedia

Keywords: lanthanide ions, trivalent erbium, wavelengths, energy levels, electron configurations, transition probabilities

1. Introduction

Spectra and energy levels of lanthanide ions at different ionization stages are fundamental data of interest in many applications such as plasma diagnostics and material sciences. In astrophysics, singly and doubly charged ions (spectra II and III) have been detected in spectra of chemically peculiar stars for many years (see for example [1] and [2]). Recently, material ejected during the merger of two neutron stars is predicted to assemble into heavy elements, such as lanthanides and actinides, through the r-process. Spectroscopic data on the four first spectra of these elements are needed to account for opacities [3, 4]. In material sciences, triply ionized lanthanide ions (spectra IV) are embedded in crystal for use as solid state laser materials [5]. Data on free ions are often references for analyzing influences of the environment on the energy levels or transition probabilities of the embedded ions. Furthermore, reliable experimental level energies provide criteria for validation of theoretical calculations. Therefore the interpretation of laboratory emission spectra resulting in the determination of energy levels of lanthanide free ions is a valuable task. The task is challenging, given the complexity of these spectra, which can be achieved only by high resolution studies. The reliability of results is greatly supported by systematic comparison of variation trends of energy parameters in isoelectronic or isoionic sequences, or in neighboring ions.

In the case of erbium, the emission spectrum of doubly charged ion Er^{2+} (Er III) was analyzed by Spector [6] and also investigated by Wyart *et al* [7]. Er III lines have been observed in chemically peculiar stars [8]. The triply charged ion Er^{3+} received special attention since erbium oxide has

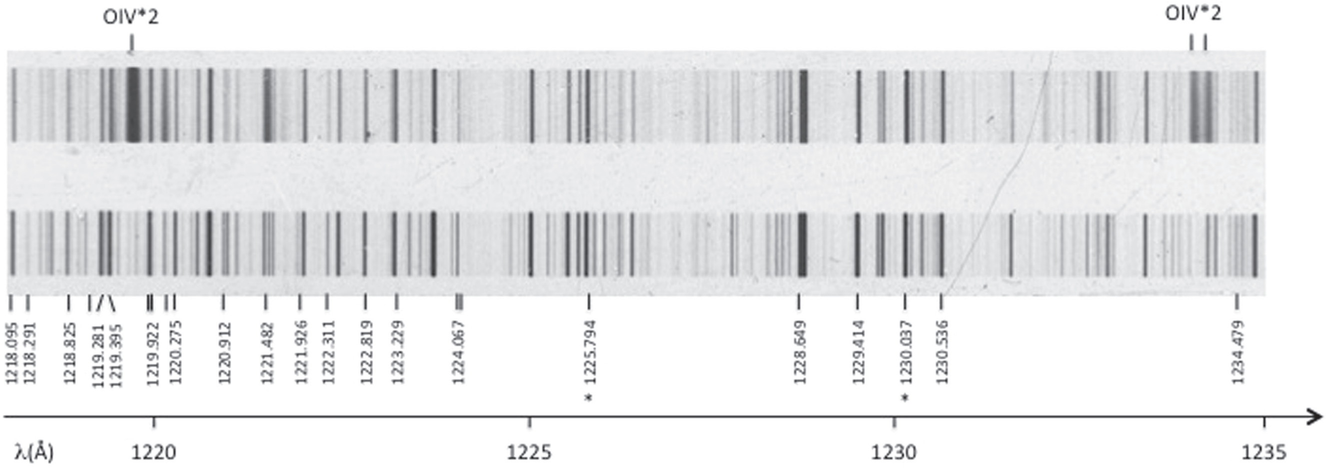

Figure 1. Section of two exposures of erbium vacuum sliding spark source on photographic plate in the wavelength range of 1218–1235. Upper trace : 11 μH; lower trace : 64 μH. Identified Er IV lines are marked with their wavelengths (Cf table 3) except a few when space is missing. The two lines marked with * were reported by Carter with erroneous identifications. In the upper trace, three impurity lines from OIV, at 609.829 Å, 616.952 Åand 617.005 Å, appear in the second order of the grating.

been tested as a candidate for fusion reactor blanket systems [9] and more recently for possible quantum information applications when embedded in silicon [10]. The spectrum of the free ion Er^{3+} (Er IV) has gained timely interest after the recent publication of a theoretical study of energy levels in its ground state configuration $4f^{11}$ [11, 12]. Among the lanthanide spark spectra studied at Johns Hopkins University in the middle of the last century, Er IV was the subject of a PhD dissertation by Carter [13] but did not lead to a specific article in the periodic literature. Semi-empirical considerations on thermodynamic properties of lanthanides led Brewer [14] to predict an energy difference of 75000 ± 3000 cm^{-1} between lowest levels of $4f^{11}$ and $4f^{10}5d$, which was larger than the value of 52481 cm^{-1} given by Carter [13]. In their critical compilation, Martin, Zalubas and Hagan [15] examined the transition array $4f^{11} - 4f^{10}5d$ classified by Carter [13] and concluded inconsistencies with the energy separation derived later from the systematic behaviour of such configurations in the rare earths. Consequently, none of the Er IV levels in [13] were retained in the compilation [15] (now transferred into the NIST database [16]), while calculated theoretical values from parametric studies of Er^{3+} ions in crystals were preferred for the lowest levels of $4f^{11}$. However, the erroneous energy values are still cited sometimes. In [11, 12], two sets of calculated energies (multiconfiguration Dirac Hartree–Fock and configuration interaction strength methods) are compared with E_{exp} values from [13] and with E_{th} values collected in [15].

We have been carrying out a systematical study of lanthanide ions [17–19] for several years. After recent advances in Nd IV [18] and Tm IV [19], the regularities in electron jumps along the lanthanide period confirm the Er IV inconsistency. The experimental data reported in [13] were limited to the presumably classified lines and no comprehensive line list for multicharged erbium ions was ever published in the literature. Therefore the spectroscopy of the free ion Er^{3+} was in a great need of revision, as had been Nd^{3+} [18] some years ago.

2. Experiment and wavelength measurements

For the present work, the emission spectra of two kinds of vacuum spark sources, sliding sparks and triggered sparks, were recorded on the vacuum ultraviolet 10.7 m normal incidence high resolution spectrograph at Meudon Observatory. In both sources, the anode was made of erbium of 99% purity, and the cathode of aluminum. The auxiliary trigger electrode in the triggered spark source was also made of aluminum. A low-inductance capacitor of 4.82 μF was charged to a voltage around 7 kV to produce electrical discharges. A supplementary inductance between 11 μH and 64 μH could be introduced into the electrical circuit to vary the discharge conditions and thus help the differentiation of lines from different ionization stages by their intensity behaviour. The spectrograph is equipped with a 3600 lines/mm holographic concave grating, leading to a linear dispersion of 0.26 Å per mm on the plates. The resulting resolution is about 150 000 with a slit width of 30 μm. The experimental set-up is similar to previous works on rare earth ions and more details can be found in [20, 21]. The wavelength region 705–2460 Å was recorded using photographic Ilford Q2 or Kodak 103AO plates and photostimulable image plates, the latter ones being preferred in intensity measurements for their linear response over five orders of magnitude. Similarly to previous works on Nd and Tm, wavelengths of low-Z impurities (C, N, O, Si) and wavelengths of erbium measured by Carter in Er IV [13] and Becher in Er III [27] were used as wavelength standards for calibration of the plates using quadratic dispersion polynomials. Estimated errors on the wavelengths are about ±0.002 Å for the various measured plates. Experimental intensity with arbitrary units was estimated for each line from the area under a triangle fitting the line profile. Relative intensities are not corrected for the wavelength dependence of the instrumental response so they are consistent only over a limited range of wavelengths.

Figure 1 displays a section of the erbium spectrum obtained on an Ilford Q2 plate with the sliding spark source. The upper and lower exposures correspond to two values of inductance, respectively 11μH and 64 μH, introduced into the discharge circuit. The excitation is thus slightly lower in the lower spectrum. In this section, 24 Er IV lines identified and measured in the present work can be seen. They are described in the line list of table 3 presented further in the text. Only two of them were reported by Carter [13].

3. Analysis, results and discussion

As for our previous works on Tm IV [19], Nd IV [18] and Nd V [21], we applied the Racah–Slater method [22] using the Cowan codes in Kramida's PC version [26] for theoretical study of atomic configurations. In the first codes of the package, RCN and RCN2, the radial integrals needed for constructing the Hamiltonian operator were determined in the Hartree–Fock option with relativistic corrections (HFR), separately for the $4f^{11}$ and $4f^{10}6p$ configurations of the odd parity, and for the $4f^{10}5d + 5f^{10}6s$ configurations of the even parity. The HFR radial integrals, or parameters P_{HFR}, were multiplied by initial scaling factors, $\mathrm{SF}(P) = P_{\mathrm{fit}}/P_{\mathrm{HFR}}$, where P_{fit} is the parameter value derived using the RCE code (see below) from the appropriate previously studied spectra mentioned above. Also, corrections were applied to average energies $E^{\mathrm{av}}_{\mathrm{HFR}}$ so to obtain the lowest levels of the four calculated configurations within the energy ranges predicted by Brewer[14]. The transition probabilities of electric dipole transitions were calculated with the RCG code and the strongest predicted lines were compared with the experimental spectrum.

The experimental level energies found in the analysis were used as input data for Cowan's latest RCE code to iteratively improve the radial integral values. The latters are treated as adjustable energy parameters in a least squares fit (LSF) minimizing the quantity $\Delta E = \sqrt{\sum_i (E_i^{\mathrm{exp}} - E_i^{\mathrm{calc}})^2/(N_i - N_p)}$, where N_i and N_p are respectively the number of experimental energies and the number of parameters. As in other previous studies, effective parameters for far configuration interactions at the second order of the perturbation theory were introduced with initial values chosen from neighboring spectra. The parameters α, β and γ are related to two-body excitations in f^{11} and f^{10}, while the parameters $F^1(f, l)$ and $G^k(f, l)$, the so-called *illegal* Slater parameters [22], act on the (S, L) terms of the $f^{10}l$ configurations. Constraints on some parameters were applied in the fits (fixed values for β and γ in f^{11} and f^{10}, equal values for $G^2(4f, 5d)$ and $G^4(4f, 5d)$) to keep the energy predictions reliable by reducing the number of free parameters. The search for new levels was furthermore supported by using the IDEN code [23, 24], which allows visualization of the great amount of experimental and calculated quantities involved. The search was pursued until the chain of transitions localizing a new level could no longer be validated unambiguously.

The present analysis based on the classification of 591 spectral lines in the range of (851–2576 Å) led to the determination of 37 odd levels above the ground state: 8 in the ground $4f^{11}$ configuration and 29 in the excited $4f^{10}6p$ configuration; and 82 even excited levels in the configurations $4f^{10}5d$ and $4f^{10}6s$.

The results on energy levels are displayed in table 1 and table 2, respectively, for the odd and the even parities, up to the highest experimentally determined level. Most of the levels are determined by more than two transitions. Only three levels of $4f^{10}5d$ in table 2 are determined by one single transition, the intensity of which providing an unambiguous identification. The experimental energy values have been optimized using the LOPT code [25], which minimizes the differences between the whole set of wave numbers from wavelength measurements and those calculated from the experimental energies by the Ritz principle. Perturbed spectral lines or lines with double identifications were excluded from the optimization procedure. The calculated energy values of levels, their percentage compositions in LS and JJ coupling schemes and their Landé factors are derived from the last LSF fit and correspond to the energy parameter values given in table 4 and table 5. Table 3 is the section corresponding to the spectral range shown in figure 1 of a complete list of identified lines, which displays for each line: measured wavelength; corresponding wave numbers; Ritz wavelength; experimental intensities from photographic plates and image plates; calculated gA; cancellation factors (as defined in equation (14.107), p423 in [22]); labels and J values of the lower level and the upper level of the transition and their optimized energies. The complete table 3 (table 3A) is available as supplementary data and also at http://molat.obspm.fr.

A comparison of the energies for the lowest levels of $4f^{10}5d$, $4f^{10}6s$ and $4f^{10}6p$ shows that some of the levels built on the ground level $^5I_8$ of the parent ion Er^{+4} located by Carter[13] are 20945.25 cm^{-1} smaller than our present values. Carter's selection of strong lines as 5d–6p and 6s-6p transitions built on the $4f^{10}(^5I_8)$ core level was correct but the erroneous attribution of J values in the $4f^{10}(^5I_8)6p(^2P_{1/2})$ doublet hampered the extension of his analysis, which likely ended with chains of fortuitous wavenumber coincidences for the $4f^{11} - 4f^{10}5d$ transition array.

Figure 2 shows the energy separations between the lowest energy levels of the configurations $4f^{n+1}$, $4f^n6p$, $4f^n5d$ and $4f^n6s$ in triply ionized lanthanides from cerium to lutetium. In figure 2(a) where experimental energies are completed by Brewer's predictions [14] where needed (Pm, Sm, Eu, Dy, Ho), the distance $4f^n - 4f^{n-1}5d$ shows a well-known accident due to the crossing of the half-filled shell with a dramatic change of energy for the ground term relative to the center of gravity of the configuration. A second accident at Er IV is now removed, the erroneous value of $4f^{10}5d$ being corrected from 52480 cm^{-1} in [13] to 73426 cm^{-1}. Comparisons with the spectra III and interpolated values are

Table 1. Odd parity energy levels of the two configurations $4f^{11}$ and $4f^{10}6p$ of the Er^{3+} ion. Energies are given in in cm^{-1}. For each level the following are given: the experimental energy value when available, together with the corresponding uncertainties in parenthesis; the calculated energy value, where E_{calc} results from the Cowan codes corresponding to the parameters given in table 4, $\Delta E = E_{exp}$-E_{calc}, N_{cl} ; the total number of transitions involving the experimental level determination; the calculated Landé factor; and the leading components of the eigenfunction and their corresponding percentages in both LS and JJ coupling schemes. The number following a term designation is an ordering number related to the seniority of the parent term as given by Cowan's code; a lowercase letter is added to distinguish two levels with the same main component.

Conf	J	E_{exp} (unc.)	E_{cal}	ΔE	N_{cl}	$g_{Landé}$	LS percentage composition						JJ percentage composition					
							Comp1	%	Comp2	%	Comp3	%	Comp1	%	Comp2	%	Comp3	%
$4f^{11}$	7.5	0.00	−32.0	32	28	1.197	^{4}I	97	^{2}K	3								
$4f^{11}$	6.5	6507.75(11)	6533.4	−26	34	1.107	^{4}I	99	^{2}K	1								
$4f^{11}$	5.5	10171.79(12)	10184.6	−13	27	0.989	^{4}I	82	^{2}H2	15	^{4}G	1						
$4f^{11}$	4.5	12468.66(12)	12399.5	69	24	0.902	^{4}I	51	^{2}H2	17	^{4}F	14						
$4f^{11}$	4.5	15404.86(12)	15295.1	110	25	1.134	^{4}F	58	^{4}I	27	^{2}G1	8						
$4f^{11}$	1.5	–	18470.4	–		1.705	^{4}S	69	^{2}P	18	^{2}D1	8						
$4f^{11}$	5.5	19331.69(11)	19385.4	−54	25	1.134	^{2}H2	48	^{4}G	35	^{4}I	15						
$4f^{11}$	3.5	–	20527.2	–		1.214	^{4}F	92	^{2}G1	4	^{2}G2	2						
$4f^{11}$	2.5	–	22159.1	–		1.053	^{4}F	84	^{2}D1	13	^{2}D2	2						
$4f^{11}$	1.5	–	22533.3	–		0.744	^{4}F	63	^{2}D1	20	^{4}S	16						
$4f^{11}$	4.5	24736.00(12)	24723.5	13	14	1.073	^{4}Fb	24	^{2}G1	19	^{2}H2	16						
$4f^{11}$	5.5	26707.79(10)	26807.1	−99	19	1.200	^{4}G	61	^{2}H2	26	^{2}H1	10						
$4f^{11}$	4.5	27766.82(11)	27798.8	−32	15	1.110	^{4}G	79	^{2}H2	15	^{4}I	5						
$4f^{11}$	7.5	–	28232.5	–		1.063	^{2}K	91	^{2}L	6	^{4}I	3						
$4f^{11}$	3.5	–	28265.1	–		0.954	^{4}G	41	^{2}G1	27	^{2}G2	24						
$4f^{11}$	1.5	–	31890.1	–		1.056	^{2}P	37	^{4}F	24	^{2}D1	21						
$4f^{11}$	0.5	–	33598.6	–		0.613	^{2}P	92	^{4}D	8								
$4f^{11}$	6.5	–	33577.5	–		0.948	^{2}K	90	^{2}I	10	^{4}I	1						
$4f^{11}$	2.5	–	33755.8	–		0.602	^{4}G	92	^{2}F2	4	^{2}F1	3						
$4f^{11}$	3.5	–	34405.9	–		0.952	^{4}G	55	^{2}G1	27	^{2}G2	15						
$4f^{11}$	2.5	–	34889.8	–		1.197	^{2}D1	57	^{2}D2	16	^{4}F	14						
$4f^{11}$	4.5	–	36928.1	–		1.031	^{2}H2	32	^{2}G1	24	^{2}G2	15						
$4f^{11}$	2.5	–	39201.1	–		1.261	^{4}D	45	^{2}D1	27	^{2}D2	24						
$4f^{11}$	3.5	–	39716.6	–		1.412	^{4}D	95	^{2}F1	3	^{4}G	1						
$4f^{11}$	5.5	–	41549.4	–		0.983	^{2}I	65	^{2}H1	31	^{2}H2	2						
$4f^{11}$	8.5	–	42355.7	–		1.059	^{2}L	100										
$4f^{11}$	1.5	–	42697.5	–		1.041	^{4}D	51	^{2}D1	30	^{2}P	9						
$4f^{11}$	1.5	–	43469.1	–		1.091	^{2}P	33	^{2}D2	26	^{4}D	23						
$4f^{11}$	6.5	–	44336.2	–		1.064	^{2}I	90	^{2}K	10								
$4f^{11}$	0.5	–	47718.1	–		0.050	^{4}D	92	^{2}P	8								
$4f^{11}$	4.5	–	48271.0	–		0.917	^{2}H1	78	^{2}H2	18	^{2}G2	3						
$4f^{11}$	7.5	–	48648.2	–		0.948	^{2}L	94	^{2}K	6								
$4f^{11}$	2.5	–	49517.1	–		1.208	^{2}D2	45	^{4}D	39	^{2}F2	8						
$4f^{11}$	5.5	–	51567.5	–		1.037	^{2}H1	55	^{2}I	34	^{2}H2	10						
$4f^{11}$	3.5	–	54909.8	–		1.147	^{2}F2	53	^{2}F1	36	^{4}D	4						
$4f^{11}$	1.5	–	55587.6	–		0.897	^{2}D2	68	^{4}D	22	^{2}D1	5						
$4f^{11}$	2.5	–	63502.4	–		0.907	^{2}F2	61	^{2}F1	19	^{2}D2	13						

Table 1. (Continued.)

Conf	J	E_{exp} (unc.)	E_{cal}	ΔE	N_{cl}	$g_{\mathrm{Landé}}$	LS percentage composition						JJ percentage composition					
							Comp1	%	Comp2	%	Comp3	%	Comp1	%	Comp2	%	Comp3	%
$4f^{11}$	3.5	–	66429.6	–		0.897	^{2}G2	58	^{2}G1	39	^{2}F2	3						
$4f^{11}$	4.5	–	70623.3	–		1.106	^{2}G2	57	^{2}G1	40	^{2}H1	2						
$4f^{11}$	2.5	–	93368.7	–		0.857	^{2}F1	74	^{2}F2	26								
$4f^{11}$	3.5	–	97568.7	–		1.140	^{2}F1	58	^{2}F2	40	^{2}G2	1						
$4f^{10}6p$	7.5	147031.30(22)	147062.3	−31	9	1.278	$(^{5}I)^{6}H$	57	$(^{5}I)^{4}I$	18	$(^{5}I)^{6}I$	15	$(^{5}I_{8})1/2$	89	$(^{3}K_{8})1/2$	2	$(^{3}K_{8})3/2$	1
$4f^{10}6p$	8.5	147458.05(22)	147473.8	−16	10	1.218	$(^{5}I)^{4}K$	40	$(^{5}I)^{6}I$	35	$(^{5}I)^{6}K$	17	$(^{5}I_{8})1/2$	92	$(^{3}K_{8})1/2$	3	$(^{5}I_{8})3/2$	1
$4f^{10}6p$	6.5	153114.10(22)	153155.5	−41	16	1.208	$(^{5}I)^{6}H$	49	$(^{5}I)^{6}I$	29	$(^{5}I)^{4}I$	12	$(^{5}I_{7})1/2$	90	$(^{5}I_{8})3/2$	4	$(^{5}I_{6})3/2$	1
$4f^{10}6p$	7.5	153525.32(22)	153547.7	−22	16	1.152	$(^{5}I)^{6}K$	34	$(^{5}I)^{4}K$	30	$(^{5}I)^{6}I$	22	$(^{5}I_{7})1/2$	94	$(^{5}I_{8})3/2$	2	$(^{5}I_{7})3/2$	1
$4f^{10}6p$	8.5	155006.25(22)	155021.3	−15	13	1.240	$(^{5}I)^{6}I$	56	$(^{5}I)^{4}K$	34	$(^{3}K)^{4}K2$	3	$(^{5}I_{8})3/2$	91	$(^{3}K_{8})3/2$	5	$(^{5}I_{8})1/2$	1
$4f^{10}6p$	9.5	155098.13(24)	155105.1	−7	5	1.256	$(^{5}I)^{6}K$	93	$(^{3}K)^{4}L2$	6	$(^{3}K)^{4}L1$	2	$(^{5}I_{8})3/2$	93	$(^{3}K_{8})3/2$	6	$(^{3}K_{8})3/2$	2
$4f^{10}6p$	7.5	155801.71(22)	155799.8	2	18	1.234	$(^{5}I)^{4}I$	60	$(^{5}I)^{6}H$	29	$(^{5}I)^{6}I$	3	$(^{5}I_{8})3/2$	90	$(^{3}K_{8})3/2$	4	$(^{5}I_{7})1/2$	2
$4f^{10}6p$	6.5	156582.86(22)	156560.9	22	16	1.212	$(^{5}I)^{4}H$	77	$(^{5}I)^{6}H$	8	$(^{3}K)^{2}I2$	4	$(^{5}I_{8})3/2$	85	$(^{3}K_{8})3/2$	3	$(^{5}I_{6})1/2$	2
$4f^{10}6p$	5.5	157327.77(22)	157354.0	−26	18	1.099	$(^{5}I)^{6}I$	38	$(^{5}I)^{6}H$	32	$(^{5}I)^{4}H$	14	$(^{5}I_{6})1/2$	89	$(^{5}I_{7})3/2$	3	$(^{5}I_{5})3/2$	1
$4f^{10}6p$	6.5	157754.93(22)	157751.7	3	13	1.061	$(^{5}I)^{6}K$	44	$(^{5}I)^{4}K$	17	$(^{5}I)^{4}I$	14	$(^{5}I_{6})1/2$	85	$(^{5}I_{8})3/2$	7		
$4f^{10}6p$	4.5	160371.83(22)	160367.0	5	12	0.931	$(^{5}I)^{6}I$	41	$(^{5}I)^{4}H$	22	$(^{5}I)^{6}H$	19	$(^{5}I_{5})1/2$	81	$(^{5}I_{4})1/2$	2	$(^{5}I_{6})3/2$	2
$4f^{10}6p$	5.5	160606.53(22)	160588.3	18	14	0.908	$(^{5}I)^{6}K$	52	$(^{5}I)^{4}I$	21	$(^{5}I)^{4}K$	7	$(^{5}I_{5})1/2$	80	$(^{5}I_{7})3/2$	3	$(^{3}H_{5})1/2$	1
$4f^{10}6p$	7.5	161112.82(22)	161137.4	−25	17	1.183	$(^{5}I)^{6}I$	53	$(^{5}I)^{4}K$	28	$(^{5}I)^{4}I$	7	$(^{5}I_{7})3/2$	95	$(^{5}I_{6})3/2$	1		
$4f^{10}6p$	8.5	161334.60(23)	161352.3	−18	10	1.200	$(^{5}I)^{6}K$	76	$(^{5}I)^{4}K$	18	$(^{5}I)^{6}I$	2	$(^{5}I_{7})3/2$	96	$(^{3}K_{7})3/2$	2		
$4f^{10}6p$	6.5	161611.07(22)	161620.8	−10	17	1.174	$(^{5}I)^{4}I$	47	$(^{5}I)^{6}H$	35	$(^{5}I)^{6}I$	13	$(^{5}I_{7})3/2$	92	$(^{5}I_{6})3/2$	3	$(^{5}I_{6})1/2$	2
$4f^{10}6p$	5.5	162312.00(22)	162301.3	11	17	1.143	$(^{5}I)^{4}H$	70	$(^{5}I)^{6}H$	23	$(^{3}K)^{4}I2$	1	$(^{5}I_{7})3/2$	86	$(^{5}I_{6})1/2$	4	$(^{5}I_{6})3/2$	3
$4f^{10}6p$	3.5	–	162947.6	–		0.596	$(^{5}I)^{6}I$	47	$(^{5}I)^{4}H$	31	$(^{5}I)^{6}H$	9	$(^{5}I_{4})1/2$	84	$(^{3}H_{4})3/2$	2	$(^{5}I_{5})3/2$	2
$4f^{10}6p$	4.5	162983.48(24)	162957.0	27	7	0.635	$(^{5}I)^{6}K$	62	$(^{5}I)^{4}I$	22	$(^{3}H)^{4}I4$	4	$(^{5}I_{4})1/2$	84	$(^{3}H_{4})1/2$	3	$(^{5}I_{6})3/2$	2
$4f^{10}6p$	4.5	164407.85(24)	164391.7	16	6	1.419	$(^{5}F)^{6}D$	48	$(^{5}F)^{6}F$	14	$(^{5}F)^{4}F$	11	$(^{5}F_{5})1/2$	69	$(^{3}G_{5})1/2$	4	$(^{3}G_{5})3/2$	2
$4f^{10}6p$	5.5	164899.21(22)	164854.4	45	13	1.281	$(^{5}F)^{4}G$	33	$(^{5}F)^{6}F$	20	$(^{5}F)^{6}G$	19	$(^{5}F_{5})1/2$	72	$(^{3}G_{5})1/2$	5	$(^{3}G_{4})3/2$	2
$4f^{10}6p$	6.5	165336.40(22)	165358.5	−22	19	1.098	$(^{5}I)^{6}I$	42	$(^{5}I)^{4}K$	19	$(^{5}I)^{4}I$	19	$(^{5}I_{6})3/2$	89	$(^{5}I_{7})3/2$	2	$(^{5}I_{5})3/2$	2
$4f^{10}6p$	5.5	165546.19(22)	165551.1	−5	19	1.087	$(^{5}I)^{6}H$	32	$(^{5}I)^{4}I$	31	$(^{5}I)^{6}I$	21	$(^{5}I_{6})3/2$	85	$(^{5}I_{5})3/2$	4	$(^{5}I_{5})1/2$	1
$4f^{10}6p$	7.5	165670.33(23)	165675.4	−5	12	1.120	$(^{5}I)^{6}K$	54	$(^{5}I)^{4}K$	37	$(^{3}H)^{4}I4$	2	$(^{5}I_{6})3/2$	91	$(^{3}H_{6})3/2$	2	$(^{5}I_{7})3/2$	1
$4f^{10}6p$	4.5	166070.33(22)	166059.5	11	14	1.022	$(^{5}I)^{6}H$	46	$(^{5}I)^{4}H$	46	$(^{3}H)^{2}G4$	2	$(^{5}I_{6})3/2$	84	$(^{5}I_{5})3/2$	5	$(^{5}I_{5})1/2$	2
$4f^{10}6p$	1.5	–	167639.5	–		2.014	$(^{5}S)^{6}P$	57	$(^{5}S)^{4}P$	10	$(^{3}P)^{4}P2$	7	$(^{5}S_{2})1/2$	67	$(^{3}P_{2})1/2$	9	$(^{3}P_{2})3/2$	3
$4f^{10}6p$	2.5	–	167936.7	–		1.536	$(^{5}S)^{6}P$	35	$(^{5}S)^{4}P$	28	$(^{3}P)^{4}D2$	7	$(^{5}S_{2})1/2$	62	$(^{3}P_{2})1/2$	11	$(^{5}F_{2})1/2$	3
$4f^{10}6p$	3.5	–	168188.0	–		1.422	$(^{5}F)^{6}D$	35	$(^{5}F)^{6}F$	30	$(^{5}F)^{4}D$	12	$(^{5}F_{4})1/2$	84	$(^{5}F_{4})3/2$	1	$(^{5}F_{2})3/2$	1
$4f^{10}6p$	4.5	–	168291.7	–		1.080	$(^{5}F)^{6}G$	18	$(^{5}I)^{6}I$	16	$(^{5}F)^{4}G$	13	$(^{5}I_{5})3/2$	24	$(^{5}F_{4})1/2$	22	$(^{5}I_{4})3/2$	10
$4f^{10}6p$	5.5	168464.07(22)	168464.5	−0.	17	0.969	$(^{5}I)^{4}I$	32	$(^{5}I)^{6}I$	28	$(^{5}I)^{6}K$	15	$(^{5}I_{5})3/2$	76	$(^{5}I_{6})3/2$	7	$(^{5}I_{4})3/2$	1
$4f^{10}6p$	4.5	168566.60(23)	168536.1	31	9	1.108	$(^{5}F)^{6}G$	21	$(^{5}I)^{6}I$	14	$(^{5}F)^{4}G$	13	$(^{5}F_{4})1/2$	24	$(^{5}I_{5})3/2$	22	$(^{5}I_{4})3/2$	9
$4f^{10}6p$	3.5	–	168552.6	–		0.813	$(^{5}I)^{6}H$	67	$(^{5}I)^{4}H$	20	$(^{3}H)^{4}G4$	3	$(^{5}I_{5})3/2$	80	$(^{5}I_{4})3/2$	5	$(^{3}H_{5})3/2$	4
$4f^{10}6p$	6.5	168839.85(22)	168818.9	21	18	1.011	$(^{5}I)^{4}K$	52	$(^{5}I)^{6}K$	32	$(^{3}H)^{4}I4$	3	$(^{5}I_{5})3/2$	77	$(^{5}I_{6})3/2$	6	$(^{3}H_{5})3/2$	5
$4f^{10}6p$	2.5	–	170411.9	–		0.327	$(^{5}I)^{6}H$	86	$(^{3}H)^{4}G4$	6	$(^{3}H)^{4}G3$	3	$(^{5}I_{4})3/2$	86	$(^{3}H_{4})3/2$	6	$(^{3}H_{4})3/2$	3
$4f^{10}6p$	2.5	–	170700.2	–		1.251	$(^{5}F)^{6}F$	31	$(^{5}F)^{6}G$	22	$(^{5}F)^{6}D$	15	$(^{5}F_{3})1/2$	79	$(^{5}F_{2})1/2$	6		
$4f^{10}6p$	7.5	170771.46(30)	170774.8	−3	3	1.135	$(^{3}K)^{4}I2$	34	$(^{3}K)^{4}I1$	11	$(^{3}K)^{2}K2$	9	$(^{3}K_{8})1/2$	52	$(^{3}K_{8})1/2$	7	$(^{3}K_{8})3/2$	4
$4f^{10}6p$	3.5	170863.07(30)	170834.3	29	5	0.749	$(^{5}I)^{6}I$	31	$(^{5}I)^{4}H$	27	$(^{5}F)^{6}G$	12	$(^{5}I_{4})3/2$	61	$(^{5}F_{3})1/2$	11	$(^{5}I_{5})3/2$	4

Table 1. (Continued.)

Conf	J	E_{exp} (unc.)	E_{cal}	ΔE	N_{cl}	$g_{\text{Landé}}$	LS percentage composition						JJ percentage composition					
							Comp1	%	Comp2	%	Comp3	%	Comp1	%	Comp2	%	Comp3	%
$4f^{10}6p$	3.5	–	170913.0	–		1.040	$(^5F)^6G$	38	$(^5F)^4F$	11	$(^5I)^6I$	10	$(^5F_3)1/2$	54	$(^5I_4)3/2$	13	$(^5I_5)3/2$	6
$4f^{10}6p$	4.5	170987.58(30)	170980.5	7	5	0.736	$(^5I)^4I$	46	$(^5I)^6K$	22	$(^5I)^6I$	17	$(^5I_4)3/2$	82	$(^5I_5)3/2$	3	$(^3H_4)3/2$	1
$4f^{10}6p$	1.5	–	171107.6	–		1.247	$(^5F)^6F$	22	$(^5F)^4D$	18	$(^5S)^6P$	14	$(^5F_2)1/2$	55	$(^5S_2)1/2$	11	$(^5S_2)3/2$	3
$4f^{10}6p$	8.5	–	171110.0	–		1.080	$(^3K)^2L2$	22	$(^3K)^4K2$	16	$(^3K)^4L2$	15	$(^3K_8)1/2$	53	$(^1L_8)1/2$	4	$(^3K_8)1/2$	3
$4f^{10}6p$	5.5	–	171182.4	–		1.357	$(^5G)^6F$	39	$(^5F)^6F$	15	$(^5G)^4G$	9	$(^5G_6)1/2$	53	$(^5F_5)3/2$	22	$(^5G_5)1/2$	1
$4f^{10}6p$	2.5	–	171326.1	–		1.209	$(^5F)^6G$	23	$(^5S)^6P$	12	$(^5F)^4F$	12	$(^5F_2)1/2$	44	$(^5S_2)3/2$	6	$(^5S_2)1/2$	6
$4f^{10}6p$	5.5	–	171538.3	–		0.809	$(^5I)^4K$	70	$(^5I)^6K$	16	$(^3H)^2I4$	4	$(^5I_4)3/2$	80	$(^3H_4)3/2$	6	$(^5I_5)3/2$	5
$4f^{10}6p$	6.5	–	171729.1	–		1.315	$(^5F)^6G$	49	$(^5G)^6G$	12	$(^5G)^4H$	9	$(^5F_5)3/2$	49	$(^5G_6)1/2$	28	$(^3G_5)3/2$	6
$4f^{10}6p$	1.5	–	172632.9	–		0.362	$(^5F)^6G$	52	$(^5F)^4F$	13	$(^3D)^4F1$	12	$(^5F_1)1/2$	68	$(^3D_1)1/2$	8	$(^3D_1)1/2$	2
$4f^{10}6p$	6.5	–	172890.8	–		1.278	$(^5F)^6G$	29	$(^5G)^4H$	27	$(^5G)^6G$	13	$(^5G_6)1/2$	47	$(^5F_5)3/2$	29	$(^3G_5)3/2$	4
$4f^{10}6p$	4.5	–	173011.3	–		1.314	$(^5F)^4F$	34	$(^5F)^6D$	27	$(^3G)^2G2$	10	$(^5F_5)3/2$	56	$(^3G_5)3/2$	8	$(^3G_5)1/2$	5
$4f^{10}6p$	0.5	–	173128.8	–		−0.002	$(^5F)^6F$	37	$(^5F)^4D$	36	$(^3D)^4D1$	9	$(^5F_1)1/2$	76	$(^3D_1)1/2$	14	$(^3D_1)3/2$	1
$4f^{10}6p$	3.5	–	173299.3	–		1.370	$(^5F)^4D$	59	$(^5F)^6D$	12	$(^3G)^2F2$	6	$(^5F_5)3/2$	70	$(^3G_5)3/2$	9	$(^5F_4)3/2$	2
$4f^{10}6p$	5.5	–	173635.5	–		1.319	$(^5F)^4G$	29	$(^5F)^6F$	23	$(^5G)^6G$	13	$(^5F_5)3/2$	50	$(^5G_6)1/2$	13	$(^3G_5)3/2$	5
$4f^{10}6p$	4.5	–	173867.1	–		1.340	$(^5G)^6F$	21	$(^5F)^6F$	17	$(^5F)^4F$	16	$(^5G_5)1/2$	19	$(^5F_5)1/2$	14	$(^5F_5)3/2$	11
$4f^{10}6p$	5.5	–	174723.1	–		1.187	$(^5G)^6H$	13	$(^5G)^4H$	11	$(^3G)^2H2$	10	$(^5G_5)1/2$	26	$(^5F_5)3/2$	5	$(^3G_5)1/2$	4
$4f^{10}6p$	3.5	–	175409.1	–		1.582	$(^5S)^6P$	66	$(^3P)^4D2$	14	$(^3D)^4F1$	3	$(^5S_2)3/2$	66	$(^3P_2)3/2$	14	$(^3D_2)3/2$	2
$4f^{10}6p$	3.5	–	175971.9	–		1.221	$(^5G)^6G$	16	$(^5F)^4F$	12	$(^5G)^4F$	11	$(^5G_4)1/2$	35	$(^5F_4)3/2$	6	$(^5F_3)1/2$	3

Table 2. Even parity energy levels of the two configurations $4f^{10}5d$ and $4f^{10}6s$ of the Er^{3+} ion. Energies are given in in cm^{-1}. For each level the following are given: the experimental energy value when available, together with the corresponding uncertainties in parenthesis; the calculated energy value, where E_{calc} results from the Cowan codes corresponding to the parameters given in table 5, $\Delta E = E_{\mathrm{exp}}$-$E_{\mathrm{calc}}$, N_{cl} ; the total number of transitions involving the experimental level determination; the calculated Landé factor and the leading components of the eigenfunction and their corresponding percentages in both LS and JJ coupling schemes. The number following a term designation is an ordering number related to the seniority of the parent term as given by Cowan's code; a lowercase letter is added to distinguish two levels with the same main component.

Conf	J	E_{exp} (unc.)	E_{cal}	ΔE	N_{cl}	$g_{\mathrm{Landé}}$	LS percentage composition						JJ percentage composition					
							Comp1	%	Comp2	%	Comp3	%	Comp1	%	Comp2	%	Comp3	%
4f^{10}5d	7.5	73426.17(16)	73458.4	−32	10	1.275	d(^{5}I)^{6}H	49	d(^{5}I)^{6}I	29	d(^{5}I)^{4}I	7	d(^{5}I$_8$)3/2	80	d(^{5}I$_8$)5/2	5	d(^{5}I$_7$)5/2	3
4f^{10}5d	8.5	73708.00(20)	73707.4	1	4	1.259	d(^{5}I)^{6}I	67	d(^{5}I)^{6}K	17	d(^{5}I)^{4}K	8	d(^{5}I$_8$)3/2	69	d(^{5}I$_8$)5/2	22	d(^{3}K$_8$)5/2	2
4f^{10}5d	6.5	74536.27(19)	74506.5	30	6	1.327	d(^{5}I)^{6}G	59	d(^{5}I)^{6}H	22	d(^{3}K)^{4}H2	5	d(^{5}I$_8$)3/2	84	d(^{3}K$_8$)3/2	3	d(^{5}I$_8$)5/2	2
4f^{10}5d	9.5	75982.90(22)	75983.7	−1	3	1.217	d(^{5}I)^{6}K	54	d(^{5}I)^{4}L	20	d(^{5}I)^{6}L	19	d(^{5}I$_8$)3/2	70	d(^{5}I$_8$)5/2	22	d(^{3}K$_8$)5/2	2
4f^{10}5d	6.5	78916.79(16)	78921.8	−5	10	1.230	d(^{5}I)^{6}I	37	d(^{5}I)^{6}G	25	d(^{5}I)^{6}H	19	d(^{5}I$_7$)3/2	63	d(^{5}I$_8$)5/2	22	d(^{5}I$_6$)5/2	3
4f^{10}5d	8.5	79154.18(16)	79114.8	39	8	1.198	d(^{5}I)^{4}K	36	d(^{5}I)^{6}I	24	d(^{5}I)^{6}K	22	d(^{5}I$_8$)5/2	61	d(^{5}I$_8$)3/2	17	d(^{5}I$_7$)5/2	8
4f^{10}5d	10.5	79275.6 (30)	79252.3	23	1	1.231	d(^{5}I)^{6}L	92	d(^{3}K)^{4}M2	6	d(^{3}K)^{4}M1	2	d(^{5}I$_8$)5/2	92	d(^{3}K$_8$)5/2	6	d(^{3}K$_8$)5/2	2
4f^{10}5d	7.5	79362.02(16)	79353.4	9	9	1.227	d(^{5}I)^{6}Hb	32	d(^{5}I)^{6}I	29	d(^{5}I)^{6}K	23	d(^{5}I$_7$)3/2	50	d(^{5}I$_8$)5/2	24	d(^{5}I$_7$)5/2	14
4f^{10}5d	9.5	79522.29(19)	79486.4	36	4	1.194	d(^{5}I)^{4}L	45	d(^{5}I)^{6}K	37	d(^{5}I)^{6}L	11	d(^{5}I$_8$)5/2	69	d(^{5}I$_8$)3/2	20	d(^{3}K$_8$)5/2	4
4f^{10}5d	5.5	79743.13(17)	79765.8	−23	8	1.232	d(^{5}I)^{6}G	42	d(^{5}I)^{6}H	35	d(^{5}I)^{6}I	11	d(^{5}I$_7$)3/2	67	d(^{5}I$_8$)5/2	11	d(^{5}I$_6$)3/2	6
4f^{10}5d	8.5	82610.32(16)	82625.0	−15	7	1.133	d(^{5}I)^{6}L	38	d(^{5}I)^{4}K	35	d(^{5}I)^{4}L	15	d(^{5}I$_7$)3/2	81	d(^{5}I$_8$)5/2	8	d(^{5}I$_7$)5/2	4
4f^{10}5d	6.5	82921.55(14)	82911.5	10	16	1.171	d(^{5}I)^{6}K	21	d(^{5}I)^{6}I	20	d(^{5}I)^{4}H	18	d(^{5}I$_8$)5/2	21	d(^{5}I$_7$)5/2	18	d(^{5}I$_6$)3/2	17
4f^{10}5d	5.5	83109.96(16)	83105.7	4	12	1.131	d(^{5}I)^{6}I	45	d(^{5}I)^{6}G	28	d(^{5}I)^{6}K	7	d(^{5}I$_6$)3/2	43	d(^{5}I$_7$)5/2	26	d(^{5}I$_8$)5/2	7
4f^{10}5d	7.5	83376.71(15)	83329.8	47	10	1.157	d(^{5}I)^{4}I	33	d(^{5}I)^{6}K	31	d(^{5}I)^{6}L	9	d(^{5}I$_8$)5/2	31	d(^{5}I$_7$)3/2	27	d(^{5}I$_6$)5/2	17
4f^{10}5d	4.5	83708.79(17)	83762.8	−55	8	1.057	d(^{5}I)^{6}H	41	d(^{5}I)^{6}G	23	d(^{5}I)^{6}I	23	d(^{5}I$_6$)3/2	54	d(^{5}I$_7$)5/2	20	d(^{5}I$_5$)3/2	12
4f^{10}5d	7.5	84992.54(15)	84968.8	24	11	1.171	d(^{5}I)^{4}Ib	35	d(^{5}I)^{6}I	30	d(^{5}I)^{4}K	18	d(^{5}I$_7$)5/2	52	d(^{5}I$_8$)5/2	27	d(^{5}I$_6$)5/2	7
4f^{10}5d	8.5	85345.53(16)	85357.2	−12	8	1.157	d(^{5}I)^{6}K	47	d(^{5}I)^{4}L	24	d(^{5}I)^{6}L	11	d(^{5}I$_7$)5/2	80	d(^{5}I$_6$)5/2	6	d(^{5}I$_7$)3/2	5
4f^{10}5d	6.5	85740.41(14)	85785.4	−45	19	1.166	d(^{5}I)^{4}H	50	d(^{5}I)^{6}K	18	d(^{5}I)^{6}H	12	d(^{5}I$_8$)5/2	28	d(^{5}I$_6$)3/2	26	d(^{5}I$_7$)3/2	14
4f^{10}5d	9.5	85914.80(23)	85944.7	−30	2	1.174	d(^{5}I)^{6}L	66	d(^{5}I)^{4}L	27	d(^{5}I)^{6}K	3	d(^{5}I$_7$)5/2	93	d(^{3}K$_7$)5/2	2	d(^{5}I$_8$)5/2	2
4f^{10}5d	4.5	86401.13(17)	86364.6	37	7	1.005	d(^{5}I)^{6}I	41	d(^{5}I)^{6}G	35	d(^{5}I)^{6}K	6	d(^{5}I$_5$)3/2	53	d(^{5}I$_6$)5/2	18	d(^{5}I$_7$)5/2	9
4f^{10}5d	5.5	86559.40(15)	86546.4	13	18	1.109	d(^{5}I)^{6}H	26	d(^{5}I)^{6}K	22	d(^{5}I)^{4}G	13	d(^{5}I$_6$)5/2	30	d(^{5}I$_5$)3/2	19	d(^{5}I$_8$)5/2	13
4f^{10}5d	3.5	–	86684.3	–		0.780	d(^{5}I)^{6}H	38	d(^{5}I)^{6}I	29	d(^{5}I)^{6}G	12	d(^{5}I$_5$)3/2	37	d(^{5}I$_6$)5/2	23	d(^{5}I$_4$)3/2	13
4f^{10}5d	6.5	86744.73(16)	86680.2	65	11	1.100	d(^{5}I)^{6}Kb	26	d(^{5}I)^{4}I	18	d(^{5}I)^{6}H	17	d(^{5}I$_7$)5/2	24	d(^{5}I$_6$)3/2	24	d(^{5}I$_6$)5/2	17
4f^{10}5d	7.5	86757.34(16)	86748.0	9	10	1.034	d(^{5}I)^{6}L	53	d(^{5}I)^{4}K	25	d(^{5}I)^{4}L	11	d(^{5}I$_6$)3/2	85	d(^{5}I$_7$)5/2	3	d(^{5}I$_5$)5/2	2
4f^{10}5d	5.5	86872.06(15)	86883.3	−11	14	1.245	d(^{5}I)^{4}G	62	d(^{5}I)^{6}G	11	d(^{5}I)^{4}H	10	d(^{5}I$_8$)5/2	47	d(^{5}I$_7$)3/2	19	d(^{5}I$_7$)5/2	15
4f^{10}5d	5.5	88456.86(16)	88415.3	42	10	0.951	d(^{5}I)^{6}K	42	d(^{5}I)^{6}I	12	d(^{5}I)^{4}I	7	d(^{5}I$_5$)3/2	48	d(^{5}I$_5$)5/2	8	d(^{5}I$_4$)5/2	8
4f^{10}5d	3.5	88834.27(20)	88813.4	21	4	0.764	d(^{5}I)^{6}I	46	d(^{5}I)^{6}G	21	d(^{5}I)^{6}H	7	d(^{5}I$_4$)3/2	41	d(^{5}I$_6$)5/2	13	d(^{5}I$_4$)5/2	13
4f^{10}5d	6.5	89157.31(19)	89135.9	21	5	0.908	d(^{5}I)^{6}L	60	d(^{5}I)^{4}K	13	d(^{5}I)^{4}L	5	d(^{5}I$_5$)3/2	74	d(^{5}I$_5$)5/2	3	d(^{5}I$_4$)5/2	2
4f^{10}5d	4.5	–	89316.7	–		0.970	d(^{5}I)^{6}K	27	d(^{5}I)^{6}G	24	d(^{5}I)^{6}H	20	d(^{5}I$_5$)5/2	39	d(^{5}I$_4$)3/2	22	d(^{5}I$_6$)5/2	10
4f^{10}5d	3.5	–	89517.5	–		1.559	d(^{5}F)^{6}P	59	d(^{5}F)^{6}D	14	d(^{3}G)^{4}D2	5	d(^{5}F$_5$)3/2	55	d(^{5}F$_5$)5/2	14	d(^{5}I$_5$)3/2	4
4f^{10}5d	2.5	–	89752.9	–		0.429	d(^{5}I)^{6}H	60	d(^{5}I)^{6}G	13	d(^{5}G)^{6}H	7	d(^{5}I$_5$)5/2	34	d(^{5}I$_4$)3/2	26	d(^{5}I$_4$)5/2	13
4f^{10}5d	7.5	89949.21(16	89990.8	−42	9	1.096	d(^{5}I)^{4}K	38	d(^{5}I)^{6}K	31	d(^{5}I)^{4}L	11	d(^{5}I$_6$)5/2	65	d(^{5}I$_7$)5/2	18	d(^{5}I$_5$)5/2	4
4f^{10}5d	4.5	–	90252.3	–		0.812	d(^{5}I)^{6}K	43	d(^{5}I)^{6}I	13	d(^{5}I)^{4}I	6	d(^{5}I$_4$)3/2	41	d(^{5}I$_4$)5/2	21	d(^{5}I$_5$)5/2	4
4f^{10}5d	6.5	90598.50(14)	90599.3	−1	16	1.097	d(^{5}I)^{4}I	42	d(^{5}I)^{4}K	21	d(^{5}I)^{6}I	13	d(^{5}I$_6$)5/2	43	d(^{5}I$_7$)5/2	27	d(^{5}I$_6$)3/2	9
4f^{10}5d	8.5	90703.64(21)	90756.8	−53	3	1.097	d(^{5}I)^{4}L	51	d(^{5}I)^{6}L	39	d(^{3}H)^{4}K4	2	d(^{5}I$_6$)5/2	87	d(^{5}I$_7$)5/2	5	d(^{5}I$_7$)3/2	2
4f^{10}5d	5.5	90711.70(14)	90729.0	−17	19	1.200	d(^{5}I)^{4}H	20	d(^{5}F)^{6}F	19	d(^{5}I)^{4}I	12	d(^{5}I$_7$)5/2	18	d(^{5}F$_5$)5/2	10	d(^{5}I$_6$)5/2	6
4f^{10}5d	4.5	–	90803.4	–		1.353	d(^{5}F)^{6}D	30	d(^{5}F)^{6}F	17	d(^{5}I)^{6}H	7	d(^{5}F$_5$)3/2	30	d(^{5}F$_5$)5/2	15	d(^{5}I$_5$)5/2	6

Table 2. (Continued.)

Conf	J	E_{exp} (unc.)	E_{cal}	ΔE	N_{cl}	$g_{\text{Landé}}$	LS percentage composition						JJ percentage composition					
							Comp1	%	Comp2	%	Comp3	%	Comp1	%	Comp2	%	Comp3	%
$4f^{10}5d$	5.5	91169.27(21)	91148.2	21	4	0.687	d(^{5}I)^{6}L	71	d(^{5}I)^{4}K	9	d(^{3}H)^{4}K4	5	d(^{5}I$_{4}$)3/2	79	d(^{3}H$_{4}$)3/2	4	d(^{5}I$_{4}$)5/2	3
$4f^{10}5d$	3.5	–	91498.2	–		1.012	d(^{5}I)^{6}G	49	d(^{5}I)^{6}H	19	d(^{5}F)^{6}H	5	d(^{5}I$_{4}$)5/2	33	d(^{5}I$_{5}$)5/2	30	d(^{5}I$_{6}$)5/2	8
$4f^{10}5d$	5.5	91511.24(15)	91538.8	–28	17	1.239	d(^{5}I)^{4}Hb	21	d(^{5}F)^{6}F	21	d(^{5}I)^{6}H	13	d(^{5}I$_{6}$)5/2	18	d(^{5}I$_{7}$)5/2	11	d(^{5}F$_{5}$)5/2	10
$4f^{10}5d$	6.5	92064.49(15)	92108.4	–44	10	1.214	d(^{5}F)^{6}H	32	d(^{5}F)^{4}H	20	d(^{5}F)^{6}G	9	d(^{5}F$_{5}$)3/2	55	d(^{5}F$_{4}$)5/2	4	d(^{5}I$_{5}$)3/2	4
$4f^{10}5d$	4.5	92187.63(16)	92199.9	–12	10	1.149	d(^{5}I)^{4}G	70	d(^{5}I)^{4}H	10	d(^{3}K)^{4}H2	2	d(^{5}I$_{7}$)5/2	55	d(^{5}I$_{6}$)3/2	22	d(^{5}I$_{6}$)5/2	3
$4f^{10}5d$	2.5	–	92927.4	–		1.060	d(^{5}I)^{6}G	49	d(^{5}F)^{6}P	8	d(^{5}F)^{6}D	7	d(^{5}I$_{4}$)5/2	32	d(^{5}I$_{5}$)5/2	20	d(^{5}F$_{4}$)3/2	9
$4f^{10}5d$	2.5	–	93184.9	–		1.412	d(^{5}F)^{6}P	28	d(^{5}I)^{6}G	21	d(^{5}F)^{6}D	20	d(^{5}F$_{4}$)3/2	37	d(^{5}I$_{5}$)5/2	12	d(^{5}F$_{4}$)5/2	8
$4f^{10}5d$	0.5	–	93501.9	–		2.874	d(^{5}S)^{6}D	54	d(^{3}P)^{4}P2	13	d(^{5}F)^{6}D	8	d(^{5}S$_{2}$)3/2	51	d(^{3}P$_{2}$)3/2	11	d(^{5}F$_{2}$)5/2	3
$4f^{10}5d$	7.5	93641.97(18)	93695.0	–53	4	1.206	d(^{5}F)^{6}H	50	d(^{5}I)^{4}L	21	d(^{3}G)^{4}I2	6	d(^{5}F$_{5}$)5/2	50	d(^{5}I$_{5}$)5/2	22	d(^{3}G$_{5}$)5/2	6
$4f^{10}5d$	6.5	93697.73(15)	93724.5	–27	13	1.017	d(^{5}I)^{4}K	44	d(^{5}I)^{6}K	17	d(^{5}I)^{4}I	8	d(^{5}I$_{5}$)5/2	57	d(^{5}I$_{6}$)5/2	12	d(^{5}I$_{4}$)5/2	3
$4f^{10}5d$	5.5	93829.40(17)	93885.3	–56	7	1.184	d(^{5}F)^{6}H	25	d(^{5}F)^{4}H	11	d(^{5}G)^{6}F	9	d(^{5}F$_{4}$)3/2	32	d(^{5}F$_{5}$)5/2	9	d(^{5}G$_{6}$)5/2	3
$4f^{10}5d$	3.5	–	94082.3	–		1.430	d(^{5}F)^{6}F	40	d(^{5}F)^{6}D	17	d(^{5}G)^{6}F	12	d(^{5}F$_{4}$)3/2	29	d(^{5}F$_{4}$)5/2	19	d(^{5}G$_{5}$)3/2	9
$4f^{10}5d$	1.5	–	94152.7	–		0.545	d(^{5}I)^{6}G	57	d(^{5}S)^{6}D	18	d(^{5}F)^{6}G	4	d(^{5}I$_{4}$)5/2	57	d(^{5}S$_{2}$)3/2	15	d(^{3}H$_{4}$)5/2	4
$4f^{10}5d$	1.5	–	94394.9	–		1.226	d(^{5}S)^{6}D	46	d(^{5}I)^{6}G	27	d(^{3}P)^{4}P2	5	d(^{5}S$_{2}$)3/2	39	d(^{5}I$_{4}$)5/2	27	d(^{5}S$_{2}$)5/2	7
$4f^{10}5d$	5.5	94476.78(15)	94497.7	–21	13	1.009	d(^{5}I)^{4}I	32	d(^{5}I)^{4}K	16	d(^{5}I)^{4}H	15	d(^{5}I$_{5}$)5/2	19	d(^{5}I$_{6}$)5/2	17	d(^{5}I$_{6}$)3/2	12
$4f^{10}5d$	7.5	94777.64(20)	94741.3	36	3	1.095	d(^{5}I)^{4}L	44	d(^{5}F)^{6}H	26	d(^{5}I)^{6}L	15	d(^{5}I$_{5}$)5/2	54	d(^{5}F$_{5}$)5/2	26	d(^{5}I$_{6}$)5/2	6
$4f^{10}5d$	2.5	–	94852.3	–		1.416	d(^{5}S)^{6}D	42	d(^{5}F)^{6}F	12	d(^{5}S)^{4}D	7	d(^{5}S$_{2}$)3/2	46	d(^{3}P$_{2}$)3/2	6	d(^{5}S$_{2}$)5/2	3
$4f^{10}5d$	4.5	94874.22(16)	94883.0	–9	10	1.069	d(^{5}I)^{4}H	28	d(^{5}I)^{4}I	16	d(^{5}F)^{6}F	9	d(^{5}I$_{6}$)5/2	20	d(^{5}I$_{5}$)3/2	13	d(^{5}I$_{5}$)5/2	11
$4f^{10}5d$	3.5	–	94991.5	–		1.394	d(^{5}S)^{6}D	39	d(^{5}S)^{4}D	7	d(^{3}P)^{4}F2	7	d(^{5}S$_{2}$)3/2	35	d(^{5}S$_{2}$)5/2	11	d(^{3}P$_{2}$)5/2	6
$4f^{10}5d$	4.5	95252.35(16)	95239.4	13	9	1.223	d(^{5}F)^{6}D	17	d(^{5}F)^{6}H	15	d(^{5}I)^{4}H	12	d(^{5}F$_{4}$)3/2	24	d(^{5}F$_{4}$)5/2	15	d(^{5}F$_{5}$)5/2	5
$4f^{10}5d$	3.5	95872.96(17)	95874.7	–2	7	0.947	d(^{5}I)^{4}G	58	d(^{5}I)^{4}H	16	d(^{3}H)^{2}F4	2	d(^{5}I$_{6}$)5/2	38	d(^{5}I$_{5}$)3/2	25	d(^{5}I$_{5}$)5/2	11
$4f^{10}5d$	5.5	96154.60(17)	96174.1	–19	7	0.836	d(^{5}I)^{4}K	52	d(^{5}I)^{6}K	11	d(^{5}I)^{6}L	7	d(^{5}I$_{4}$)5/2	66	d(^{5}I$_{5}$)5/2	7	d(^{3}H$_{4}$)5/2	2
$4f^{10}5d$	2.5	–	96172.0	–		1.528	d(^{5}F)^{6}P	32	d(^{5}F)^{6}F	27	d(^{5}S)^{6}D	11	d(^{5}F$_{3}$)3/2	26	d(^{5}F$_{3}$)5/2	15	d(^{5}F$_{4}$)5/2	8
$4f^{10}5d$	4.5	96309.02(18)	96387.6	–79	6	1.181	d(^{5}F)^{6}H	36	d(^{5}G)^{6}F	11	d(^{5}F)^{6}F	9	d(^{5}F$_{3}$)3/2	30	d(^{5}F$_{4}$)5/2	7	d(^{5}F$_{4}$)3/2	6
$4f^{10}5d$	1.5	–	96329.6	–		1.785	d(^{5}F)^{6}D	29	d(^{5}F)^{6}P	25	d(^{5}F)^{6}F	16	d(^{5}F$_{3}$)3/2	42	d(^{5}F$_{4}$)5/2	16	d(^{5}F$_{3}$)5/2	8
$4f^{10}5d$	6.5	–	96980.0	–		1.181	d(^{3}K)^{4}H2	23	d(^{5}F)^{4}H	12	d(^{5}F)^{6}H	8	d(^{5}F$_{5}$)5/2	19	d(^{3}K$_{8}$)3/2	17	d(^{5}F$_{4}$)5/2	7
$4f^{10}5d$	3.5	–	97058.0	–		1.005	d(^{5}F)^{6}H	43	d(^{5}F)^{4}D	7	d(^{3}D)^{4}G1	5	d(^{5}F$_{2}$)3/2	24	d(^{5}F$_{1}$)5/2	10	d(^{5}F$_{3}$)3/2	7
$4f^{10}5d$	4.5	97183.02(16)	97128.9	54	12	0.835	d(^{5}I)^{4}I	42	d(^{5}I)^{4}H	15	d(^{5}I)^{6}I	8	d(^{5}I$_{4}$)5/2	51	d(^{5}I$_{5}$)5/2	8	d(^{5}I$_{4}$)3/2	7
$4f^{10}5d$	6.5	–	97380.4	–		0.857	d(^{5}I)^{4}L	70	d(^{5}I)^{6}L	8	d(^{3}H)^{2}K4	4	d(^{5}I$_{4}$)5/2	68	d(^{5}I$_{5}$)5/2	9	d(^{3}H$_{4}$)5/2	2
$4f^{10}5d$	1.5	–	97408.3	–		1.437	d(^{5}F)^{6}F	33	d(^{5}F)^{6}P	21	d(^{5}G)^{6}F	7	d(^{5}F$_{2}$)5/2	20	d(^{5}F$_{3}$)5/2	12	d(^{5}F$_{2}$)3/2	11
$4f^{10}5d$	0.5	–	97614.2	–		0.857	d(^{5}F)^{6}F	39	d(^{5}S)^{6}D	20	d(^{5}F)^{6}D	8	d(^{5}F$_{2}$)3/2	27	d(^{5}S$_{2}$)3/2	20	d(^{5}F$_{3}$)5/2	15
$4f^{10}5d$	3.5	–	97841.7	–		1.302	d(^{5}F)^{4}D	18	d(^{5}S)^{6}D	15	d(^{5}S)^{4}D	9	d(^{5}S$_{2}$)3/2	22	d(^{5}F$_{5}$)5/2	18	d(^{5}F$_{3}$)3/2	4
$4f^{10}5d$	2.5	–	98018.7	–		0.517	d(^{5}F)^{6}H	50	d(^{3}D)^{4}G1	9	d(^{5}I)^{6}H	8	d(^{5}F$_{1}$)3/2	32	d(^{5}F$_{2}$)3/2	11	d(^{5}I$_{4}$)3/2	11
$4f^{10}5d$	3.5	98252.07(16)	98267.1	–15	8	0.785	d(^{5}I)^{4}H	47	d(^{5}I)^{4}G	18	d(^{5}I)^{6}H	6	d(^{5}I$_{4}$)5/2	41	d(^{5}I$_{4}$)3/2	19	d(^{5}I$_{5}$)5/2	10
$4f^{10}5d$	4.5	–	98315.9	–		1.447	d(^{5}S)^{6}D	49	d(^{3}P)^{4}F2	9	d(^{5}G)^{6}F	8	d(^{5}S$_{2}$)5/2	49	d(^{5}G$_{6}$)3/2	10	d(^{3}P$_{2}$)5/2	9
$4f^{10}5d$	6.5	–	98407.5	–		1.321	d(^{5}F)^{6}G	56	d(^{5}F)^{6}H	7	d(^{5}G)^{6}G	5	d(^{5}F$_{5}$)5/2	34	d(^{5}F$_{4}$)5/2	27	d(^{5}G$_{6}$)3/2	4
$4f^{10}5d$	5.5	98664.60(16)	98630.5	34	8	1.245	d(^{5}F)^{4}G	36	d(^{5}F)^{6}H	19	d(^{5}F)^{6}G	14	d(^{5}F$_{4}$)3/2	25	d(^{5}F$_{5}$)3/2	22	d(^{5}F$_{3}$)5/2	14
$4f^{10}5d$	9.5	–	99061.8	–		1.058	d(^{3}K)^{4}M2	21	d(^{3}K)^{2}M2	19	d(^{3}K)^{4}L2	10	d(^{3}K$_{8}$)3/2	49	d(^{1}L$_{8}$)3/2	6	d(^{3}L$_{8}$)3/2	5
$4f^{10}5d$	0.5	–	99234.2	–		1.815	d(^{5}F)^{6}D	32	d(^{5}F)^{6}F	20	d(^{5}S)^{6}D	9	d(^{5}F$_{1}$)3/2	33	d(^{5}F$_{2}$)5/2	22	d(^{5}S$_{2}$)3/2	9
$4f^{10}5d$	2.5	–	99248.4	–		0.752	d(^{5}I)^{4}G	58	d(^{5}I)^{6}H	6	d(^{5}F)^{4}P	5	d(^{5}I$_{5}$)5/2	25	d(^{5}I$_{4}$)3/2	23	d(^{5}I$_{4}$)5/2	15

Table 2. (Continued.)

Conf	J	E_{exp} (unc.)	E_{cal}	ΔE	N_{cl}	$g_{\mathrm{Landé}}$	LS percentage composition						JJ percentage composition					
							Comp1	%	Comp2	%	Comp3	%	Comp1	%	Comp2	%	Comp3	%
4f^{10}5d	8.5	–	99288.2	–		1.087	d(^{3}K)^{4}K2	22	d(^{3}K)^{4}L2	18	d(^{3}K)^{2}L2	11	d(^{3}K$_8$)3/2	48	d(^{3}K$_8$)3/2	7	d(^{3}K$_8$)5/2	2
4f^{10}5d	2.5	–	99426.3	–		1.396	d(^{5}F)^{6}D	25	d(^{5}F)^{4}P	15	d(^{5}I)^{4}G	8	d(^{5}F$_2$)5/2	14	d(^{5}F$_5$)5/2	14	d(^{5}F$_3$)5/2	7
4f^{10}5d	4.5	–	99435.3	–		1.283	d(^{5}F)^{4}F	12	d(^{5}G)^{6}D	9	d(^{5}F)^{6}D	9	d(^{5}F$_5$)5/2	17	d(^{5}G$_6$)3/2	13	d(^{5}S$_2$)5/2	7
4f^{10}5d	3.5	–	99639.0	–		1.205	d(^{5}F)^{6}G	42	d(^{5}S)^{6}D	9	d(^{5}F)^{6}D	6	d(^{5}F$_3$)3/2	20	d(^{5}F$_4$)3/2	9	d(^{5}F$_4$)5/2	9
4f^{10}5d	1.5	–	99944.5	–		1.446	d(^{5}F)^{6}P	23	d(^{5}F)^{6}D	17	d(^{5}F)^{6}G	11	d(^{5}F$_2$)5/2	22	d(^{5}F$_1$)5/2	19	d(^{5}F$_1$)3/2	6
4f^{10}5d	5.5	99987.95(30)	99987.0	1	3	1.223	d(^{5}F)^{4}H	23	d(^{5}F)^{6}G	20	d(^{5}G)^{6}F	11	d(^{5}F$_4$)5/2	36	d(^{5}G$_6$)3/2	10	d(^{5}G$_6$)5/2	5
4f^{10}5d	4.5	–	99987.1	–		1.279	d(^{5}F)^{6}G	36	d(^{5}S)^{6}D	12	d(^{5}F)^{4}F	9	d(^{5}F$_4$)3/2	34	d(^{5}S$_2$)5/2	12	d(^{5}F$_3$)5/2	6
4f^{10}5d	7.5	100035.15(30)	100055.2	−20	2	1.109	d(^{3}K)^{4}K2	19	d(^{3}K)^{4}I2	19	d(^{5}I)^{4}I	8	d(^{3}K$_8$)3/2	41	d(^{5}I$_8$)5/2	4	d(^{3}K$_8$)3/2	3
4f^{10}5d	2.5	–	100189.9	–		1.172	d(^{5}F)^{4}P	22	d(^{5}F)^{6}G	20	d(^{5}I)^{4}G	7	d(^{5}F$_3$)3/2	13	d(^{5}F$_5$)5/2	11	d(^{5}F$_1$)3/2	9
4f^{10}5d	6.5	100337.92(30)	100342.4	−4	3	1.197	d(^{5}F)^{6}Hb	27	d(^{5}F)^{4}H	19	d(^{3}K)^{4}H2	6	d(^{5}F$_4$)5/2	35	d(^{5}F$_5$)5/2			
4f^{10}5d	3.5	–	100963.3	–		1.323	d(^{5}F)^{6}D	31	d(^{5}F)^{6}F	11	d(^{5}F)^{4}F	7	d(^{5}F$_3$)5/2	23	d(^{5}F$_2$)5/2	10	d(^{5}F$_4$)5/2	9
4f^{10}5d	2.5	–	100989.6	–		1.165	d(^{5}F)^{4}P	17	d(^{5}F)^{6}G	13	d(^{5}F)^{6}H	8	d(^{5}F$_4$)3/2	13	d(^{5}F$_1$)3/2	11	d(^{5}F$_1$)5/2	9
4f^{10}5d	5.5	–	101068.1	–		1.315	d(^{5}G)^{6}G	22	d(^{5}F)^{6}F	18	d(^{5}G)^{6}F	9	d(^{5}G$_6$)3/2	19	d(^{5}F$_4$)5/2	14	d(^{5}F$_5$)5/2	6
4f^{10}5d	6.5	–	101395.6	–		1.263	d(^{5}G)^{6}G	29	d(^{5}G)^{6}H	11	d(^{5}G)^{4}H	9	d(^{5}G$_6$)3/2	40	d(^{5}G$_6$)5/2	6	d(^{5}F$_5$)5/2	6
4f^{10}5d	4.5	–	101422.6	–		1.362	d(^{5}G)^{6}D	28	d(^{5}F)^{6}F	18	d(^{3}H)^{4}F4	5	d(^{5}G$_6$)3/2	16	d(^{5}F$_3$)5/2	9	d(^{5}F$_4$)5/2	8
4f^{10}5d	7.5	101556.6(5)	101566.5	−10	1	1.210	d(^{5}G)^{4}I	33	d(^{5}G)^{6}I	23	d(^{5}G)^{6}H	12	d(^{5}G$_6$)3/2	66	d(^{5}F$_5$)5/2	4	d(^{3}H$_5$)5/2	3
4f^{10}5d	1.5	–	101630.4	–		0.637	d(^{5}F)^{6}G	41	d(^{5}F)^{6}D	12	d(^{3}D)^{4}F1	12	d(^{5}F$_1$)3/2	34	d(^{5}F$_1$)5/2	13	d(^{5}F$_2$)3/2	6
4f^{10}6s	8.5	101709.83(14)	101671.5	38	7	1.286	s(^{5}I)^{6}I	92	s(^{3}K)^{4}K2	5	s(^{3}K)^{4}K1	2	s(^{5}I$_8$)1/2	92	s(^{3}K$_8$)1/2	5	s(^{3}K$_8$)1/2	2
4f^{10}5d	2.5	–	101810.1	–		1.345	d(^{5}S)^{4}D	35	d(^{5}F)^{4}D	33	d(^{5}G)^{4}D	5	d(^{5}S$_2$)5/2	22	d(^{5}F$_4$)5/2	14	d(^{5}S$_2$)3/2	13
4f^{10}5d	5.5	–	101959.5	–		1.210	d(^{5}F)^{6}G	27	d(^{5}F)^{4}H	7	d(^{5}F)^{4}G	6	d(^{5}F$_3$)5/2	17	d(^{5}F$_4$)3/2	11	d(^{5}F$_4$)5/2	5
4f^{10}5d	10.5	–	102163.2	–		1.125	d(^{3}K)^{4}M2	50	d(^{3}K)^{4}M1	16	d(^{3}L)^{4}N	12	d(^{3}K$_8$)5/2	50	d(^{3}K$_8$)5/2	16	d(^{1}L$_8$)5/2	9
4f^{10}5d	4.5	–	102589.1	–		1.130	d(^{5}F)^{4}H	26	d(^{5}F)^{4}G	15	d(^{5}F)^{4}F	12	d(^{5}F$_5$)5/2	17	d(^{5}F$_4$)5/2	16	d(^{5}F$_3$)5/2	15
4f^{10}5d	0.5	–	102601.7	–		1.532	d(^{5}F)^{6}D	20	d(^{5}F)^{4}D	12	d(^{5}G)^{6}F	7	d(^{5}F$_3$)5/2	31	d(^{5}F$_2$)5/2	4	d(^{5}F$_1$)3/2	3
4f^{10}5d	1.5	–	102675.2	–		1.353	d(^{5}F)^{4}D	26	d(^{5}S)^{4}D	24	d(^{5}F)^{4}P	12	d(^{5}F$_4$)5/2	24	d(^{5}S$_2$)5/2	20	d(^{5}F$_3$)3/2	10
4f^{10}5d	5.5	–	102785.7	–		1.171	d(^{3}K)^{4}H2	14	d(^{3}G)^{4}G2	10	d(^{5}F)^{4}G	7	d(^{3}G$_5$)5/2	6	d(^{3}K$_7$)3/2	6	d(^{3}K$_7$)5/2	4
4f^{10}6s	7.5	103116.18(14)	103107.2	9	6	1.194	s(^{5}I)^{4}I	65	s(^{5}I)^{6}I	22	s(^{3}K)^{2}K2	3	s(^{5}I$_8$)1/2	86	s(^{3}K$_8$)1/2	5	s(^{5}I$_7$)1/2	2
4f^{10}5d	9.5	–	103150.5	–		1.116	d(^{3}K)^{4}L2	42	d(^{3}K)^{4}L1	14	d(^{3}K)^{2}M2	11	d(^{3}K$_8$)5/2	53	d(^{3}K$_8$)5/2	11	d(^{1}L$_8$)5/2	5
4f^{10}5d	2.5	–	103166.9	–		1.229	d(^{5}G)^{6}F	18	d(^{5}F)^{4}D	16	d(^{5}F)^{6}G	14	d(^{5}F$_3$)3/2	15	d(^{5}S$_2$)5/2	8	d(^{5}G$_4$)3/2	6
4f^{10}5d	6.5	103183.27(24)	103074.1	109	4	1.125	d(^{5}G)^{6}I	16	d(^{5}F)^{4}H	15	d(^{5}G)^{4}I	8	d(^{5}G$_5$)3/2	18	d(^{5}F$_5$)3/2	9	d(^{3}K$_8$)5/2	4
4f^{10}5d	1.5	–	103360.2	–		1.340	d(^{5}S)^{4}D	29	d(^{5}F)^{4}P	15	d(^{5}F)^{4}D	10	d(^{5}S$_2$)5/2	24	d(^{5}F$_4$)5/2	17	d(^{5}F$_3$)3/2	6
4f^{10}5d	8.5	–	103423.2	–		1.093	d(^{3}K)^{4}K2	33	d(^{3}K)^{4}M2	10	d(^{3}K)^{4}K1	9	d(^{3}K$_8$)5/2	40	d(^{3}K$_7$)3/2	7	d(^{3}K$_8$)5/2	6
4f^{10}5d	3.5	–	103472.8	–		1.352	d(^{5}S)^{4}D	14	d(^{5}G)^{6}D	12	d(^{5}F)^{6}G	9	d(^{5}S$_2$)5/2	21	d(^{5}G$_5$)3/2	4	d(^{5}G$_5$)5/2	3
4f^{10}5d	0.5	–	103825.3	–		0.370	d(^{5}S)^{4}D	70	d(^{3}P)^{2}P2	7	d(^{3}P)^{4}D2	6	d(^{5}S$_2$)5/2	68	d(^{3}P$_2$)5/2	13	d(^{5}S$_2$)3/2	3
4f^{10}5d	3.5	103899.38(30)	103864.4	35	3	1.214	d(^{5}G)^{6}G	10	d(^{5}S)^{4}D	10	d(^{5}S)^{6}D	9	d(^{5}S$_2$)5/2	18	d(^{5}G$_4$)3/2	4	d(^{5}F$_4$)3/2	3
4f^{10}5d	4.5	103907.95(21)	103963.0	−55	5	1.157	d(^{5}F)^{4}H	21	d(^{5}F)^{4}G	14	d(^{5}F)^{6}F	6	d(^{5}F$_3$)5/2	18	d(^{5}F$_2$)5/2	18	d(^{5}F$_4$)5/2	10
4f^{10}5d	8.5	–	103943.4	–		1.267	d(^{5}G)^{6}I	78	d(^{3}H)^{4}K4	9	d(^{3}H)^{4}K1	5	d(^{5}G$_6$)5/2	78	d(^{3}H$_6$)5/2	9	d(^{3}H$_6$)5/2	5
4f^{10}5d	2.5	–	104005.5	–		1.267	d(^{5}F)^{6}F	13	d(^{5}F)^{4}F	11	d(^{5}F)^{4}P	10	d(^{5}F$_4$)5/2	12	d(^{5}F$_4$)3/2	11	d(^{5}S$_2$)5/2	5
4f^{10}5d	1.5	–	104097.9	–		1.421	d(^{5}F)^{4}P	29	d(^{5}F)^{6}G	7	d(^{5}F)^{6}D	6	d(^{5}F$_4$)5/2	21	d(^{5}F$_3$)5/2	19	d(^{5}F$_1$)3/2	6
4f^{10}5d	5.5	104157.95(19)	104127.0	31	6	1.187	d(^{5}F)^{4}Gb	23	d(^{3}K)^{4}H2	15	d(^{5}F)^{6}H	7	d(^{5}F$_3$)5/2	14	d(^{5}F$_5$)5/2	12	d(^{3}K$_7$)3/2	6
4f^{10}5d	7.5	–	104167.2	–		1.137	d(^{3}K)^{4}I2	25	d(^{5}G)^{6}H	10	d(^{3}K)^{4}I1	8	d(^{3}K$_8$)5/2	18	d(^{3}K$_7$)3/2	11	d(^{5}G$_6$)5/2	8

Table 2. (Continued.)

Conf	J	E_{exp} (unc.)	E_{cal}	ΔE	N_{cl}	$g_{\text{Landé}}$	LS percentage composition						JJ percentage composition					
							Comp1	%	Comp2	%	Comp3	%	Comp1	%	Comp2	%	Comp3	%
$4f^{10}5d$	6.5	–	104446.2	–		1.032	$d(^3K)^4K2$	24	$d(^3K)^4I2$	15	$d(^3L)^4K$	8	$d(^3K_7)3/2$	29	$d(^3K_8)5/2$	11	$d(^3K_6)5/2$	5
$4f^{10}5d$	7.5	–	104495.3	–		1.150	$d(^5G)^6H$	16	$d(^3L)^4I$	11	$d(^3K)^2K2$	11	$d(^3L_9)3/2$	14	$d(^5G_6)5/2$	12	$d(^3K_8)5/2$	5
$4f^{10}5d$	3.5	–	104540.4	–		0.914	$d(^5F)^4H$	36	$d(^3D)^2G1$	5	$d(^3D)^4G1$	4	$d(^5F_1)5/2$	19	$d(^5F_2)5/2$	10	$d(^3D_1)5/2$	7
$4f^{10}5d$	6.5	104900.68(22)	104829.5	71	5	1.125	$d(^5G)^6Ib$	16	$d(^3K)^2I2$	14	$d(^3K)^4H2$	7	$d(^3K_8)5/2$	18	$d(^5G_4)5/2$	11	$d(^5G_5)3/2$	4
$4f^{10}5d$	7.5	–	104930.6	–		1.098	$d(^3K)^4L2$	18	$d(^5G)^6H$	17	$d(^3G)^4I2$	6	$d(^3K_7)3/2$	16	$d(^5G_6)5/2$	13	$d(^3G_5)5/2$	6
$4f^{10}5d$	5.5	–	104948.8	–		1.039	$d(^5G)^6I$	36	$d(^3G)^4I2$	9	$d(^5G)^4I$	8	$d(^5G_4)3/2$	31	$d(^5G_5)3/2$	6	$d(^3G_4)3/2$	5
$4f^{10}5d$	4.5	–	104965.7	–		1.258	$d(^5G)^6D$	17	$d(^5F)^4F$	16	$d(^5F)^4G$	8	$d(^5G_6)3/2$	8	$d(^5F_4)5/2$	7	$d(^5G_5)3/2$	5
$4f^{10}5d$	8.5	–	105119.5	–		1.003	$d(^3K)^4M2$	28	$d(^3K)^2L2$	22	$d(^3K)^4M1$	9	$d(^3K_7)3/2$	31	$d(^3K_7)3/2$	10	$d(^3K_6)5/2$	7
$4f^{10}5d$	3.5	–	105231.0	–		1.191	$d(^5F)^4F$	16	$d(^5G)^6D$	12	$d(^5F)^4H$	9	$d(^5G_5)3/2$	12	$d(^5F_3)3/2$	7	$d(^5F_2)5/2$	7
$4f^{10}5d$	2.5	–	105415.5	–		1.021	$d(^5F)^4F$	15	$d(^5F)^6G$	12	$d(^5F)^4G$	8	$d(^5F_4)5/2$	19	$d(^5F_3)5/2$	11	$d(^5F_5)5/2$	4
$4f^{10}5d$	4.5	105422.46(22)	105367.8	55	5	1.221	$d(^5G)^6G$	20	$d(^5F)^4G$	9	$d(^5G)^6H$	9	$d(^5G_5)3/2$	21	$d(^5F_4)3/2$	6	$d(^5G_4)5/2$	6
$4f^{10}5d$	5.5	–	105599.3	–		1.252	$d(^5G)^4G$	20	$d(^5G)^6G$	11	$d(^5G)^6F$	9	$d(^5G_6)5/2$	23	$d(^5G_5)5/2$	10	$d(^5G_6)3/2$	4
$4f^{10}5d$	7.5	–	105792.6	–		1.169	$d(^3L)^4I$	25	$d(^5G)^6I$	12	$d(^3G)^4I2$	10	$d(^3L_9)3/2$	18	$d(^5G_5)5/2$	15	$d(^3G_5)5/2$	10
$4f^{10}5d$	6.5	–	105841.2	–		1.221	$d(^5G)^6G$	27	$d(^5G)^4H$	11	$d(^5G)^6H$	9	$d(^5G_6)5/2$	31	$d(^5G_5)5/2$	13	$d(^3G_5)5/2$	4
$4f^{10}5d$	3.5	–	105919.2	–		1.100	$d(^5F)^4G$	18	$d(^5S)^4D$	7	$d(^5F)^6H$	7	$d(^5F_1)5/2$	12	$d(^5F_3)5/2$	12	$d(^5S_2)3/2$	5
$4f^{10}5d$	4.5	–	106039.1	–		1.101	$d(^5G)^6H$	14	$d(^5G)^6I$	11	$d(^5F)^4G$	10	$d(^5G_4)3/2$	24	$d(^5F_4)5/2$	3	$d(^3H_6)3/2$	3
$4f^{10}5d$	0.5	–	106052.4	–		0.663	$d(^5F)^4D$	43	$d(^5F)^4P$	11	$d(^5G)^4D$	7	$d(^5F_1)3/2$	27	$d(^5F_2)5/2$	21	$d(^5F_3)5/2$	5
$4f^{10}5d$	6.5	–	106195.3	–		1.178	$d(^3H)^4I4$	13	$d(^3H)^4I3$	10	$d(^5G)^6H$	8	$d(^5G_6)3/2$	8	$d(^3H_5)5/2$	7	$d(^3G_5)5/2$	6
$4f^{10}5d$	5.5	106391.16(23)	106354.3	37	4	1.235	$d(^5G)^4G$	23	$d(^3H)^4G4$	13	$d(^3H)^4G3$	8	$d(^5G_5)3/2$	21	$d(^5G_6)3/2$	11	$d(^3H_6)3/2$	6
$4f^{10}5d$	1.5	–	106663.7	–		0.536	$d(^5F)^4F$	31	$d(^3F)^4F4$	10	$d(^5G)^6G$	10	$d(^5F_2)5/2$	10	$d(^5F_3)5/2$	9	$d(^5F_1)3/2$	7
$4f^{10}5d$	2.5	–	106681.7	–		0.796	$d(^5F)^4G$	39	$d(^3D)^2F1$	11	$d(^5S)^4D$	8	$d(^5F_2)5/2$	15	$d(^5F_3)5/2$	8	$d(^5F_1)5/2$	8
$4f^{10}5d$	10.5	–	106680.9	–		1.050	$d(^3L)^2N$	46	$d(^3L)^4N$	28	$d(^3M)^4O$	9	$d(^3L_9)3/2$	79	$d(^3M_9)3/2$	11	$d(^3M_9)5/2$	2
$4f^{10}5d$	3.5	–	106743.7	–		1.058	$d(^5F)^4G$	13	$d(^5G)^6G$	9	$d(^3F)^4F4$	7	$d(^5G_4)3/2$	9	$d(^5F_3)5/2$	8	$d(^5F_4)5/2$	4
$4f^{10}5d$	1.5	–	106991.1	–		1.102	$d(^5F)^6F$	18	$d(^5G)^6F$	13	$d(^5G)^6D$	10	$d(^5G_4)5/2$	9	$d(^5G_3)3/2$	8	$d(^5F_3)3/2$	5
$4f^{10}5d$	7.5	–	107173.9	–		1.144	$d(^3H)^2K4$	13	$d(^5G)^6I$	13	$d(^3H)^4K4$	11	$d(^3H_6)3/2$	20	$d(^5G_6)5/2$	11	$d(^5G_6)3/2$	8
$4f^{10}5d$	4.5	–	107207.4	–		1.096	$d(^5G)^6G$	7	$d(^3F)^4G4$	7	$d(^3F)^4F4$	7	$d(^3F_4)3/2$	8	$d(^3F_4)5/2$	5	$d(^1G_4)5/2$	4
$4f^{10}5d$	0.5	–	107353.6	–		0.923	$d(^5F)^4P$	31	$d(^5G)^6F$	19	$d(^3D)^4D1$	7	$d(^5G_2)3/2$	18	$d(^5F_1)3/2$	11	$d(^5F_3)5/2$	7
$4f^{10}5d$	3.5	107500.00(23)	107523.7	−24	4	1.140	$d(^5F)^4F$	12	$d(^5F)^4D$	10	$d(^5G)^6H$	9	$d(^5G_4)3/2$	8	$d(^5F_3)3/2$	7	$d(^5F_4)5/2$	7
$4f^{10}5d$	2.5	–	107541.2	–		1.109	$d(^5G)^6D$	18	$d(^5F)^4F$	9	$d(^5G)^6G$	8	$d(^5G_4)5/2$	12	$d(^5G_3)3/2$	7	$d(^5F_2)3/2$	5
$4f^{10}5d$	6.5	–	107544.2	–		1.096	$d(^5G)^6I$	23	$d(^5F)^4H$	8	$d(^5G)^4I$	6	$d(^5G_5)3/2$	21	$d(^5G_4)5/2$	5	$d(^5F_5)3/2$	5
$4f^{10}5d$	5.5	107671.45(21)	107618.0	53	5	1.133	$d(^3K)^2H2$	11	$d(^5F)^4H$	11	$d(^5G)^6G$	7	$d(^3K_8)5/2$	8	$d(^5F_4)3/2$	6	$d(^5F_5)5/2$	6
$4f^{10}5d$	1.5	–	107709.9	–		0.987	$d(^5F)^4P$	12	$d(^3P)^4D2$	10	$d(^5F)^4D$	10	$d(^5F_2)3/2$	20	$d(^5F_2)5/2$	4	$d(^3P_2)3/2$	4
$4f^{10}5d$	4.5	107754.8(3)	107804.5	−50	3	1.257	$d(^3H)^4F4$	22	$d(^3H)^4F3$	16	$d(^5F)^4F$	9	$d(^3H_6)3/2$	14	$d(^3H_6)3/2$	10	$d(^3H_6)5/2$	6
$4f^{10}5d$	5.5	107867.73(18)	107911.9	−44	6	0.963	$d(^3K)^4K2$	21	$d(^3K)^4I2$	14	$d(^3K)^2H2$	10	$d(^3K_7)3/2$	17	$d(^3K_6)3/2$	15	$d(^3K_7)5/2$	7
$4f^{10}6s$	7.5	108064.95(14)	108092.2	−27	6	1.222	$s(^5I)^6I$	68	$s(^5I)^4I$	22	$d(^3L)^4I$	2	$s(^5I_7)1/2$	88	$s(^3K_7)1/2$	2	$d(^3L_9)3/2$	1
$4f^{10}5d$	3.5	–	108122.6	–		0.875	$d(^5G)^6I$	24	$d(^5F)^4G$	9	$d(^3F)^4H4$	7	$d(^5G_2)3/2$	17	$d(^5F_2)3/2$	10	$d(^3F_2)3/2$	5
$4f^{10}5d$	4.5	–	108184.9	–		1.095	$d(^5G)^6I$	28	$d(^5G)^6G$	8	$d(^5G)^6F$	7	$d(^5G_3)3/2$	20	$d(^5G_4)5/2$	13	$d(^5G_2)5/2$	4
$4f^{10}5d$	2.5	–	108265.3	–		0.962	$d(^5G)^6G$	26	$d(^3F)^4F4$	12	$d(^5G)^6H$	7	$d(^5G_3)3/2$	28	$d(^5G_4)3/2$	6	$d(^3F_3)3/2$	5
$4f^{10}5d$	3.5	–	108290.7	–		1.084	$d(^3G)^2F2$	6	$d(^5F)^4F$	6	$d(^1G)^2G4$	6	$d(^5G_4)5/2$	5	$d(^3G_5)5/2$	4	$d(^1G_4)3/2$	3
$4f^{10}5d$	5.5	–	108366.8	–		1.135	$d(^5G)^6H$	22	$d(^5G)^4H$	7	$d(^3G)^4G2$	6	$d(^5G_5)3/2$	15	$d(^5G_4)5/2$	6	$d(^3K_8)5/2$	4

Table 2. (Continued.)

Conf	J	E_{exp} (unc.)	E_{cal}	ΔE	N_{cl}	$g_{\mathrm{Landé}}$	LS percentage composition						JJ percentage composition					
							Comp1	%	Comp2	%	Comp3	%	Comp1	%	Comp2	%	Comp3	%
$4f^{10}5d$	7.5	–	108388.4	–		1.018	$d(^3K)^4M2$	25	$d(^3K)^4K2$	19	$d(^3K)^4M1$	5	$d(^3K_6)3/2$	23	$d(^3K_7)5/2$	13	$d(^3K_6)3/2$	5
$4f^{10}5d$	6.5	108402.77(18)	108385.1	18	5	1.142	$d(^3H)^4H4$	15	$d(^3H)^4H3$	11	$d(^5G)^4I$	11	$d(^3H_6)5/2$	10	$d(^3H_6)5/2$	7	$d(^3H_6)3/2$	4
$4f^{10}5d$	9.5	–	108420.4	–		1.079	$d(^3L)^4L$	20	$d(^3K)^2M2$	14	$d(^3L)^4M$	13	$d(^3L_9)3/2$	41	$d(^3K_7)5/2$	23	$d(^3K_8)5/2$	2
$4f^{10}6s$	6.5	108590.81(14)	108691.8	−101	8	1.066	$s(^5I)^6I$	29	$s(^5I)^4I$	28	$d(^3K)^4L2$	11	$s(^5I_7)1/2$	55	$d(^3K_6)3/2$	9	$d(^3K_7)5/2$	4
$4f^{10}5d$	4.5	–	108718.1	–		1.093	$d(^3K)^4H2$	18	$d(^3G)^4F2$	7	$d(^5G)^6I$	6	$d(^3K_7)5/2$	10	$d(^5G_3)3/2$	5	$d(^5G_5)3/2$	4
$4f^{10}5d$	8.5	–	108726.5	–		1.138	$d(^3L)^4K$	64	$d(^3L)^4L$	9	$d(^3M)^4L$	8	$d(^3L_9)3/2$	69	$d(^3L_9)5/2$	9	$d(^3M_9)5/2$	3
$4f^{10}5d$	7.5	–	109000.7	–		1.161	$d(^3H)^4I4$	18	$d(^3L)^4I$	17	$d(^5G)^6I$	11	$d(^3H_6)5/2$	15	$d(^3L_9)3/2$	12	$d(^3H_6)5/2$	9
$4f^{10}5d$	6.5	–	109050.1	–		1.014	$d(^3K)^4L2$	23	$s(^5I)^6I$	21	$s(^5I)^4I$	15	$s(^5I_7)1/2$	33	$d(^3K_6)3/2$	17	$d(^3K_6)5/2$	5
$4f^{10}5d$	8.5	–	109067.1	–		1.055	$d(^3K)^4L2$	33	$d(^3K)^4L1$	11	$d(^3K)^2L2$	11	$d(^3K_7)5/2$	48	$d(^3K_7)5/2$	7	$d(^3K_8)3/2$	3
$4f^{10}5d$	3.5	–	109103.7	–		1.151	$d(^5F)^4G$	12	$d(^5F)^4F$	10	$d(^5G)^6D$	10	$d(^5G_4)5/2$	12	$d(^5G_3)3/2$	8	$d(^5F_2)3/2$	7
$4f^{10}5d$	5.5	–	109291.1	–		1.067	$d(^3K)^4K2$	9	$d(^3F)^4G4$	9	$d(^5F)^4H$	6	$d(^3K_6)3/2$	12	$d(^3F_4)5/2$	7	$d(^5F_4)3/2$	2
$4f^{10}5d$	2.5	–	109321.5	–		0.883	$d(^5F)^4F$	13	$d(^3F)^4G4$	10	$d(^5G)^4G$	9	$d(^5G_2)3/2$	12	$d(^5F_2)3/2$	7	$d(^3F_2)3/2$	6
$4f^{10}5d$	9.5	–	109312.2	–		1.064	$d(^3K)^4M2$	27	$d(^3L)^2M$	16	$d(^3L)^4M$	15	$d(^3L_9)3/2$	42	$d(^3K_7)5/2$	18	$d(^3K_8)3/2$	8
$4f^{10}5d$	11.5	–	109322.5	–		1.117	$d(^3L)^4N$	78	$d(^3M)^4O$	18	$d(^3M)^4N$	4	$d(^3L_9)5/2$	78	$d(^3M_9)5/2$	10	$d(^3M_{10})3/2$	10
$4f^{10}5d$	4.5	–	109588.0	–		1.121	$d(^5G)^6F$	8	$d(^3G)^2G2$	6	$d(^5G)^6G$	6	$d(^5G_4)5/2$	7	$d(^3F_4)5/2$	3	$d(^3G_5)5/2$	3
$4f^{10}5d$	0.5	–	109690.5	–		1.476	$d(^5F)^4P$	18	$d(^5G)^6F$	18	$d(^3D)^4P1$	12	$d(^3P_2)3/2$	9	$d(^5G_3)5/2$	8	$d(^5F_1)3/2$	7
$4f^{10}5d$	7.5	–	109676.1	–		0.944	$d(^3K)^4M2$	28	$d(^3K)^2L2$	19	$d(^3K)^4K2$	10	$d(^3K_6)3/2$	36	$d(^3K_7)5/2$	23	$d(^3K_7)3/2$	3
$4f^{10}5d$	4.5	–	109768.6	–		1.082	$d(^5G)^4G$	14	$d(^3K)^4H2$	9	$d(^5G)^6F$	7	$d(^5G_5)5/2$	14	$d(^5G_3)3/2$	8	$d(^3K_7)5/2$	5
$4f^{10}5d$	3.5	–	109780.9	–		0.916	$d(^5G)^6I$	25	$d(^3G)^2F2$	6	$d(^3D)^4G1$	6	$d(^5G_2)3/2$	19	$d(^3G_5)5/2$	4	$d(^3F_2)3/2$	3
$4f^{10}5d$	5.5	–	109867.9	–		1.059	$d(^5G)^6H$	8	$d(^3K)^4K2$	7	$d(^3G)^2H2$	6	$d(^5G_4)5/2$	9	$d(^3K_8)5/2$	4	$d(^3K_6)3/2$	4
$4f^{10}5d$	1.5	–	109891.9	–		0.969	$d(^5F)^4F$	17	$d(^3D)^4S1$	10	$d(^3P)^4F2$	7	$d(^3D_3)3/2$	11	$d(^5F_2)5/2$	6	$d(^5F_3)5/2$	5
$4f^{10}5d$	6.5	–	109919.4	–		1.052	$d(^3K)^2K2$	13	$d(^3K)^4L2$	8	$d(^5G)^4I$	8	$d(^3K_6)3/2$	16	$d(^3K_7)5/2$	9	$d(^5G_5)3/2$	3
$4f^{10}5d$	2.5	–	110045.4	–		1.159	$d(^5G)^6F$	20	$d(^5D)^6F$	9	$d(^3G)^4D2$	8	$d(^5G_4)3/2$	7	$d(^5G_3)5/2$	6	$d(^5G_2)5/2$	5
$4f^{10}5d$	3.5	–	110051.7	–		1.089	$d(^5F)^6F$	8	$d(^3F)^4G4$	8	$d(^3G)^4F2$	4	$d(^3F_3)3/2$	4	$d(^3F_2)5/2$	3	$d(^5F_4)3/2$	3
$4f^{10}5d$	4.5	–	110574.8	–		1.162	$d(^5G)^4F$	32	$d(^3H)^2G4$	8	$d(^5G)^4G$	4	$d(^5G_6)5/2$	28	$d(^5G_6)3/2$	5	$d(^3H_6)5/2$	5
$4f^{10}5d$	5.5	110614.87(23)	110586.8	28	5	1.080	$d(^5G)^6G$	15	$d(^3H)^2H4$	7	$d(^3K)^2H2$	7	$d(^5G_5)5/2$	6	$d(^3K_8)5/2$	5	$d(^5G_6)3/2$	4
$4f^{10}5d$	7.5	–	110706.6	–		1.157	$d(^5G)^4I$	38	$d(^5G)^6I$	9	$d(^3L)^4I$	8	$d(^5G_5)5/2$	23	$d(^5G_6)3/2$	12	$d(^5G_6)5/2$	11
$4f^{10}5d$	8.5	–	110742.0	–		1.181	$d(^3H)^4K4$	34	$d(^3H)^4K3$	26	$d(^5G)^6I$	12	$d(^3H_6)5/2$	34	$d(^3H_6)5/2$	26	$d(^5G_6)5/2$	12
$4f^{10}5d$	2.5	–	110743.4	–		1.218	$d(^5G)^4D$	10	$d(^3F)^4D4$	8	$d(^3D)^4G1$	4	$d(^5G_5)5/2$	5	$d(^3D_1)3/2$	4	$d(^5G_4)3/2$	3
$4f^{10}5d$	6.5	–	110820.8	–		1.181	$d(^5G)^6H$	26	$d(^5G)^4H$	16	$d(^3L)^4I$	9	$d(^5G_5)5/2$	34	$d(^5G_6)5/2$	14	$d(^3L_8)3/2$	4
$4f^{10}5d$	1.5	–	110965.2	–		0.881	$d(^5S)^4D$	10	$d(^5G)^6G$	10	$d(^5G)^6F$	8	$d(^5G_2)5/2$	10	$d(^5S_2)5/2$	8	$d(^5G_2)3/2$	5
$4f^{10}5d$	5.5	110962.71(18)	110943.2	20	6	0.999	$d(^3K)^2I2$	18	$d(^3K)^4I2$	10	$d(^3K)^4H2$	8	$d(^3K_7)5/2$	34	$d(^3K_6)3/2$	2	$d(^3K_6)3/2$	2
$4f^{10}5d$	4.5	–	111023.8	–		1.123	$d(^3D)^4G1$	12	$d(^5G)^4H$	10	$d(^3P)^4F2$	9	$d(^3P_2)5/2$	9	$d(^3D_2)5/2$	8	$d(^1D_2)5/2$	5
$4f^{10}5d$	6.5	–	111163.8	–		1.089	$d(^3K)^4I2$	14	$d(^5G)^6H$	10	$d(^3K)^4K2$	8	$d(^3K_6)5/2$	12	$d(^3K_7)5/2$	11	$d(^5G_5)5/2$	5
$4f^{10}5d$	1.5	–	111351.5	–		1.116	$d(^5G)^6G$	22	$d(^5G)^6D$	12	$d(^3D)^4P1$	11	$d(^5G_3)5/2$	21	$d(^3D_3)3/2$	13	$d(^5G_2)3/2$	10
$4f^{10}5d$	5.5	–	111463.8	–		1.072	$d(^5G)^4G$	13	$d(^5G)^4I$	11	$d(^5G)^4H$	7	$d(^5G_4)5/2$	9	$d(^5G_3)5/2$	7	$d(^5G_5)3/2$	7
$4f^{10}5d$	3.5	–	111490.1	–		1.153	$d(^5G)^4D$	20	$d(^5G)^6G$	11	$d(^5G)^6F$	7	$d(^5G_6)5/2$	14	$d(^5G_4)3/2$	8	$d(^5G_3)5/2$	7
$4f^{10}5d$	2.5	–	111572.9	–		0.920	$d(^5G)^6H$	19	$d(^5G)^6D$	11	$d(^5F)^4G$	7	$d(^5G_2)5/2$	12	$d(^5G_2)3/2$	7	$d(^5G_4)5/2$	7
$4f^{10}5d$	7.5	–	111712.2	–		1.146	$d(^5G)^6H$	12	$d(^5G)^6I$	12	$d(^3H)^2K4$	10	$d(^5G_5)5/2$	18	$d(^5G_6)5/2$	7	$d(^3G_5)5/2$	5
$4f^{10}5d$	4.5	–	111749.1	–		1.095	$d(^5G)^4G$	8	$d(^5G)^4F$	7	$d(^3K)^4I2$	6	$d(^5G_5)5/2$	11	$d(^5G_5)3/2$	10	$d(^3K_6)5/2$	4

Table 2. (Continued.)

Conf	J	E_{exp} (unc.)	E_{cal}	ΔE	N_{cl}	$g_{\mathrm{Landé}}$	LS percentage composition						JJ percentage composition					
							Comp1	%	Comp2	%	Comp3	%	Comp1	%	Comp2	%	Comp3	%
$4f^{10}5d$	11.5	–	111729.4	–		1.053	$d(^3M)^2O$	62	$d(^3M)^4O$	26	$d(^3L)^4N$	8	$d(^3M_{10})3/2$	83	$d(^3L_9)5/2$	8	$d(^3M_{10})5/2$	6
$4f^{10}5d$	6.5	111812.5(4)	111827.7	−15	2	1.159	$d(^5G)^4H$	37	$d(^3G)^4H2$	7	$d(^5G)^4I$	5	$d(^5G_5)3/2$	15	$d(^5G_6)3/2$	12	$d(^5G_6)5/2$	11
$4f^{10}5d$	0.5	–	111837.4	–		1.757	$d(^5G)^6D$	34	$d(^5F)^6F$	9	$d(^3D)^4P1$	5	$d(^5G_3)5/2$	18	$d(^5G_2)5/2$	16	$d(^5G_2)3/2$	5
$4f^{10}5d$	3.5	–	111854.2	–		1.097	$d(^5G)^6G$	9	$d(^5G)^6I$	8	$d(^5G)^6H$	6	$d(^5G_2)3/2$	8	$d(^5G_4)3/2$	7	$d(^5G_5)5/2$	7
$4f^{10}5d$	1.5	–	111953.7	–		1.411	$d(^5G)^6D$	26	$d(^3D)^4S1$	10	$d(^3P)^4F2$	8	$d(^5G_3)5/2$	11	$d(^5G_2)5/2$	8	$d(^5G_4)5/2$	4
$4f^{10}5d$	10.5	–	112079.1	–		1.123	$d(^3L)^4M$	79	$d(^3L)^2N$	9	$d(^3M)^4N$	5	$d(^3L_9)5/2$	85	$d(^3M_9)5/2$	7	$d(^3L_9)3/2$	2
$4f^{10}5d$	4.5	–	112108.4	–		1.098	$d(^5G)^4F$	7	$d(^3H)^2G3$	7	$d(^3H)^2G4$	6	$d(^3H_6)5/2$	6	$d(^5G_6)5/2$	4	$d(^3K_6)5/2$	4
$4f^{10}5d$	1.5	–	112232.2	–		1.122	$d(^3D)^4P1$	9	$d(^5G)^6F$	8	$d(^3P)^4P2$	8	$d(^3D_3)3/2$	4	$d(^3D_1)5/2$	3	$d(^5G_2)5/2$	3
$4f^{10}5d$	3.5	–	112281.9	–		0.893	$d(^3K)^4H2$	31	$d(^3K)^4H1$	6	$d(^3G)^4H2$	5	$d(^3K_6)5/2$	31	$d(^3K_6)5/2$	6	$d(^3G_3)3/2$	3
$4f^{10}5d$	2.5	–	112289.6	–		1.151	$d(^5G)^6D$	17	$d(^5G)^6G$	7	$d(^5F)^4G$	6	$d(^5G_3)5/2$	9	$d(^5G_4)3/2$	8	$d(^5G_5)5/2$	4
$4f^{10}5d$	4.5	–	112415.4	–		1.036	$d(^3K)^4I2$	13	$d(^5G)^4G$	7	$d(^3H)^2G4$	5	$d(^3K_6)3/2$	12	$d(^3K_6)5/2$	5	$d(^3H_6)5/2$	3
$4f^{10}5d$	8.5	112331.4(6)	112422.4	−91	1	1.154	$d(^3M)^4K$	69	$d(^3M)^4L$	4	$d(^3L)^4L$	4	$d(^3M_{10})3/2$	63	$d(^3M_{10})5/2$	10	$d(^3H_6)5/2$	3
$4f^{10}5d$	2.5	–	112517.0	–		1.068	$d(^3F)^4F4$	6	$d(^3G)^2D2$	6	$d(^3G)^4G2$	5	$d(^3F_3)3/2$	5	$d(^3G_5)5/2$	3	$d(^3G_4)3/2$	3
$4f^{10}5d$	9.5	–	112538.5	–		1.017	$d(^3L)^4N$	34	$d(^3L)^4L$	23	$d(^3M)^4O$	12	$d(^3L_8)3/2$	39	$d(^3L_9)5/2$	19	$d(^3M_8)3/2$	10
$4f^{10}6s$	5.5	–	112563.6	–		1.022	$s(^5I)^6I$	67	$s(^5I)^4I$	21	$s(^3H)^4H4$	1	$s(^5I_6)1/2$	81	$s(^5I_5)1/2$	7	$s(^3H_6)1/2$	2
$4f^{10}5d$	5.5	112645.46(14)	112581.5	64	6	1.075	$d(^3F)^4G4$	12	$d(^5D)^6F$	11	$d(^5G)^4I$	7	$d(^3F_4)5/2$	9	$d(^5D_4)5/2$	7	$d(^3H_4)3/2$	4
$4f^{10}6s$	6.5	112700.02(14)	112672.3	28	8	1.131	$s(^5I)^4I$	49	$s(^5I)^6I$	41	$s(^3H)^4H4$	2	$s(^5I_6)1/2$	84	$s(^5I_7)1/2$	5	$s(^3H_6)1/2$	2
$4f^{10}5d$	7.5	112845.3(4)	112982.8	−137	2	1.057	$d(^3L)^4I$	8	$d(^3K)^2L2$	8	$d(^3K)^4L2$	7	$d(^3L_9)5/2$	20	$d(^3K_6)5/2$	12	$d(^3L_8)5/2$	2
$4f^{10}5d$	3.5	–	112919.1	–		1.111	$d(^5G)^4D$	10	$d(^3D)^4F1$	7	$d(^5G)^6F$	7	$d(^5G_6)5/2$	9	$d(^5G_3)5/2$	7	$d(^5F_1)5/2$	3
$4f^{10}5d$	0.5	–	112981.7	–		0.567	$d(^3P)^4D2$	30	$d(^3D)^4D1$	13	$d(^5F)^6F$	7	$d(^3P_1)3/2$	22	$d(^3P_2)3/2$	4	$d(^3D_1)3/2$	4
$4f^{10}5d$	2.5	–	113000.1	–		1.315	$d(^3D)^4P1$	21	$d(^3F)^4P4$	9	$d(^3D)^4P2$	7	$d(^3D_3)3/2$	14	$d(^3D_3)5/2$	9	$d(^3F_4)3/2$	4
$4f^{10}5d$	6.5	–	113334.3	–		1.002	$d(^3K)^2K2$	14	$d(^3K)^4K2$	10	$d(^3K)^4L2$	9	$d(^3K_6)5/2$	31	$d(^3L_9)5/2$	3	$d(^3M_8)3/2$	3
$4f^{10}5d$	9.5	–	113339.6	–		1.123	$d(^3M)^4L$	53	$d(^3M)^4M$	12	$d(^3L)^2M$	11	$d(^3M_{10})3/2$	62	$d(^3L_9)5/2$	19	$d(^3M_{10})5/2$	6
$4f^{10}5d$	3.5	113372.2(4)	113455.5	−83	2	1.218	$d(^3D)^4D1$	13	$d(^5G)^4G$	6	$d(^5G)^4D$	4	$d(^3D_3)5/2$	7	$d(^5G_6)5/2$	4	$d(^3D_2)5/2$	3
$4f^{10}5d$	6.5	–	113513.2	–		1.072	$d(^3L)^4I$	29	$d(^5G)^4I$	10	$d(^3M)^4K$	10	$d(^3L_9)5/2$	25	$d(^3M_9)5/2$	6	$d(^3L_8)5/2$	5
$4f^{10}5d$	5.5	–	113548.3	–		1.116	$d(^5G)^6I$	15	$d(^5G)^4I$	13	$d(^5G)^4G$	11	$d(^5G_3)5/2$	31	$d(^5G_6)5/2$	7	$d(^5G_6)3/2$	4
$4f^{10}5d$	9.5	–	113603.6	–		1.053	$d(^3L)^4L$	22	$d(^3M)^4L$	19	$d(^3M)^4O$	16	$d(^3L_9)5/2$	35	$d(^3M_8)3/2$	13	$d(^3M_{10})3/2$	10
$4f^{10}5d$	2.5	–	113690.4	–		0.920	$d(^3P)^4F2$	15	$d(^3H)^4G4$	5	$d(^3G)^2F2$	5	$d(^3P_1)3/2$	7	$d(^3P_2)3/2$	3	$d(^3P0)5/2$	3
$4f^{10}5d$	5.5	–	113759.4	–		1.063	$d(^3K)^4I2$	12	$d(^3K)^2I2$	12	$d(^5D)^6F$	10	$d(^3K_6)5/2$	31	$d(^5D_4)5/2$	7	$d(^3D_3)5/2$	5
$4f^{10}5d$	8.5	–	113752.0	–		1.061	$d(^3L)^4L$	30	$d(^3L)^4M$	12	$d(^3L)^2L$	11	$d(^3L_9)5/2$	40	$d(^3L_8)3/2$	12	$d(^3L_9)3/2$	5
$4f^{10}5d$	8.5	–	113977.4	–		0.978	$d(^3K)^2M2$	45	$d(^3K)^4M2$	17	$d(^3K)^2M1$	10	$d(^3K_6)5/2$	65	$d(^3K_6)5/2$	13	$d(^3K_8)3/2$	2
$4f^{10}5d$	1.5	–	114011.1	–		1.008	$d(^3P)^4F2$	18	$d(^5G)^6D$	10	$d(^3P)^2P2$	7	$d(^3P_1)3/2$	17	$d(^5G_3)5/2$	4	$d(^3H_4)5/2$	4
$4f^{10}5d$	4.5	–	114016.1	–		1.060	$d(^3K)^2H2$	13	$d(^3F)^4F4$	9	$d(^5D)^6F$	7	$d(^3K_6)3/2$	7	$d(^3F_4)5/2$	5	$d(^3K_7)5/2$	5
$4f^{10}5d$	7.5	–	114046.0	–		1.013	$d(^3L)^4K$	23	$d(^3K)^2L2$	16	$d(^3L)^4L$	8	$d(^3K_6)5/2$	25	$d(^3L_8)3/2$	18	$d(^3L_9)5/2$	5
$4f^{10}5d$	4.5	–	114065.9	–		0.962	$d(^5G)^6H$	18	$d(^5G)^4I$	16	$d(^1G)^2H4$	6	$d(^5G_3)5/2$	38	$d(^1G_4)3/2$	4	$d(^5G_4)3/2$	2
$4f^{10}5d$	3.5	–	114366.0	–		1.117	$d(^5G)^6H$	8	$d(^3F)^4D4$	7	$d(^3K)^4H2$	6	$d(^3K_6)5/2$	6	$d(^5G_3)3/2$	3	$d(^3F_4)5/2$	3
$4f^{10}5d$	2.5	–	114395.0	–		1.109	$d(^3D)^4F1$	11	$d(^3D)^2D1$	7	$d(^3D)^4D1$	7	$d(^3D_3)3/2$	17	$d(^3D_3)5/2$	4	$d(^3D_2)5/2$	3
$4f^{10}5d$	12.5	–	114364.4	–		1.118	$d(^3M)^4O$	97	$d(^1N)^2Q$	3			$d(^3M_{10})5/2$	97	$d(^1N_{10})5/2$	3		
$4f^{10}5d$	0.5	–	114442.6	–		1.556	$d(^5G)^6D$	19	$d(^3F)^2P2$	14	$d(^3P)^4P2$	9	$d(^5G_2)5/2$	14	$d(^3P_2)3/2$	7	$d(^3F_2)3/2$	7
$4f^{10}5d$	4.5	–	114494.2	–		0.908	$d(^3K)^4I2$	18	$d(^3K)^4H2$	12	$d(^3K)^2H2$	7	$d(^3K_6)5/2$	35	$d(^3L_7)5/2$	6	$d(^5G_2)5/2$	3

Table 2. (Continued.)

Conf	J	E_{exp} (unc.)	E_{cal}	ΔE	N_{cl}	$g_{\text{Landé}}$	LS percentage composition						JJ percentage composition					
							Comp1	%	Comp2	%	Comp3	%	Comp1	%	Comp2	%	Comp3	%
$4f^{10}5d$	5.5	–	114644.7	–		1.102	$d(^5G)^4H$	15	$d(^5G)^6I$	6	$d(^3K)^4I2$	5	$d(^5G_5)5/2$	7	$d(^5G_3)5/2$	6	$d(^5G_5)3/2$	5
$4f^{10}5d$	3.5	–	114681.0	–		1.079	$d(^5G)^4F$	7	$d(^3P)^4F2$	6	$d(^3H)^4F3$	6	$d(^3P_1)5/2$	3	$d(^3F_4)5/2$	3	$d(^5G_5)5/2$	3
$4f^{10}5d$	2.5	–	114792.2	–		1.090	$d(^5F)^4F$	7	$d(^3P)^2D2$	6	$d(^5G)^4D$	5	$d(^5G_5)5/2$	7	$d(^5S_2)5/2$	3	$d(^3P_2)5/2$	3
$4f^{10}5d$	6.5	–	114801.3	–		1.066	$d(^3F)^4H4$	12	$d(^5G)^4I$	7	$d(^3K)^2K2$	7	$d(^3F_4)5/2$	12	$d(^1G_4)5/2$	5	$d(^3H_4)5/2$	3
$4f^{10}5d$	3.5	–	114838.0	–		0.978	$d(^3K)^4H2$	12	$d(^5D)^6F$	8	$d(^5G)^4H$	6	$d(^3K_6)5/2$	12	$d(^3K_6)5/2$	4	$d(^5G_3)5/2$	2
$4f^{10}5d$	9.5	–	114996.0	–		0.979	$d(^1L)^2N2$	34	$d(^3M)^4O$	16	$d(^3L)^4N$	14	$d(^1L_8)3/2$	29	$d(^3L_8)3/2$	15	$d(^3M_8)3/2$	13
$4f^{10}5d$	4.5	–	115117.8	–		1.036	$s(^5I)^6I$	26	$d(^3D)^2G1$	9	$d(^5G)^4F$	7	$s(^5I_5)1/2$	19	$d(^3D_3)3/2$	13	$s(^5I_4)1/2$	7
$4f^{10}5d$	1.5	–	115206.2	–		0.749	$d(^3P)^4F2$	11	$d(^5G)^6G$	10	$d(^3P)^4P2$	7	$d(^3P_1)3/2$	11	$d(^5G_3)5/2$	9	$d(^5G_2)5/2$	4
$4f^{10}6s$	4.5	–	115247.7	–		0.944	$s(^5I)^6I$	53	$s(^5I)^4I$	5	$d(^3D)^2G1$	5	$s(^5I_5)1/2$	55	$s(^5I_4)1/2$	3	$d(^3D_3)3/2$	2
$4f^{10}5d$	7.5	–	115288.0	–		1.027	$d(^3M)^2K$	17	$d(^1L)^2K2$	12	$d(^3K)^2L2$	11	$d(^1L_8)3/2$	18	$d(^3M_{10})5/2$	11	$d(^3K_6)5/2$	5
$4f^{10}5d$	8.5	–	115420.4	–		0.954	$d(^3L)^4N$	26	$d(^3L)^2L$	13	$d(^3M)^4N$	13	$d(^3L_7)3/2$	24	$d(^3L_8)3/2$	21	$d(^3M_8)3/2$	8
$4f^{10}5d$	4.5	–	115507.9	–		0.956	$d(^3G)^4I2$	15	$d(^3F)^4H2$	12	$d(^3F)^4H4$	10	$d(^3G_3)3/2$	19	$d(^3F_3)3/2$	7	$d(^3F_3)3/2$	6
$4f^{10}5d$	5.5	–	115678.4	–		1.047	$d(^3L)^4I$	12	$d(^5G)^4H$	9	$d(^5G)^6I$	7	$d(^5G_4)3/2$	10	$d(^3L_8)5/2$	7	$d(^1G_4)3/2$	5
$4f^{10}5d$	4.5	–	115850.9	–		1.082	$d(^5G)^4I$	7	$d(^5D)^6F$	7	$d(^5G)^4G$	6	$d(^5G_2)5/2$	5	$d(^1G_4)5/2$	3	$d(^5G_5)5/2$	3
$4f^{10}5d$	2.5	–	115988.2	–		0.992	$d(^5G)^6H$	14	$d(^3P)^4P2$	14	$d(^5G)^4G$	9	$d(^5G_3)5/2$	10	$d(^5G_2)5/2$	7	$d(^3P_1)5/2$	6
$4f^{10}6s$	5.5	115983.15(15)	115960.9	22	4	1.015	$s(^5I)^4I$	61	$s(^5I)^6I$	18	$s(^3H)^4H4$	2	$s(^5I_5)1/2$	73	$s(^5I_6)1/2$	6	$s(^3H_5)1/2$	4
$4f^{10}5d$	6.5	–	116071.4	–		1.031	$d(^3L)^2I$	14	$d(^3M)^2K$	14	$d(^3K)^2I2$	12	$d(^3L_9)5/2$	10	$d(^3M_8)3/2$	7	$d(^3K_8)5/2$	7
$4f^{10}5d$	3.5	–	116091.5	–		1.067	$d(^5G)^4G$	13	$d(^3P)^4F2$	10	$d(^3G)^2G2$	5	$d(^3P_1)5/2$	5	$d(^5G_4)5/2$	5	$d(^3P_2)3/2$	4
$4f^{10}5d$	1.5	–	116121.9	–		1.173	$d(^3P)^4P2$	12	$d(^3P)^4D2$	12	$d(^3P)^2P2$	11	$d(^3P0)3/2$	31	$d(^3P_1)5/2$	6	$d(^3P_1)3/2$	5
$4f^{10}5d$	3.5	–	116199.2	–		1.114	$d(^5G)^4F$	12	$d(^3D)^4D1$	8	$d(^3G)^4G2$	8	$d(^5G_5)5/2$	7	$d(^5G_4)3/2$	6	$d(^3F_2)3/2$	4
$4f^{10}5d$	2.5	–	116256.5	–		1.090	$d(^3G)^4G2$	13	$d(^3P)^4P2$	6	$d(^3F)^4P3$	5	$d(^3G_3)3/2$	7	$d(^3G_3)5/2$	4	$d(^3P_1)5/2$	3
$4f^{10}5d$	10.5	–	116343.9	–		1.051	$d(^3L)^2N$	28	$d(^3M)^4O$	20	$d(^3L)^4N$	19	$d(^3L_8)5/2$	42	$d(^3M_8)5/2$	19	$d(^3K_8)5/2$	12
$4f^{10}5d$	1.5	–	116374.9	–		1.082	$d(^5D)^6F$	13	$d(^5G)^4F$	9	$d(^5G)^4D$	8	$d(^5G_2)3/2$	9	$d(^5D_2)3/2$	5	$d(^5G_3)5/2$	4
$4f^{10}5d$	3.5	–	116554.2	–		1.110	$d(^5D)^6F$	14	$d(^3D)^2F1$	6	$d(^5G)^4H$	6	$d(^5G_4)5/2$	4	$d(^5D_3)3/2$	4	$d(^5D_1)5/2$	4
$4f^{10}5d$	8.5	–	116613.9	–		0.966	$d(^3L)^4N$	18	$d(^3L)^4M$	17	$d(^3L)^2M$	10	$d(^3L_7)3/2$	21	$d(^3L_8)3/2$	13	$d(^1K_7)3/2$	8
$4f^{10}5d$	5.5	–	116642.9	–		1.083	$d(^3D)^4G1$	17	$d(^3L)^4I$	10	$d(^5G)^4I$	8	$d(^3D_3)5/2$	17	$d(^3L_8)5/2$	6	$d(^3D_3)5/2$	5
$4f^{10}5d$	2.5	–	116648.2	–		1.281	$d(^5G)^4D$	14	$d(^3F)^4P3$	9	$d(^3F)^4D3$	7	$d(^3F_4)3/2$	13	$d(^5G_3)3/2$	7	$d(^5G_4)5/2$	5
$4f^{10}5d$	0.5	–	116874.1	–		1.679	$d(^3P)^4P2$	19	$d(^1D)^2S3$	15	$d(^3D)^4P1$	6	$d(^1D_2)3/2$	18	$d(^3P_2)3/2$	16	$d(^5G_2)5/2$	4
$4f^{10}5d$	4.5	–	116884.8	–		1.040	$d(^3G)^2H2$	8	$d(^3K)^2H2$	7	$d(^3D)^2G1$	7	$d(^3K_6)3/2$	4	$d(^3D_3)3/2$	4	$d(^3G_3)5/2$	3
$4f^{10}5d$	1.5	–	116918.7	–		0.971	$d(^5G)^4D$	16	$d(^5D)^6F$	10	$d(^5G)^4F$	7	$d(^5G_4)5/2$	13	$d(^5G_3)3/2$	9	$d(^5D_2)3/2$	4
$4f^{10}5d$	3.5	–	116947.1	–		0.950	$d(^3F)^4H2$	12	$d(^5G)^6I$	6	$d(^3P)^4D2$	5	$d(^3F_2)3/2$	9	$d(^5G_2)3/2$	4	$d(^3P_2)5/2$	3
$4f^{10}5d$	6.5	117050.7(3)	116991.1	60	4	1.029	$d(^3L)^2I$	17	$d(^3M)^4L$	12	$d(^3L)^4I$	9	$d(^3L_8)3/2$	15	$d(^3L_8)5/2$	12	$d(^3M_8)5/2$	9
$4f^{10}5d$	2.5	–	117139.8	–		1.145	$d(^5G)^4F$	14	$d(^3D)^4P1$	12	$d(^3D)^2F1$	8	$d(^3D_3)5/2$	9	$d(^3D_1)5/2$	5	$d(^5G_4)5/2$	5
$4f^{10}5d$	10.5	–	117124.9	–		1.089	$d(^3M)^4M$	40	$d(^3M)^4N$	27	$d(^3M)^2N$	19	$d(^3M_{10})3/2$	84	$d(^3L_8)5/2$	3	$d(^3M_8)5/2$	2
$4f^{10}5d$	0.5	–	117183.6	–		0.544	$d(^5D)^6F$	14	$d(^3F)^4D4$	9	$d(^3G)^4D2$	8	$d(^3G_3)5/2$	8	$d(^5D_1)3/2$	8	$d(^5G_2)3/2$	5
$4f^{10}5d$	3.5	–	117197.3	–		0.973	$d(^5G)^4H$	16	$s(^5I)^6I$	10	$d(^3F)^4H2$	5	$s(^5I_4)1/2$	10	$d(^5G_3)5/2$	5	$d(^5G_2)5/2$	5
$4f^{10}5d$	4.5	–	117267.3	–		1.116	$d(^3G)^4G2$	14	$d(^3D)^4F1$	8	$d(^3G)^4G3$	6	$d(^3G_4)5/2$	7	$d(^3D_3)5/2$	6	$d(^3G_5)3/2$	5
$4f^{10}6s$	3.5	–	117330.1	–		0.543	$s(^5I)^6I$	77	$s(^3H)^4H4$	5	$s(^3H)^4H3$	3	$s(^5I_4)1/2$	77	$s(^3H_4)1/2$	5	$s(^3H_4)1/2$	3
$4f^{10}5d$	5.5	–	117373.6	–		1.207	$d(^5D)^6F$	20	$d(^3D)^4G1$	14	$d(^5G)^4H$	5	$d(^3D_3)5/2$	14	$d(^5D_4)5/2$	13	$d(^5G_4)5/2$	7
$4f^{10}5d$	7.5	117384.3(5)	117441.3	–57	2	1.082	$d(^3M)^4K$	33	$d(^3I)^4K1$	13	$d(^3I)^4I1$	8	$d(^3M_9)3/2$	15	$d(^3I_7)3/2$	12	$d(^3M_{10})5/2$	9

Table 2. (Continued.)

Conf	J	E_{exp} (unc.)	E_{cal}	ΔE	N_{cl}	$g_{\mathrm{Landé}}$	LS percentage composition						JJ percentage composition					
							Comp1	%	Comp2	%	Comp3	%	Comp1	%	Comp2	%	Comp3	%
$4f^{10}5d$	6.5	117429.1(4)	117487.8	−59	3	1.056	$d(^{3}L)^{4}K$	8	$d(^{3}I)^{4}H1$	7	$d(^{1}L)^{2}I2$	6	$d(^{1}L_{8})3/2$	5	$d(^{3}I_{7})3/2$	3	$d(^{3}I_{7})5/2$	3
$4f^{10}5d$	1.5	–	117490.1	–		1.088	$d(^{5}D)^{6}F$	10	$d(^{3}F)^{2}P4$	8	$d(^{3}F)^{2}P2$	6	$d(^{3}F_{4})5/2$	5	$d(^{5}D_{2})3/2$	4	$d(^{5}G_{3})3/2$	4
$4f^{10}5d$	3.5	–	117568.0	–		1.133	$d(^{3}P)^{4}D2$	9	$d(^{3}D)^{4}G1$	5	$d(^{3}P)^{2}F2$	5	$d(^{3}P_{1})5/2$	7	$d(^{3}P_{2})3/2$	6	$d(^{3}D_{3})3/2$	3
$4f^{10}5d$	10.5	–	117592.0	–		0.997	$d(^{3}M)^{4}O$	49	$d(^{3}L)^{4}N$	23	$d(^{3}M)^{2}O$	20	$d(^{3}M_{9})3/2$	58	$d(^{3}L_{8})5/2$	16	$d(^{3}M_{9})5/2$	9
$4f^{10}5d$	2.5	–	117649.3	–		1.117	$d(^{5}D)^{6}F$	19	$d(^{3}G)^{4}F2$	9	$d(^{3}P)^{4}F2$	6	$d(^{5}D_{3})3/2$	9	$d(^{5}D_{1})3/2$	7	$d(^{3}G_{3})5/2$	4
$4f^{10}5d$	6.5	–	117721.6	–		0.965	$d(^{3}L)^{4}K$	18	$d(^{3}I)^{4}L1$	13	$d(^{3}L)^{4}L$	9	$d(^{3}L_{7})3/2$	12	$d(^{3}I_{5})3/2$	10	$d(^{3}L_{8})5/2$	10
$4f^{10}5d$	5.5	–	117797.0	–		0.970	$d(^{3}I)^{4}K1$	20	$d(^{3}I)^{4}K2$	4	$d(^{1}H)^{2}I1$	4	$d(^{3}I_{5})3/2$	13	$d(^{3}I_{5})5/2$	6	$d(^{1}H_{5})3/2$	3
$4f^{10}5d$	8.5	–	117818.7	–		1.048	$d(^{3}M)^{4}L$	32	$d(^{1}L)^{2}L2$	8	$d(^{3}L)^{4}N$	7	$d(^{3}M_{10})5/2$	18	$d(^{1}L_{8})3/2$	13	$d(^{3}M_{10})3/2$	9
$4f^{10}5d$	2.5	–	117879.4	–		1.124	$d(^{5}G)^{4}D$	23	$d(^{3}P)^{4}F2$	8	$d(^{5}G)^{6}G$	5	$d(^{5}G_{4})3/2$	12	$d(^{5}G_{5})5/2$	10	$d(^{3}P_{1})3/2$	4
$4f^{10}5d$	5.5	–	118056.3	–		1.047	$d(^{3}I)^{4}H1$	7	$d(^{3}I)^{4}I1$	6	$d(^{3}I)^{4}K1$	5	$d(^{3}I_{6})3/2$	10	$d(^{3}I_{5})3/2$	3	$d(^{3}G_{5})5/2$	3
$4f^{10}5d$	3.5	–	118118.2	–		1.082	$d(^{3}P)^{4}F2$	14	$d(^{3}D)^{2}G1$	6	$d(^{3}F)^{4}D3$	6	$d(^{3}P_{1})5/2$	7	$d(^{3}P_{2})3/2$	6	$d(^{1}D_{2})3/2$	4
$4f^{10}5d$	7.5	–	118103.2	–		0.973	$d(^{3}L)^{4}L$	30	$d(^{3}L)^{4}M$	15	$d(^{3}L)^{4}K$	8	$d(^{3}L_{8})5/2$	24	$d(^{3}L_{7})3/2$	21	$d(^{3}L_{8})3/2$	6
$4f^{10}5d$	4.5	–	118155.0	–		0.963	$s(^{5}I)^{4}I$	11	$d(^{5}G)^{4}H$	7	$d(^{5}G)^{4}G$	6	$s(^{5}I_{4})1/2$	8	$d(^{5}G_{3})5/2$	6	$d(^{5}G_{4})3/2$	5
$4f^{10}5d$	1.5	–	118281.1	–		1.130	$d(^{3}D)^{2}P1$	15	$d(^{1}D)^{2}P3$	9	$d(^{3}G)^{4}D2$	9	$d(^{3}D_{3})5/2$	14	$d(^{1}D_{2})5/2$	7	$d(^{3}D_{2})3/2$	4
$4f^{10}5d$	1.5	–	118297.0	–		0.974	$d(^{3}P)^{2}D2$	20	$d(^{5}G)^{4}D$	11	$d(^{5}D)^{6}F$	7	$d(^{3}P_{1})5/2$	13	$d(^{3}P_{2})5/2$	5	$d(^{3}P0)3/2$	5
$4f^{10}5d$	7.5	–	118356.0	–		1.078	$d(^{3}M)^{4}K$	18	$d(^{3}I)^{4}I1$	14	$d(^{3}M)^{4}L$	12	$d(^{3}M_{9})3/2$	20	$d(^{3}I_{7})3/2$	14	$d(^{3}M_{10})5/2$	7
$4f^{10}5d$	3.5	–	118443.0	–		1.124	$d(^{3}I)^{2}G1$	10	$d(^{3}D)^{4}D1$	7	$d(^{3}D)^{2}F1$	6	$d(^{3}D_{3})5/2$	12	$d(^{3}I_{5})3/2$	5	$d(^{3}I_{6})5/2$	4
$4f^{10}5d$	0.5	–	118562.4	–		1.069	$d(^{5}D)^{6}F$	20	$d(^{3}D)^{4}P1$	11	$d(^{3}G)^{4}D2$	7	$d(^{5}D_{1})3/2$	11	$d(^{3}D_{3})5/2$	7	$d(^{3}G_{3})5/2$	7
$4f^{10}5d$	1.5	–	118586.1	–		1.168	$d(^{5}D)^{6}F$	12	$d(^{3}P)^{4}D2$	8	$d(^{3}G)^{4}D2$	8	$d(^{5}G_{4})5/2$	5	$d(^{5}D_{2})3/2$	5	$d(^{5}G_{3})3/2$	5
$4f^{10}6s$	4.5	–	118697.3	–		0.867	$s(^{5}I)^{4}I$	47	$s(^{5}I)^{6}I$	6	$s(^{3}H)^{2}H4$	3	$s(^{5}I_{4})1/2$	51	$d(^{3}L_{7})5/2$	3	$s(^{5}I_{5})1/2$	2
$4f^{10}5d$	2.5	–	118715.9	–		1.157	$d(^{3}P)^{4}P2$	18	$d(^{3}D)^{2}D1$	6	$d(^{3}P)^{2}F2$	6	$d(^{3}P_{1})5/2$	19	$d(^{5}G_{4})5/2$	4	$d(^{5}G_{2})5/2$	4
$4f^{10}5d$	9.5	–	118707.5	–		1.061	$d(^{3}L)^{4}M$	37	$d(^{3}L)^{2}M$	20	$d(^{3}L)^{2}N$	8	$d(^{3}L_{8})5/2$	59	$d(^{3}I_{7})5/2$	7	$d(^{3}K_{8})5/2$	6
$4f^{10}5d$	8.5	–	118762.3	–		1.001	$d(^{3}L)^{4}N$	19	$d(^{3}I)^{4}L1$	13	$d(^{1}L)^{2}M2$	10	$d(^{3}I_{7})3/2$	17	$d(^{3}L_{7})3/2$	17	$d(^{1}L_{8})3/2$	7
$4f^{10}5d$	5.5	–	118805.2	–		1.081	$d(^{3}G)^{4}H2$	6	$d(^{3}L)^{2}I$	6	$d(^{3}G)^{2}I2$	6	$d(^{3}G_{4})5/2$	9	$d(^{3}L_{7})3/2$	3	$d(^{3}F_{4})3/2$	3
$4f^{10}5d$	6.5	–	118997.0	–		1.084	$d(^{3}I)^{4}H1$	11	$d(^{3}L)^{2}I$	8	$d(^{3}G)^{4}I2$	7	$d(^{3}I_{7})3/2$	13	$d(^{3}L_{9})5/2$	5	$d(^{3}I_{5})3/2$	5
$4f^{10}5d$	10.5	–	118997.7	–		1.030	$d(^{1}L)^{2}N2$	44	$d(^{3}M)^{2}O$	27	$d(^{3}L)^{2}N$	8	$d(^{1}L_{8})5/2$	44	$d(^{3}M_{8})5/2$	18	$d(^{3}L_{8})5/2$	14
$4f^{10}5d$	2.5	–	119144.2	–		1.080	$d(^{5}D)^{6}F$	13	$d(^{5}G)^{4}F$	6	$d(^{5}D)^{6}D$	6	$d(^{5}D_{3})3/2$	10	$d(^{5}G_{5})5/2$	3	$d(^{5}D_{4})3/2$	3
$4f^{10}6s$	5.5	119203.1(4)	119229.1	−26	3	1.188	$s(^{5}F)^{6}F$	32	$d(^{3}L)^{4}I$	8	$d(^{3}F)^{4}H4$	4	$s(^{5}F_{5})1/2$	32	$d(^{3}L_{8})5/2$	5	$s(^{3}G_{5})1/2$	4
$4f^{10}5d$	4.5	–	119225.6	–		1.160	$d(^{3}D)^{4}F1$	15	$d(^{5}D)^{6}D$	12	$d(^{5}G)^{4}I$	10	$d(^{3}D_{3})5/2$	11	$d(^{5}G_{2})5/2$	6	$d(^{5}D_{4})5/2$	5
$4f^{10}5d$	6.5	–	119232.2	–		1.040	$d(^{3}I)^{4}K1$	16	$d(^{1}L)^{2}I2$	8	$d(^{3}I)^{4}I1$	8	$d(^{3}I_{6})3/2$	17	$d(^{1}L_{8})3/2$	6	$d(^{3}I_{7})3/2$	4
$4f^{10}5d$	3.5	–	119235.7	–		1.093	$d(^{5}D)^{6}F$	7	$d(^{3}G)^{4}H2$	5	$d(^{3}D)^{4}D1$	4	$d(^{3}G_{3})3/2$	3	$d(^{1}H_{5})5/2$	2	$d(^{3}D_{3})5/2$	2
$4f^{10}5d$	7.5	–	119288.7	–		0.944	$d(^{3}L)^{4}M$	28	$d(^{3}I)^{4}L1$	16	$d(^{3}L)^{2}L$	10	$d(^{3}L_{7})3/2$	35	$d(^{3}I_{6})3/2$	20	$d(^{3}I_{6})5/2$	3
$4f^{10}5d$	11.5	–	119286.7	–		1.126	$d(^{3}M)^{4}N$	92	$d(^{3}M)^{4}O$	2	$d(^{3}L)^{4}N$	2	$d(^{3}M_{10})5/2$	88	$d(^{3}M_{10})3/2$	4	$d(^{3}M_{9})5/2$	3
$4f^{10}6s$	5.5	–	119324.7	–		1.239	$s(^{5}F)^{6}Fb$	43	$s(^{3}G)^{4}G2$	6	$d(^{3}F)^{4}H4$	5	$s(^{5}F_{5})1/2$	43	$s(^{3}G_{5})1/2$	6	$d(^{3}F_{3})5/2$	3
$4f^{10}5d$	4.5	–	119346.3	–		1.050	$d(^{5}D)^{6}F$	9	$d(^{3}I)^{4}I1$	7	$d(^{3}H)^{4}I4$	4	$d(^{3}I_{5})3/2$	4	$d(^{3}I_{5})5/2$	3	$d(^{5}D_{4})3/2$	3
$4f^{10}5d$	0.5	–	119355.3	–		0.564	$d(^{3}G)^{4}D2$	16	$d(^{5}D)^{6}F$	11	$d(^{3}F)^{4}D2$	6	$d(^{3}G_{3})5/2$	16	$d(^{3}G_{3})5/2$	6	$d(^{5}D_{1})3/2$	6
$4f^{10}5d$	5.5	–	119419.5	–		1.042	$d(^{5}G)^{4}H$	9	$d(^{3}G)^{4}I2$	6	$d(^{5}G)^{4}I$	6	$d(^{5}G_{4})3/2$	6	$d(^{5}G_{3})5/2$	5	$d(^{3}I_{5})3/2$	3
$4f^{10}5d$	4.5	–	119503.1	–		0.992	$s(^{5}I)^{4}I$	14	$d(^{3}K)^{2}H2$	6	$d(^{3}D)^{4}F1$	5	$s(^{5}I_{4})1/2$	10	$d(^{3}L_{7})5/2$	4	$d(^{3}D_{3})5/2$	4
$4f^{10}5d$	2.5	–	119572.4	–		1.149	$d(^{3}P)^{4}F2$	9	$d(^{3}G)^{4}D2$	8	$d(^{3}P)^{4}D2$	8	$d(^{3}P0)5/2$	8	$d(^{3}P_{1})3/2$	7	$d(^{3}G_{4})5/2$	3
$4f^{10}5d$	6.5	–	119639.0	–		1.031	$d(^{3}M)^{4}K$	17	$d(^{3}L)^{4}I$	6	$d(^{3}L)^{4}L$	6	$d(^{3}M_{9})5/2$	10	$d(^{1}L_{8})3/2$	4	$d(^{3}M_{8})3/2$	4

Table 2. (Continued.)

Conf	J	E_{exp} (unc.)	E_{cal}	ΔE	N_{cl}	$g_{\mathrm{Landé}}$	LS percentage composition						JJ percentage composition					
							Comp1	%	Comp2	%	Comp3	%	Comp1	%	Comp2	%	Comp3	%
$4f^{10}5d$	2.5	–	119666.1	–		1.071	$d(^5G)^4G$	19	$d(^5D)^6P$	10	$d(^3G)^2F2$	5	$d(^5G_3)5/2$	7	$d(^5G_2)3/2$	6	$d(^5D_4)3/2$	4
$4f^{10}5d$	8.5	–	119712.3	–		1.034	$d(^3M)^4L$	22	$d(^3M)^4M$	12	$d(^1L)^2M2$	11	$d(^3M_9)3/2$	21	$d(^1L_8)3/2$	7	$d(^3M_{10})5/2$	5
$4f^{10}5d$	3.5	–	119739.1	–		1.218	$d(^3G)^4F2$	10	$d(^3F)^4D3$	8	$d(^3F)^4D4$	6	$d(^3F_4)3/2$	9	$d(^3G_4)5/2$	4	$d(^3F_4)5/2$	3
$4f^{10}5d$	5.5	–	119903.8	–		1.059	$d(^3I)^4I1$	10	$d(^5D)^4G$	7	$d(^3L)^4K$	7	$d(^3L_7)5/2$	5	$d(^5D_4)3/2$	4	$d(^3I_6)3/2$	4
$4f^{10}5d$	4.5	–	120004.5	–		1.080	$d(^3I)^4I1$	12	$d(^5D)^6F$	9	$d(^3P)^4F2$	6	$d(^3I_5)3/2$	6	$d(^3P_2)5/2$	6	$d(^3I_5)5/2$	5
$4f^{10}5d$	5.5	–	120009.5	–		1.125	$d(^3I)^4G1$	24	$d(^3I)^4G2$	7	$d(^3I)^4H1$	6	$d(^3I_7)3/2$	26	$d(^3M_8)5/2$	6	$d(^3I_7)3/2$	5
$4f^{10}5d$	1.5	–	120018.7	–		1.095	$d(^3P)^2D2$	9	$d(^3F)^2D2$	7	$d(^3F)^4D2$	7	$d(^3F_2)5/2$	7	$d(^3P_2)3/2$	5	$d(^3P0)3/2$	5
$4f^{10}5d$	6.5	–	120110.6	–		0.969	$d(^3I)^4L1$	20	$d(^3L)^4K$	12	$d(^1L)^2I2$	5	$d(^3I_5)3/2$	16	$d(^1L_8)5/2$	9	$d(^3L_8)5/2$	4
$4f^{10}5d$	4.5	–	120277.4	–		1.117	$d(^5D)^4F$	10	$s(^5F)^4F$	6	$d(^3F)^4F3$	5	$s(^5F_5)1/2$	5	$d(^5D_4)5/2$	4	$d(^3I_7)5/2$	3
$4f^{10}5d$	9.5	–	120284.8	–		1.015	$d(^1L)^2M2$	21	$d(^3L)^2N$	19	$d(^3L)^4N$	10	$d(^3L_7)5/2$	28	$d(^1L_8)5/2$	18	$d(^1K_7)5/2$	9
$4f^{10}5d$	7.5	–	120291.1	–		0.958	$d(^1L)^2L2$	25	$d(^3L)^4M$	14	$d(^3M)^4M$	12	$d(^3M_8)3/2$	19	$d(^1L_8)5/2$	13	$d(^1L_8)3/2$	12
$4f^{10}5d$	5.5	–	120348.2	–		1.027	$d(^3I)^4I1$	9	$d(^1L)^2I2$	7	$d(^3L)^2I$	7	$d(^1L_8)5/2$	7	$d(^3I_6)3/2$	4	$d(^3L_7)3/2$	4
$4f^{10}5d$	8.5	–	120400.8	–		1.044	$d(^3L)^4L$	26	$d(^3L)^2L$	24	$d(^3L)^4M$	9	$d(^3L_8)5/2$	55	$d(^3L_9)5/2$	6	$d(^3K_8)5/2$	4
$4f^{10}5d$	0.5	–	120434.3	–		0.646	$d(^5D)^6F$	16	$d(^3G)^4D$	14	$d(^3D)^2S1$	10	$d(^5D_1)3/2$	9	$d(^5G_2)3/2$	9	$d(^3F_2)3/2$	5
$4f^{10}6s$	4.5	–	120660.8	–		1.275	$s(^5F)^4F$	45	$s(^5F)^6F$	22	$s(^3G)^2G2$	6	$s(^5F_5)1/2$	62	$s(^3G_5)1/2$	10	$s(^5F_4)1/2$	4
$4f^{10}5d$	2.5	–	120737.9	–		1.086	$d(^3P)^2F2$	12	$d(^3P)^4P2$	9	$d(^3P)^4D2$	5	$d(^3P0)5/2$	18	$d(^3P_2)5/2$	3	$d(^3P_2)3/2$	2
$4f^{10}5d$	1.5	–	120799.7	–		1.163	$d(^5G)^4F$	16	$d(^5D)^6P$	12	$d(^5G)^4D$	7	$d(^5G_2)3/2$	13	$d(^5G_3)5/2$	7	$d(^5D_3)3/2$	4
$4f^{10}5d$	3.5	–	120832.8	–		1.136	$d(^5G)^4G$	8	$d(^5D)^6P$	6	$d(^3P)^2F2$	5	$d(^5G_4)5/2$	3	$d(^3P_2)3/2$	3	$d(^5G_6)5/2$	3
$4f^{10}5d$	9.5	–	120815.4	–		1.050	$d(^3M)^4M$	39	$d(^3M)^2M$	17	$d(^3M)^4N$	16	$d(^3M_{10})5/2$	47	$d(^3M_9)3/2$	14	$d(^3M_{10})3/2$	11
$4f^{10}5d$	3.5	–	120852.5	–		1.146	$d(^5D)^6P$	6	$d(^5D)^6F$	6	$d(^3D)^2F1$	5	$d(^5D_3)5/2$	5	$d(^5D_3)3/2$	4	$d(^3P_2)5/2$	3
$4f^{10}5d$	2.5	–	120896.8	–		1.107	$d(^5D)^6P$	11	$d(^3P)^2F2$	10	$d(^3D)^2D1$	7	$d(^3P_1)5/2$	6	$d(^3P0)5/2$	6	$d(^5D_4)3/2$	4
$4f^{10}5d$	5.5	120929.5(3)	120888.10	41	5	0.995	$d(^3L)^4K$	10	$d(^3F)^2H3$	10	$d(^3I)^4I1$	6	$d(^3L_7)5/2$	7	$d(^3F_4)3/2$	5	$d(^1L_8)5/2$	5
$4f^{10}5d$	6.5	–	120986.1	–		1.132	$d(^5G)^4I$	13	$d(^5D)^6G$	11	$d(^3F)^4H4$	11	$d(^5D_4)5/2$	11	$d(^3F_4)5/2$	11	$d(^5G_5)3/2$	5
$4f^{10}5d$	5.5	121140.31(23)	121029.70	111	8	1.036	$d(^3M)^4K$	13	$d(^3I)^4G1$	8	$d(^3I)^4I1$	7	$d(^3M_8)5/2$	13	$d(^1L_8)5/2$	7	$d(^3I_7)3/2$	7

Table 3. Section of classified lines of Er IV (1218–1234 Å). The experimentally measured wavelengths (λ_{exp} in Å) are followed by the deviations $\Delta\lambda = \lambda_{\mathrm{exp}} - \lambda_{\mathrm{Ritz}}$ from the Ritz wavelengths (in Å), intensities Int from photographic plates or from image plates are in arbitrary units, calculated transition probabilities gA (in 10^6 s^{-1}), g being the statistical weight of the upper level, A being the Einstein coefficient of spontaneous emission. CF is the cancellation factor defined by equation(14.107), p432 in [22]. λ_{Ritz} is derived from the optimized level energies as $\lambda_{\mathrm{Ritz}} = (E_{\mathrm{upper}} - E_{\mathrm{lower}})^{-1}$. All energies and wave numbers are in cm^{-1}.

λ_{exp}	σ_{exp}	λ_{Ritz}	$\Delta\lambda$	Int$_{PP}$	Int$_{IP}$	gA	CF	Lower level[a]	Upper level[a]	E_{lower}	E_{upper}	Comm.[b]
1218.095	82095.40	1218.099	−0.004	132	54	528.9	0.16	$4f^{10}5d\,(^5I)^6Kb$ 6.5	$4f^{10}6p\,(^5I)^4K$ 6.5	86744.73	168839.9	
1218.291	82082.20	1218.286	0.004	25	3	202.2	−0.02	$4f^{10}5d\,(^5I)^6L$ 7.5	$4f^{10}6p\,(^5I)^4K$ 6.5	86757.34	168839.9	
1218.825	82046.20	1218.820	0.006	114	49	524	0.29	$4f^{10}5d\,(^5I)^6G$ 6.5	$4f^{10}6p\,(^5I)^4H$ 6.5	74536.27	156582.9	
1219.083	82028.90	1219.084	−0.001	63	15	376.6	−0.10	$4f^{10}5d\,(^5I)^6I$ 3.5	$4f^{10}6p\,(^5I)^6I$ 3.5	88834.27	170863.1	
1219.281	82015.50	1219.277	0.005	140	15	63.85	0.11	$4f^{11}\,(^4I)^4I$ 5.5	$4f^{10}5d\,(^5I^4G$ 4.5	10171.79	92187.63	
1219.395	82007.89	1219.391	0.004	167	75	81.45	0.14	$4f^{11}\,(^4I)^4I$ 4.5	$4f^{10}5d\,(^5I^4I$ 5.5	12468.66	94476.78	D
1219.395	82007.89	1219.405	−0.010	167	75	114	−0.04	$4f^{10}5d\,(^5I)^6H$ 5.5	$4f^{10}6p\,(^5F)^6G$ 4.5	86559.40	168566.6	D
1219.857	81976.80	1219.845	0.013	40		100.3	0.11	$4f^{10}5d\,(^5I)^6K$ 6.5	$4f^{10}6p\,(^5F)^4K$ 5.5	82921.55	164899.2	
1219.922	81972.50	1219.920	0.002	218	119	1059	0.55	$4f^{10}5d\,(^5I)^6Hb$ 7.5	$4f^{10}6p\,(^5I)^6K$ 8.5	79362.02	161334.6	
1220.125	81958.82	1220.127	−0.002	114	17	229.6	0.02	$4f^{10}5d\,(^5I)^4K$ 8.5	$4f^{10}6p\,(^5I)^6I$ 7.5	79154.18	161112.8	D
1220.125	81958.82	1220.111	0.013	114	17	162.8	0.02	$4f^{10}5d\,(^5I)^4$ 7.5	$4f^{10}6p\,(^5I)^6I$ 6.5	83376.71	165336.4	D
1220.275	81948.70	1220.270	0.006	138	53	54.45	−0.07	$4f^{11}\,(^4I)^4I$ 6.5	$4f^{10}5d\,(^5I)^6K$ 5.5	6507.750	88456.86	
1220.931	81904.70	1220.932	−0.001	90		355.1	0.08	$4f^{10}5d\,(^5I)^6H$ 5.5	$4f^{10}6p\,(^5I)^4I$ 5.5	86559.40	168464.1	
1221.482	81867.80	1221.479	0.003	129	39	586.2	0.09	$4f^{10}5d\,(^5I)^6G$ 5.5	$4f^{10}6p\,(^5I)^4I$ 6.5	79743.13	161611.1	
1221.926	81838.00	1221.935	−0.009	86		138.7	−0.03	$4f^{10}5d\,(^5I)^6H$ 4.5	$4f^{10}6p\,(^5I)^6H$ 5.5	83708.79	165546.2	
1222.311	81812.20	1222.310	0.001	83	12	322.7	0.03	$4f^{10}5d\,(^5I)^4L$ 9.5	$4f^{10}6p\,(^5I)^6K$ 8.5	79522.29	161334.6	
1222.819	81778.30	1222.820	−0.002	115	68	77.56	0.05	$4f^{11}\,(^4F)^4F$ 4.5	$4f^{10}5d\,(^5I)^4I$ 4.5	15404.86	97183.02	
1223.229	81750.80	1223.230	0.000	204	104	1459	−0.16	$4f^{10}5d\,(^5I)^6Hb$ 7.5	$4f^{10}6p\,(^5I)^6I$ 7.5	79362.02	161112.8	
1224.067	81694.90	1224.065	0.001	95	22	59.65	0.07	$4f^{11}\,(^4G)^4G$ 5.5	$4f^{10}5d\,(^3H)^4H4$ 6.5	26707.79	108402.8	
1224.134	81690.40	1224.144	−0.010	5		13.82	−0.01	$4f^{10}5d\,(^5I)^6I$ 6.5	$4f^{10}6p\,(^5I)^6K$ 5.5	78916.79	160606.5	
1225.794	81579.80	1225.789	0.004	256	104	1836	0.38	$4f^{10}5d\,(^5I)^6H$ 7.5	$4f^{10}6p\,(^5I)^6I$ 8.5	73426.17	155006.2	
1228.649	81390.20	1228.650	−0.001	263	138	2170	0.99	$4f^{10}5d\,(^5I)^6I$ 8.5	$4f^{10}6p\,(^5I)^6K$ 9.5	73708.00	155098.1	
1229.414	81339.60	1229.416	−0.002	245	87	150.6	0.14	$4f^{11}\,(^4I)^4I$ 5.5	$4f^{10}5d\,(^5I)^4Hb$ 5.5	10171.79	91511.24	
1230.037	81298.40	1230.039	−0.002	322	219	3045	−0.29	$4f^{10}5d\,(^5I)^6I$ 8.5	$4f^{10}6p\,(^5I)^6I$ 8.5	73708.00	155006.2	
1230.536	81265.40	1230.535	0.000	246	136	1402	0.22	$4f^{10}5d\,(^5I)^6G$ 6.5	$4f^{10}6p\,(^5I)^4I$ 7.5	74536.27	155801.7	
1234.479	81005.80	1234.473	0.006	112	12	14.2	−0.01	$4f^{11}\,(^2H)^2H2$ 5.5	$4f^{10}5d\,(^5F)^6H$ 6.5	19331.69	100337.9	

[a] Term designation and J value. The number following a term designation is a seniority number as given by Cowan's code [22]; the lowercase letter is a notation to distinguish two levels with the same main component.

[b] D : double identification.

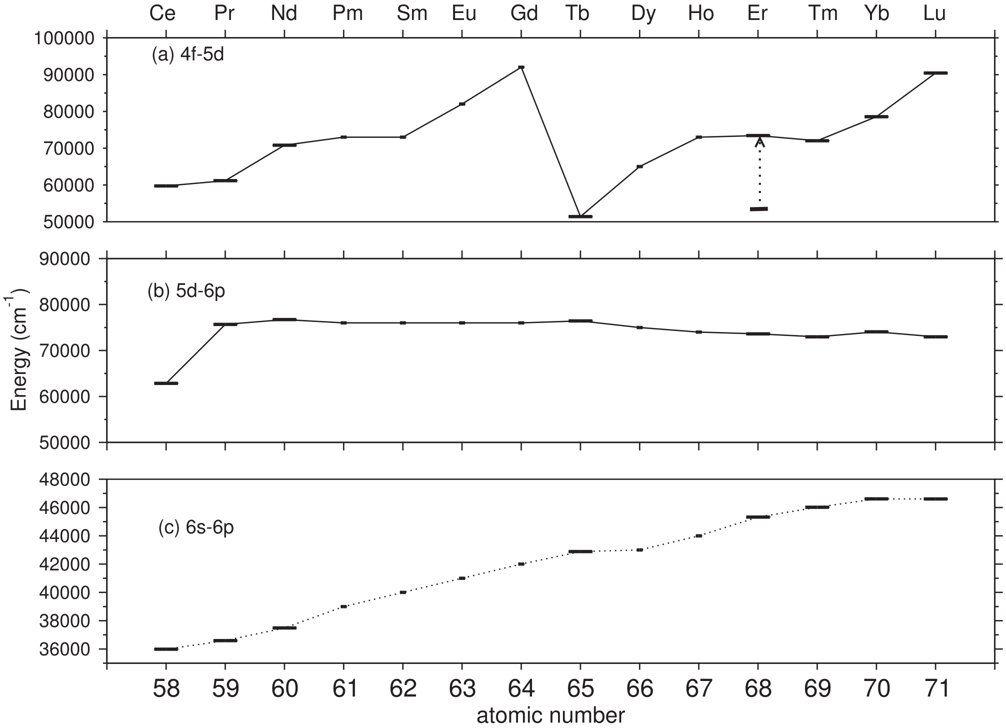

Figure 2. Energy separations between lowest energy levels for the main configurations of triply ionized lanthanides (a) $4f^{n+1}$-$4f^n5d$, (b) $4f^n5d$-$4f^n6p$ and (c) $4f^n6s$-$4f^n6p$ (long bars: experimentally known levels; short bars: interpolated levels).

Table 4. Fitted parameters (in cm^{-1}) for the odd parity configurations $4f^{11}$ and $4f^{10}6p$ of Er IV compared with HFR radial integrals. Columns 5 and 9 give the scaling factors $SF(P) = P_{\text{fit}}/P_{\text{HFR}}$ except for average energies E_{av} where $P_{\text{fit}} - P_{\text{HFR}}$ are given. Constraints on some parameters are indicated in the columns of standard errors 'Unc': f as 'fixed' (see details in the text).

	$4f^{11}$				$4f^{10}6p$			
Param. P	P_{fit}	Unc.	P_{HFR}	SF	P_{fit}	Unc.	P_{HFR}	SF
E_{av}	35997	44	0		207022	76	152887	54135
$F^2(ff)$	99750	428	129798	0.769	104983	r	136606	0.769
$F^4(ff)$	72727	768	81425	0.893	76857	r	86049	0.893
$F^6(ff)$	50541	516	58575	0.863	53498	r	62003	0.863
α	24.5	3			17.3	f		
β	−500	f			−500	f		
γ	1480	f			1480	f		
ζ_f	2407	4	2438	0.987	2552	r	2586	0.987
ζ_p					5310	12	4525	1.173
$F^1(fp)$					292	51		
$F^2(fp)$					7543	451	9398	0.803
$G^2(fp)$					2264	f	2405	0.941
$G^4(fp)$					2053	f	2181	0.941

r: all the parameters of the same name are linked by a constant ratio. f: fixed parameter.

used to draw the figures 2(b) and (c) that report the electron jumps $4f^n5d$- $4f^n6p$ and $4f^n6s$- $4f^n6p$, respectively.

Table 4 reports the results from the final loop RCE/RCG for the odd configurations, i.e., the HFR and fitted energy parameters and their standard errors in the LSF fit performed with 38 experimental levels of $4f^{11}$ and $4f^{10}6p$. The mean error of the fit with 11 free parameters is 41 cm^{-1}. Table 5 reports similar results for the even configurations. The fit performed with 82 experimental levels and 16 free parameters led to a mean error of 49 cm^{-1}.

4. Conclusions

Based on newly recorded high resolution emission spectra of erbium, we achieved a completely revised analysis of the Er IV spectrum, leading to the determination of 120 energy levels belonging to the $4f^{11}$, $4f^{10}5d$, $4f^{10}6s$ and $4f^{10}6p$ configurations. This prepares the way for further line identifications in Er IV, supported by theoretical energies and transition probabilities. Expected extension concerns, on one hand, levels with high J and large gA values, but very few

Table 5. Fitted parameters (in cm^{-1}) for the even parity configurations $4f^{10}5d$ and $4f^{10}6s$ of Er IV compared with HFR radial integrals. Columns 5 and 9 give the scaling factors $SF(P) = P_{\mathrm{fit}}/P_{\mathrm{HFR}}$ except for average energies E_{av} where $P_{\mathrm{fit}} - P_{\mathrm{HFR}}$ are given. Constraints on some parameters are indicated in the columns of standard errors 'Unc': f as 'fixed' or r as 'ratio fixed'; $G^2(fd)$ and $G^4(fd)$ are kept equal (see details in the text).

	$4f^{10}5d$				$4f^{10}6s$			
Param. P	P_{fit}	Unc.	P_{HFR}	SF	P_{fit}	Unc.	P_{HFR}	SF
E_{av}	133502	67	78792	54710	156929	68	104113	52816
$F^2(ff)$	106024	601	136066	0.779	106402	r	136550	0.779
$F^4(ff)$	75440	1152	85682	0.880	75730	r	86011	0.880
$F^6(ff)$	54152	879	61731	0.877	54365	r	61975	0.877
α	17.6	1			17.6	r		
β	−500	f			−500	f		
γ	1480	f			1400	f		
ζ_f	2555	5	2579	0.991	2562	r	2585	0.991
ζ_d	1635	11	1755	0.932				
$F^1(fd)$	1066	109						
$F^2(fd)$	24370	218	30311	0.804				
$F^4(fd)$	16574	423	14390	1.152				
$G^1(fd)$	8597	88	12410	0.693				
$G^2(fd)$	1939	232						
$G^3(fd)$	10139	291	10500	0.966				
$G^4(fd)$	1939	232						
$G^5(fd)$	6661	224	8108	0.822				
$G^3(fs)$					2734	112	3286	0.832
Configuration interaction								
$f^2d - f^2s$								
$R^2(fd, fs)$	965	f	1379	0.7				
$R^3(fd, sf)$	2164	f	3091	0.7				

r: all the parameters of the same name are linked by a constant ratio. f: fixed parameter.

transitions, and on the other hand, levels with small J values and relatively weak gA values. This work represents a new step in the description of the triply ionized lanthanide spectra.

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