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Supplementary Tables for  
A Systematic Analysis of the Spectra of the Lanthanides Doped  
into Single Crystal  $\text{LaF}_3$

by

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Supplementary tables to which we refer in our article of the same title in the Journal of Chemical Physics are reproduced here. These tables along with certain supplementary figures and an expanded discussion of the experimental data are also contained in an unpublished report, ANL-88-8. This report is available from the NTIS Distribution Service, P. O. Box 1300, Oak Ridge, TN 37831 (telephone number: (615) 576-1301).

Table of Contents for Supplement

<u>Appendix</u>	<u>Title</u>	<u>Page</u>
I.	Experimental and Computed Energy Level Structure of $\text{Nd}^{3+}:\text{LaF}_3$	2
II.	Experimental and Computed Energy Level Structure of $\text{Pr}^{3+}:\text{LaF}_3$	9
III.	Experimental and Computed Energy Level Structure of $\text{Pm}^{3+}:\text{LaF}_3$	13
IV.	Experimental and Computed Energy Level Structure of $\text{Sm}^{3+}:\text{LaF}_3$	17
V.	Experimental and Computed Energy Level Structure of $\text{Er}^{3+}:\text{LaF}_3$	27
VI.	Experimental and Computed Energy Level Structure of $\text{Tm}^{3+}:\text{LaF}_3$	31
VII.	Experimental and Computed Energy Level Structure of $\text{Ho}^{3+}:\text{LaF}_3$	35
VIII.	Experimental and Computed Energy Level Structure of $\text{Dy}^{3+}:\text{LaF}_3$	43
IX.	Experimental and Computed Energy Level Structure of $\text{Tb}^{3+}:\text{LaF}_3$	55
X.	Experimental and Computed Energy Level Structure of $\text{Gd}^{3+}:\text{LaF}_3$	62

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Appendix I.  
Experimental and Computed Energy Level Structure of  $\text{Nd}^{3+}:\text{LaF}_3$

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> ( $\text{cm}^{-1}$ )	Calc. <sup>c</sup> ( $\text{cm}^{-1}$ )	O-C	Caspers et al. <sup>d</sup> ( $\text{cm}^{-1}$ )	Wong et al. <sup>e</sup> ( $\text{cm}^{-1}$ )	Voron'ko et al. <sup>f</sup> ( $\text{cm}^{-1}$ )
$4\text{I}_{9/2}$	0	5	-5	0		0
	45	48	-3	45		44
	136	153	-17	136		140
	296	304	-8	296		297
	500	513	-13	500		502
$4\text{I}_{11/2}$	1978	1965	13	1978		1980
	2037	2027	10	2037		2039
	2068	2070	-2	2068		2069
	2091	2089	2	2091		2093
	2187	2193	-6	2187		2190
	2223	2226	-3	2223		2225
$4\text{I}_{13/2}$	3918	3902	16	3919		3919
	3978	3970	8	3979		3973
	4038	4033	5	4039		4039
	4076	4087	-11	4078		4077
	4118	4115	3	4120		4119
	4208	4205	3	4213		4213
	4278	4267	11	4278		4277
$4\text{I}_{15/2}$	5816	5804	12	5815		5817
	5874	5871	3	5877		5876
	5986	5999	-13	5988		5989
	6141	6163	-22			6142
	6167	6185	-18			6173

JCPSA-90-3443-63

## Appendix I. (cont.)

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	Caspers et al. <sup>d</sup> (cm <sup>-1</sup> )	Wong et al. <sup>e</sup> (cm <sup>-1</sup> )	Voron'ko et al. <sup>f</sup> (cm <sup>-1</sup> )
<sup>4</sup> I <sub>15/2</sub>	6323	6113	10			6320
	6454	6445	9			6448
	6556	6538	18			6551
<sup>4</sup> F <sub>3/2</sub>	11592	11596	-4	11592	11591.6	11594
	634	638	-4	634	633.6	637
<sup>2</sup> H <sub>9/2</sub> ,	12596	12576	20	12596	12595.6	
<sup>4</sup> F <sub>5/2</sub>	614	595	19	613	612.9	
	622	633	-11	621	620.7	
	676	680	-4	675	674.6	
	694	704	-10	693	692.6	
	754	761	-7	755	755.3	
	843	847	-4	-	-	
	902	874	27	-	-	
<sup>4</sup> F <sub>7/2</sub>	13514	13521	-7	13515	13514.8	
	590	591	-1	591	590.8	
<sup>4</sup> S <sub>3/2</sub>	671	670	1	671	670.9	
	676	678	-2	677	676.7	
<sup>4</sup> F <sub>7/2</sub>	711	690	21	710	710.1	
	715	725	-10	714	714.2	
<sup>4</sup> F <sub>9/2</sub>	14834	14840	-6	14835	14834.7	
	861	860	1	860	861.8	
	892	891	1	891	890.6	

JCPSA-90-3443-63

## Appendix I. (cont.)

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	Caspers et al. <sup>d</sup> (cm <sup>-1</sup> )	Wong et al. <sup>e</sup> (cm <sup>-1</sup> )
<sup>4</sup> F <sub>9/2</sub>	14926	14925	1	14927	
	959	955	4	958	14959.4
<sup>2</sup> H <sub>11/2</sub>	15997	16025	-28	15998	15998.1
	16033	043	-10	16033	-
	046	049	-3	045	16046.4
	060	067	-7	059	-
	100	093	7	103	-
	165	136	29	-	-
<sup>4</sup> G <sub>5/2</sub> , <sup>4</sup> G <sub>7/2</sub>	17306	17301	5	17304	17304.6
	316	318	-2	315	316.0
	363	360	3	364	362.9
	511	492	19	512	509.2
	518	512	6	520	520.3
	571	567	4	570	
	605	607	-2	601	603.2
<sup>4</sup> G <sub>7/2</sub>	19147	19134	13	19147	19147.4
	235	243	-8	235	236.2
	252	266	-14	251	252.1
	324	322	2	323	325.4
<sup>2</sup> K <sub>13/2</sub> , <sup>4</sup> G <sub>9/2</sub>	19567	19570	-3	19568	19568.2
	615	622	-7	617	
	651	638	13	651	650.9
	686	681	5	685	686.2

JCPSA - 90-3443-63

## Appendix I. (cont.)

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	Caspers et al. <sup>d</sup> (cm <sup>-1</sup> )	Wong et al. <sup>e</sup> (cm <sup>-1</sup> )
<sup>2</sup> K <sub>13/2</sub> ,	19704	19696	8	19702	19704.0
<sup>4</sup> G <sub>9/2</sub>	-	727		-	-
	741	741	0	739	739.4
	799	786	13	801	
	835	834	1	839	
	-	892		-	
	-	946		-	
	960	970	-10	-	
<sup>2</sup> G <sub>9/2</sub>	21155	21151	4	21158	
	176	180	-4	176	
	198	202	-4	201	
	232	242	-10	234	
	252	271	-19	254	
<sup>2</sup> D <sub>3/2</sub>	21338	21337	1	21339	
	353	355	-2	351	
<sup>4</sup> G <sub>11/2</sub> ,	21542	21535	7		
<sup>2</sup> K <sub>15/2</sub>	-	618			
	633	630	3		
	718	704	14		
	-	754			
	768	767	1		
	-	783			
	807	810	-3		
	-	821			
	846	861	-15		
	-	884			

## Appendix I. (cont.)

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	Caspers et al. <sup>d</sup> (cm <sup>-1</sup> )
<sup>4</sup> G <sub>11/2</sub> ,	-	21929		
<sup>2</sup> K <sub>15/2</sub>	-	957		
	21992	989	3	
<sup>2</sup> P <sub>1/2</sub>	23473	23463	10	23468
<sup>2</sup> D <sub>5/2</sub>	23991	23985	6	23991
	24033	24035	-2	
	080	075	5	
<sup>2</sup> P <sub>3/2</sub>	26378	26389	-11	
	426	424	2	
<sup>4</sup> D <sub>3/2</sub>	28341	28342	-1	
	374	371	3	
<sup>4</sup> D <sub>5/2</sub>	28501	28500	1	
	525	526	-1	
	676	672	4	
<sup>4</sup> D <sub>1/2</sub>	28962	28943	19	
<sup>2</sup> I <sub>11/2</sub>	29463	29467	-4	
	489	476	13	
	568	558	10	
	644	646	-2	
	-	648		
	773	777	-4	

JCPSA-90-3443-63

## Appendix I. (cont.)

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup>	Obsd. <sup>b</sup> (vac cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>2</sup> L <sub>15/2</sub> ,	30275	30270	5	<sup>2</sup> L <sub>17/2</sub>	-	31987	
<sup>4</sup> D <sub>7/2</sub>	318	317	1		-	32008	
	-	363			-	030	
	-	471			-	074	
	517	523	-6		-	172	
	-	536					
	576	593	-17	<sup>2</sup> H <sub>9/2</sub>	33030	33036	-6
	-	600			107	117	-10
	631	644	-13		181	178	3
	682	691	-9		228	226	2
	719	722	-3		255	255	0
	807	796	11				
				<sup>2</sup> D <sub>3/2</sub>	33619	33616	3
<sup>2</sup> I <sub>13/2</sub>	-	30860			649	647	2
	30893	898	-5				
	933	948	-15	<sup>2</sup> H <sub>11/2</sub> ,	34292	34264	28
	994	31010	-16	<sup>2</sup> D <sub>5/2</sub>	380	368	12
	31030	31029	1		419	443	-24
	068	054	14		-	501	
	-	118			521	534	-13
					-	578	
<sup>2</sup> L <sub>17/2</sub>	31781	31768	13		678	659	19
	-	817			706	723	-17
	859	851	8		-	811	
	-	983					



## Appendix I. (cont.)

JCLPSA-90-3443-65

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup>	Obsd. <sup>b</sup> (vac cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>2</sup> F <sub>5/2</sub>	38690	38708	-18	<sup>2</sup> G <sub>7/2</sub>	48839	48852	-13
	735	764	-29		908	868	40
	841	811	30		977	979	-2
					49088	49071	17
<sup>2</sup> F <sub>7/2</sub>	40103	40104	-1	<sup>2</sup> F <sub>7/2</sub>	-	66565	
	-	120			-	716	
	155	176	-21		-	772	
	288	247	41		-	916	
<sup>2</sup> G <sub>9/2</sub>	-	47867		<sup>2</sup> F <sub>5/2</sub>	-	67856	
	47894	887	7		-	900	
	937	954	-17		-	68126	
	999	48021	-22				
	48043	056	-13				

---

<sup>a</sup>The principal component of the eigenvector is given.

<sup>b</sup>(cm<sup>-1</sup> vac). Components of <sup>4</sup>I<sub>9/2</sub> and <sup>4</sup>I<sub>11/2</sub> taken from ref. 32.

<sup>c</sup>Energy level parameters are given in Table 1.

<sup>d</sup>Ref. 32.

<sup>e</sup>Ref. 6.

<sup>f</sup>Ref. 34.

Appendix II.

Experimental and Computed Energy Level Structure for  $\text{Pr}^{3+}:\text{LaF}_3$

SLJ State	Model <sup>a</sup> ( $\text{cm}^{-1}$ )	Expt. <sup>b</sup> ( $\text{cm}^{-1}$ )	Calc. <sup>c</sup> ( $\text{cm}^{-1}$ )	O-C	SLJ State	Model <sup>a</sup> ( $\text{cm}^{-1}$ )	Expt. <sup>b</sup> ( $\text{cm}^{-1}$ )	Calc. <sup>c</sup> ( $\text{cm}^{-1}$ )	O-C
$^3\text{H}_4$	0	0	0.2	0	$^3\text{H}_5$	2281	2272	2284	-12
	90	57	71	-14		2289	2299	2290	9
	95	71	95	-24		2294	2304	2295	9
	124	136	138	-2		2327	2354	2318	36
	144	195	183	12		2363	2412	2399	13
	226	204 <sup>d</sup>	221	-17		2441	2431	2412	19
	305	322 <sup>d</sup>	333	-11		2442	2457	2438	19
	386	-	444			2538	2567	2540	27
	479	(508) <sup>e</sup>	463		$^3\text{H}_6$	4220	-	4179	
$^3\text{H}_5$	2160	-	2126			4230	4223	4200	23
	2184	-	2158			4319	4268	4283	-15
	2188	2179	2191	-12		4381	4305	4321	-16

JCPSA-90-3443-63

## Appendix II. (Cont.)

SLJ	Model <sup>a</sup> (cm <sup>-1</sup> )	Expt. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ State	Model <sup>a</sup> (cm <sup>-1</sup> )	Expt. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>3</sup> H <sub>6</sub>	4414	4388	4384	4	<sup>3</sup> F <sub>2</sub>	5263	5280 <sup>d</sup>	5276	4
	4473	4440 <sup>d</sup>	4467	-27					
	4494	-	4478		<sup>3</sup> F <sub>3</sub>	6420	6453	6456	-3
	4507	4508	4496	12		6481	6495	6490	5
	4545	4529	4508	21		6489	6499	6508	-9
	4621	4581	4590	-9		6562	6587	6579	8
	4713	4673	4693	-20		6576	6602	6600	2
	4715	-	4712			6602	6622	6628	-6
	4821	4785	4814	-29		6701	6722	6740	-18
<sup>3</sup> F <sub>2</sub>	5130	5137	5145	-8	<sup>3</sup> F <sub>4</sub>	6907	6927	6918	9
	5153	5182	5182	0		6920	-	6936	
	5180	5201	5185	16		6944	6946	6950	4
	5245	5275	5270	5		6956	-	6952	

Appendix II (Cont.)

SLJ	Model <sup>a</sup> (cm <sup>-1</sup> )	Expt. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ	State	Model <sup>a</sup> (cm <sup>-1</sup> )	Expt. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>3</sup> F <sub>4</sub>	6958	6946	6953	-7	<sup>1</sup> G <sub>4</sub>	State	10477	10499	10516	-17
	6996	6980	6983	-3						
	7000	7029	7034	-5			16879	16873	16887	-14
	7084	7104	7096	8			925	893	895	-2
<sup>1</sup> G <sub>4</sub>	7129	7165	7152	13	<sup>1</sup> D <sub>2</sub>	State	17072	17083	17082	1
							095	-	117	
	9720	9716	9721	-5			149	183	170	13
	9761	9751	9762	-11						
<sup>1</sup> G <sub>4</sub>	9840	9876	9860	16	<sup>3</sup> P <sub>0</sub>	State	20942	20927	20911	16
	9936	9912	9927	-15						
	9937	-	9958				21276	21279	21284	-5
	9979	10005	9996	9			21313	-	304	
<sup>1</sup> G <sub>4</sub>	10031	042	10030	12	<sup>1</sup> I <sub>6</sub>	State	320	331	340	-9
	10154	10163	10150	13			398	404	390	14

Appendix II (Cont.)

SLJ	Model <sup>a</sup> (cm <sup>-1</sup> )	Expt. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	SLJ	State	O-C	Model <sup>a</sup> (cm <sup>-1</sup> )	Expt. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>1</sup> I <sub>6</sub>	21440	21418	21406	<sup>1</sup> I <sub>6</sub>	<sup>1</sup> I <sub>6</sub>	12	21852	21897	21889	8
	447	-	481				905	942	958	-16
<sup>3</sup> P <sub>1</sub>	21472	21475	21487			-12				
	532	522	519	<sup>3</sup> P <sub>2</sub>	<sup>3</sup> P <sub>2</sub>	3	22607	22691	22668	23
<sup>1</sup> I <sub>6</sub>	21541	-	21570				664	714	704	10
<sup>3</sup> P <sub>1</sub>	21556	21567	21592			-25	673	734	738	-4
<sup>1</sup> I <sub>6</sub>	598	585	588			-3	725	772	787	-15
	619	-	637				767	819	817	2
	650	668	666			2				
	738	-	804				46961	46965 <sup>f</sup>	46965	0
							<sup>1</sup> S <sub>0</sub>			

<sup>a</sup>Ref. 13. Values for the <sup>1</sup>I<sub>6</sub> components (but not the <sup>3</sup>P<sub>1</sub>) were reduced by 100 cm<sup>-1</sup> to correspond to present assignments.

<sup>b</sup>Ref. 36 and 39 except as indicated; cm<sup>-1</sup> vac.

<sup>c</sup>Energy level parameters are given in Table 1.

<sup>d</sup>Ref. 38.

<sup>e</sup>Not used in fitting parameters.

<sup>f</sup>Ref. 42.

JCPSA-90-3443-63

Appendix III.  
Computed Energy Level Structure for  $\text{Pm}^{3+}:\text{LaF}_3$

SLJ <sup>a</sup> State	Calc. <sup>b</sup> (cm <sup>-1</sup> )	SLJ <sup>a</sup> State	Calc. <sup>b</sup> (cm <sup>-1</sup> )	SLJ <sup>a</sup> State	Calc. <sup>b</sup> (cm <sup>-1</sup> )	SLJ <sup>a</sup> State	Calc. <sup>b</sup> (cm <sup>-1</sup> )
$5I_4$	0	$5I_6$	3376	$5I_8$	6556	$5F_2$	13156
	135		3389		6605		170
	189		3392		6621		
	233		3413		6653	$5F_3$	13853
	266		3413		6672		900
	294		3416		6746		918
	332		3439		6763		952
	437		3462		6824		965
	474		3470		6827		998
					6857		14020
$5I_5$	1667	$5I_7$	5042		6959		
	1710		5045		6977	$5S_2$	14525
	1717		5059		7060		529
	1769		5060		7063		529
	1769		5066		7129		529
	1810		5074		7131		530
	1812		5078		7152		
	1821		5084			$5F_4$	14804
	1828		5086	$5F_1$	12650		837
	1829		5090		671		892
	1845		5110		684		894
			5114				895
$5I_6$	3285		5116	$5F_2$	13031		898
	3322		5143		076		926
	3326		5149		091		965
	3369						998

JCPA-90-3443-63

## Appendix III. (cont.)

SLJ <sup>a</sup>	Calc. <sup>b</sup>	SLJ <sup>a</sup>	Calc. <sup>b</sup>	SLJ <sup>a</sup>	Calc. <sup>b</sup>	SLJ <sup>a</sup>	Calc. <sup>b</sup>
State	(cm <sup>-1</sup> )	State	(cm <sup>-1</sup> )	State	(cm <sup>-1</sup> )	State	(cm <sup>-1</sup> )
<sup>5</sup> F <sub>5</sub>	16145	<sup>5</sup> G <sub>4</sub> ,	18045	<sup>5</sup> G <sub>3</sub>	18679	<sup>5</sup> G <sub>5</sub> ,	20471
	148	<sup>5</sup> G <sub>3</sub> ,	066	<sup>3</sup> K <sub>7</sub>	689	<sup>5</sup> G <sub>4</sub>	492
	149	<sup>3</sup> K <sub>7</sub>	068				532
	151		076	<sup>3</sup> K <sub>8</sub>	19854		541
	212		079		859		579
	226		104		870		592
	249		104		872		611
	250		126		885		664
	273		147		890		700
	307		252		928		713
	322		316		951		
			364		973	<sup>3</sup> G <sub>3</sub>	21968
<sup>3</sup> K <sub>6</sub>	17071		381		974		974
	088		408		20005		22020
	088				012		040
	091	<sup>5</sup> G <sub>3</sub> ,	18426		035		062
	092	<sup>3</sup> K <sub>7</sub>	426		036		070
	093		444		107		117
	104		461		111		
	106		500		136	<sup>5</sup> G <sub>5</sub> ,	22424
	109		508			<sup>5</sup> G <sub>6</sub>	429
	115		510	<sup>5</sup> G <sub>5</sub> ,	20243		433
	123		535	<sup>5</sup> G <sub>4</sub>	260		461
	123		536		294		469
	137		545		303		480
			557		20361		500
<sup>5</sup> G <sub>2</sub>	17904		559		365		503
	932		611		366		512
	949		657		387		539
	18007		665		445		563
	017				463		575

JCPSA-90-3443-63

## Appendix III. (cont.)

SLJ <sup>a</sup>	Calc. <sup>b</sup>	SLJ <sup>a</sup>	Calc. <sup>b</sup>	SLJ <sup>a</sup>	Calc. <sup>b</sup>
State	(cm <sup>-1</sup> )	State	(cm <sup>-1</sup> )	State	(cm <sup>-1</sup> )
<sup>5</sup> G <sub>5</sub> ,	22663	<sup>3</sup> L <sub>7</sub>	24028	<sup>3</sup> H <sub>6</sub> ,	24992
<sup>5</sup> G <sub>6</sub>	683		043	<sup>3</sup> G <sub>4</sub> ,	25014
	696		046	<sup>3</sup> L <sub>8</sub>	018
	696				023
	754	<sup>3</sup> P <sub>1</sub>	24289		038
	769		299		068
	779		306		071
	827				073
	831	<sup>3</sup> H <sub>6</sub> ,	24635		122
	895	<sup>3</sup> G <sub>4</sub> ,	661		136
	909	<sup>3</sup> L <sub>8</sub>	664		156
	942		678		157
			695		171
<sup>3</sup> D <sub>2</sub>	23189		708		172
	253		762		224
	288		772		263
	327		780		
	327		785		(25816-50000 <sup>c</sup> )
			810		
<sup>3</sup> L <sub>7</sub>	23699		817		
	701		834		
	828		849		
	840		869		
	841		874		
	887		893		
	889		24905		
	954		917		
	956		918		
	965		924		
	968		945		
	24022		950		



## Appendix III. (cont.)

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<sup>a</sup>The leading component of the state eigenvector is indicated.

<sup>b</sup>The energy level parameters (interpolated) used to compute these level energies are given in Table 1.

<sup>c</sup>Since there are no experimental data available, the tabulation has been arbitrarily stopped at  $25263 \text{ cm}^{-1}$ . At higher energies, starting with the next level at  $25816 \text{ cm}^{-1}$ , the computed density of states is relatively high. Some additional results are given for  $\text{Pm}^{3+}:\text{LaCl}_3$  in Ref. 45. Figure 7 indicates the larger gaps in energy where no crystal-field components are computed to occur.

## Appendix IV.

Experimental and Computed Energy Level Structure of  $\text{Sm}^{3+}:\text{LaF}_3$ 

SLJ <sup>a</sup> State	Expt. <sup>b</sup> ( $\text{cm}^{-1}$ )	Calc. <sup>c</sup> ( $\text{cm}^{-1}$ )	O-C	Rast <sup>d</sup>	
				et al. ( $\text{cm}^{-1}$ )	Dieke <sup>e</sup> ( $\text{cm}^{-1}$ )
$^6\text{H}_{5/2}$	0	-6	6	0	0
	44	53	-9	48	44
	159	135	24	115	159
$^6\text{H}_{7/2}$	1000	990	10	1000	1003
	1044	1027	17	044	046
	1185	1205	-20	185	100
	1280	1262	18	280	187
$^6\text{H}_{9/2}$	2209	2193	16	2209	2213
	244	233	11	244	247
	342	332	10	342	344
	409	408	1	409	404
	473	468	5	473	493
$^6\text{H}_{11/2}$	3520	3510	10	3517	
	568	553	15	567	
	651	628	23	647	
	671	667	4	670	
	727	739	-12	726	
	791 <sup>d</sup>	793	-2	791	
$^6\text{H}_{13/2}$	4972	4947	25	4971	4969
	982	975	7	982	
	5007	5004	3	5007	5005
	046	042	4	047	044
	057	059	-2	057	
	122	114	8	122	
	160	170	-10	160	

## Appendix IV. (cont.)

SLJ <sup>a</sup>	Expt. <sup>b</sup>	Calc. <sup>c</sup>		Rast <sup>d</sup>	
State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C	et al. (cm <sup>-1</sup> )	Dieke <sup>e</sup> (cm <sup>-1</sup> )
<sup>6</sup> H <sub>15/2</sub> ,	6309	6300	9	-	
<sup>6</sup> F <sub>1/2</sub>	341	334	7	6346	
	406	417	-11	408	6404
	460	465	-5	454	
	-	472		462	
	-	553		492	
	568	578	-10	538	
	609	605	4	571	
	-	666			
<sup>6</sup> F <sub>3/2</sub>	6707	6724	-17	6707	
	-	738		-	
<sup>6</sup> F <sub>5/2</sub>	7177	7177	0	7174	7173
	184	190	-6	184	180
	223	239	-16	225	
<sup>6</sup> F <sub>7/2</sub>	7992	8008	-16	7993	7987
	8041	026	15	8042	8034
	060	059	1	059	054
	092	108	-16	092	086
<sup>6</sup> F <sub>9/2</sub>	9170	9173	-3	9170	9162
	178	189	-11	180	173
	228	223	5	231	222
	252	243	9	254	247
	268	281	-13	270	262
<sup>6</sup> F <sub>11/2</sub>	10561	10567	-6	10559	
	584	583	1	581	
	592	590	2	590	
	603	621	-18	602	
	613	633	-20		
	644	656	-12		

## Appendix IV. (cont.)

SLJ <sup>a</sup>	Expt. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	Rast <sup>d</sup>	
				et al. (cm <sup>-1</sup> )	Dieke <sup>e</sup> (cm <sup>-1</sup> )
<sup>4</sup> G <sub>5/2</sub>	17858	17863	-5		17858
	949	960	-11		949
	(18045)	18087			18046
<sup>4</sup> F <sub>3/2</sub>	18924	18933	-9		18924
	942	951	-9		942
<sup>4</sup> G <sub>7/2</sub>	20037	20041	-4		20037
	093	094	-1		093
	112	123	-11		111
	164	168	-4		
<sup>4</sup> I <sub>9/2</sub>	20416	20406	10		20417
	472	472	0		471
	499	505	-6		497
	522	531	-9		523
	570	551	19		
<sup>4</sup> M <sub>15/2</sub> ,	-	20685			
<sup>4</sup> I <sub>11/2</sub>	-	770			
	-	808			
	-	858			
	-	892			
	-	904			
	-	922			20944
	-	974			
	-	21004			
	-	071			
	-	164			
	-	179			
	-	248			
	-	265			

## Appendix IV. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>	Dieke <sup>e</sup>	SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>	Dieke <sup>e</sup>
State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C	State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C
$4I_{13/2}$	21520	21541	-21	$4M_{17/2}$	-	23116	
	602	602	0	$4G_{9/2}$	-	158	
	636	616	20	$4I_{15/2}$			
	665	649	16	$4M_{19/2}$	23988	23989	-1
	-	652		$6P_{5/2}$	24022	24035	-13
	674	666	8		031	068	-37
	706	684	22		064	080	-16
					084	101	-17
$4F_{3/2}$	22164	22178	-14		119	126	-7
	207	213	-6		135	134	1
	240	254	-14		153	162	-9
					-	169	
$4M_{17/2}$	22501	22500	1		-	181	
$4G_{9/2}$	531	539	-8		-	186	
$4I_{15/2}$	542	552	-10		-	207	
	-	573			-	218	
	579	581	-2				
	628	630	-2	$4L_{13/2}$	24608	24616	-8
	695	693	2		629	632	-3
	-	738			631	642	-11
	-	770			644	658	-14
	808	801	7		679	689	-10
	829	834	-5		683	695	-12
	-	867			710	720	-10
	-	912					
	942	943	-1	$4F_{7/2}$	24911	24900	11
	-	982			993	987	6
	-	23020			25007	25002	5
	-	023			064	071	-7
	-	036		$6P_{3/2}$	081	088	-7
	-	054			-	106	
	-	083					

## Appendix IV. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>	Dieke <sup>e</sup>	SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>	Dieke <sup>e</sup>
State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C	State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )
<sup>4</sup> G <sub>11/2</sub>	25166	25169	-3	<sup>4</sup> L <sub>17/2</sub>	26702	26694	8
<sup>4</sup> M <sub>21/2</sub>	182	177	5	<sup>6</sup> P <sub>7/2</sub>	712	705	7
<sup>4</sup> M <sub>15/2</sub>	204	203	1		717	718	-1
<sup>4</sup> H <sub>11/2</sub>	216	217	-1		743	751	-8
-	-	220			776	763	13
-	-	243			792	777	15
248	259	-11			797	800	-3
282	285	-3			-	803	
-	308				812	812	0
-	343				822	826	-4
-	398				859	349	10
-	439				-	862	
-	476				874	868	6
-	543						
-	565			<sup>4</sup> K <sub>13/2</sub>	26942	26931	11
611	603	8	25614		962	955	7
636	621	15	632		27003	991	12
650	645	5	649		018	27014	4
672	654	18	666		031	026	5
684	682	2	681		061	073	-12
-	698				120	109	11
711	708	3					
718	713	5		<sup>4</sup> F <sub>9/2</sub>	27417	27381	36
771	762	9	767		432	443	-11
789	782	7	787		448	467	-19
801	795	6	798		508	510	-2
826	823	3			-	552	
832	845	-13					
866	866	0		<sup>4</sup> D <sub>3/2</sub>	27648	27646	2
904	882	22			658	654	4
-	921						
<sup>4</sup> D <sub>1/2</sub>	26495	26472	23				
			26495				

## Appendix IV. (cont.)

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	Dieke <sup>e</sup> (cm <sup>-1</sup> )	SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	Dieke <sup>e</sup> (cm <sup>-1</sup> )
$4P_{5/2}$	27691	27714	-23	27692	$(^4K, ^4L)_{17/2}$	29166	29169	-3	
	734	763	-29	735		-	183		
	758	787	-29	759		195	191	4	
						-	219		
$4H_{7/2}$	28247	28242	5	28247		-	238		
	261	252	9	262	$^4L_{19/2},$	29268	29270	-2	
	344	359	-15		$^4H_{11/2},$	304	298	6	
	409	393	16	410	$^4H_{13/2}$	-	315		
						-	325		
$4K_{15/2}$	28722	28735	-13			-	335		
	732	743	-11	28732		-	347		
	760	757	3			-	356		
	-	770				-	363		
	784	783	1			-	397		
	797	793	4			-	416		
	-	804				-	457		
	817	823	-6			-	478		
						-	505		
$4H_{9/2}$	28938	28925	13	28938		-	514		
	-	929				-	555		
	981	989	-8	980		-	558		
	29035	29045	-10	036		-	562		
	055	070	-15	052		-	607		
						-	615		
$4D_{7/2}$	29086	29098	-12	29083		-	650		
	094	108	-14	092		709	681	28	
	112	115	-3	111		723	693	30	
	-	122				738	738	0	
$(^4K, ^4L)_{17/2^-}$		137							
	-	140			$^4G_{7/2},$	30027	30031	-4	30028
	29154	154	0	29154	$^4G_{9/2}$	120	118	2	120
	-	156				136	159	-23	136

## Appendix IV. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>		Dieke <sup>e</sup>	SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>		Dieke <sup>e</sup>
State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C	(cm <sup>-1</sup> )	State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C	(cm <sup>-1</sup> )
<sup>4</sup> G <sub>7/2</sub> ,	-	30193			<sup>4</sup> P <sub>5/2</sub>	32800	32797	3	32799
<sup>4</sup> G <sub>9/2</sub>	30216	210	6	213		823	824	-1	823
	235	212	23			857	856	1	858
	-	260							
	293	289	4		<sup>2</sup> F <sub>5/2</sub> ,	-	33548		
	332	347	-15		<sup>2</sup> K <sub>13/2</sub> ,	33615	642	-27	
					<sup>4</sup> F <sub>9/2</sub>	-	708		
<sup>4</sup> G <sub>5/2</sub>	-	30438				777	787	-10	
	-	508				-	813		
	-	549				-	865		
						-	900		
<sup>4</sup> P <sub>1/2</sub>	-	31226				-	955		
						-	962		
<sup>2</sup> L <sub>15/2</sub> ,	-	31337				-	977		
<sup>4</sup> G <sub>11/2</sub> ,	-	352				-	34007		
<sup>4</sup> P <sub>3/2</sub>	31410	394	16	31412		-	028		
	433	445	-12	435		-	049		
	463	476	-13	465		-	081		
	488	495	-7	489		-	095		
	511	504	7	511					
	523	513	10	524	<sup>2</sup> L <sub>17/2</sub> ,	-	34341		
	532	530	2	533	<sup>4</sup> I <sub>9/2</sub>	-	358		
	543	558	-15	538		-	386		
	583	604	-21	582		-	426		
	624	623	1	627		-	434		
	-	630				34454	467	-13	
	-	682				468	468	0	
	-	707				481	488	-7	34484
	759	734	25			497	495	2	499
						519	536	-17	
						-	552		
						-	590		



SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>	
State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C

<sup>2</sup> L <sub>17/2</sub> ,	-	34612	
<sup>4</sup> I <sub>9/2</sub>	-	654	

<sup>4</sup> F <sub>7/2</sub> ,		(35612-35823) <sup>f</sup>	
<sup>2</sup> N <sub>19/2</sub>			

<sup>2</sup> P <sub>1/2</sub>	-	35846	
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<sup>4</sup> I <sub>11/2</sub>	35890	35892	-2
	905	905	0
	-	932	
	954	945	9
	996	987	9
	36007	999	8
	055	36054	1

(36315-37273)<sup>f</sup>  
(39 levels)

<sup>4</sup> H <sub>9/2</sub>	37623	37607	16
	-	618	
	634	638	-4
	657	654	3
	679	667	12

<sup>2</sup> F <sub>7/2</sub> ,	-	38175	
<sup>2</sup> P <sub>3/2</sub>	-	219	
	-	300	
	38467	461	6
	492	485	7
	-	512	

SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>	
State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C

(38906-41774)<sup>f,8</sup>  
46 levels

<sup>2</sup> G <sub>9/2</sub>	-	42039	
	42066	072	-6
	124	104	20
	135	137	-2
	176	183	-7

<sup>2</sup> O <sub>23/2</sub> ,	42227	42215	12
<sup>4</sup> G <sub>5/2</sub> ,	378	400	-22
<sup>4</sup> G <sub>7/2</sub>	-	456	
	462	472	-10
	486	480	6
	-	506	
	-	514	
	-	546	
	-	574	
	-	594	
	-	612	
	616	614	2
	-	642	
	-	643	
	658	661	-3
	-	668	
	-	699	
	711	720	-9
	-	744	
<sup>2</sup> O <sub>21/2</sub> ,	-	809	
<sup>4</sup> K <sub>15/2</sub>	-	914	
	-	951	
	959	963	-4

## Appendix IV. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>	
State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C
<sup>2</sup> O <sub>21/2</sub> ,	-	42976	
<sup>4</sup> K <sub>15/2</sub>	42990	996	-6
	-	43022	
	43040	041	-1
	-	056	
	074	080	-6
		(43088-43658) <sup>f</sup>	
		27 levels	

<sup>2</sup> H <sub>11/2</sub>	43769	43760	9
	-	762	
	-	808	
	844	855	-11
	-	869	
	-	921	

<sup>2</sup> G <sub>7/2</sub>	43991	43975	16
	-	44005	
	-	033	
	-	041	

SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>	
State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C
		(44491-47029) <sup>f</sup>	
		54 levels	
<sup>2</sup> H <sub>11/2</sub>	47336	47306	30
	374	363	11
	-	430	
	-	523	
	-	536	
	-	675	

		(47812-48909) <sup>f</sup>	
		45 levels	
<sup>4</sup> P <sub>1/2</sub> ,	(49581-49865) <sup>f</sup>		
<sup>2</sup> H <sub>9/2</sub> ,			
<sup>2</sup> F <sub>5/2</sub>			

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<sup>a</sup>Largest or two largest eigenvector components are indicated.

<sup>b</sup>Experimental results for the  ${}^6\text{H}_{5/2}$  state taken from Ref. 1 based on correlation with model calculation. Observed data for the  ${}^6\text{H}_{9/12}$  and  ${}^6\text{H}_{9/2}$  states in the ground multiplet from Ref. 46. Values in parentheses were not included in the parameter fitting process. All entries in  $\text{cm}^{-1}$  vac.

<sup>c</sup>Energy level parameters are given in Table 1.

<sup>d</sup>Ref. 46.

<sup>e</sup>Ref. 1.

<sup>f</sup>In certain regions of the spectrum where no structure was observed and computations indicated a high density of levels, only the initial and final energies of the group are indicated. In some cases one or two very weak bands were observed consistent with calculation, but not included.

<sup>g</sup>There is an energy gap,  $39500\text{--}40340\text{ cm}^{-1}$ , in which no levels are computed to occur.

JCPSA 90-3843-63

## Appendix V.

Experimental and Computed Energy Level Structure for  $\text{Er}^{3+}:\text{LaF}_3$ 

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> ( $\text{cm}^{-1}$ )	Calc. <sup>c</sup> ( $\text{cm}^{-1}$ )	O-C	SLJ <sup>a</sup> State	Obsd. <sup>b</sup> ( $\text{cm}^{-1}$ )	Calc. <sup>c</sup> ( $\text{cm}^{-1}$ )	O-C
$^4\text{I}_{15/2}$	0	-22	22	$^4\text{F}_{9/2}$	15391	15406	-15
	51.2	27	24		432	443	-11
	121.2	92	30		443	462	-19
	199.7	176	24		474	488	-14
	219.4	193	26		527	538	-11
	313.8	289	25	$^4\text{S}_{3/2}$	18557	18577	-20
	400.3	375	25		588	610	-22
	442.9	420	23				
$^4\text{I}_{13/2}$	6604	6612	-8	$^2\text{H}_{11/2}$	19266	19299	-33
	630	637	-7		307	324	-17
	670	686	-16		314	344	-30
	700	699	1		363	371	-8
	723	732	-9		367	379	-12
	754	771	-17		419	430	-11
	823	830	-7	$^4\text{F}_{7/2}$	20656	20654	2
					703	697	6
$^4\text{I}_{11/2}$	10301	10300	1		734	735	-1
	311	314	-3	$^4\text{F}_{5/2}$	786	790	-4
	330	336	-6		22370	22380	-10
	344	351	-7		374	389	-15
	358	364	-6		407	414	-7
	395	405	-10	$^4\text{F}_{3/2}$	22684	22692	-8
					751	748	3
$^4\text{I}_{9/2}$	12419	12392	27				
	518	512	6				
	615	596	19				
	701	681	20				
	730	720	10				

JCPA-90-3443-63

## Appendix V. (cont.)

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>2</sup> G <sub>9/2</sub>	24602	24587	15	<sup>2</sup> G <sub>7/2</sub>	28239	28233	16
	680	698	-18		255	237	18
	754	755	-1		-	246	
	840	831	9		264	250	14
	862	864	-2	<sup>2</sup> P <sub>3/2</sub>	31695	31723	-28
<sup>4</sup> G <sub>11/2</sub>	26526	26534	-8		752	786	-34
	554	559	-5	<sup>2</sup> K <sub>13/2</sub>	33107	33086	21
	582	586	-4		116	106	10
	(621) <sup>d</sup>	637			141	154	-13
	647	640	7		163	161	2
	707	700	7		186	196	-10
<sup>4</sup> G <sub>9/2</sub>	27602	27608	-6		-	228	
	616	615	1	<sup>2</sup> P <sub>1/2</sub>	33346	33350	-4
	628	625	3				
	641	637	4	<sup>2</sup> K <sub>13/2</sub>	397	405	-8
	668	660	8				
<sup>2</sup> K <sub>15/2</sub>	27817	27826	-9	<sup>4</sup> G <sub>5/2</sub>	-	33510	
	827	838	-11		-	522	
	872	877	-5		-	628	
	898	893	5	<sup>4</sup> G <sub>7/2</sub>	34159	34154	5
	933	932	1		197	182	15
	-	978			222	215	7
	-	28014			280	271	9
	28125	132	-7				

JCPSA-90-3443-63

## Appendix V. (cont.)

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>2</sup> D <sub>5/2</sub>	35026	35043	-17	<sup>2</sup> L <sub>17/2</sub>	41802	41832	-30
	052	052	0		-	861	
	085	091	-6		-	922	
<sup>2</sup> H <sub>9/2</sub>	36520	36526	-6		934	957	-23
	556	549	7		42002	42045	-43
	623	637	-14		-	054	
	720	729	-9	<sup>4</sup> D <sub>3/2</sub>	42499	42484	15
	804	796	8		529	517	12
<sup>4</sup> D <sub>5/2</sub>	38807	38815	-8	<sup>2</sup> D <sub>3/2</sub>	43090	43108	-18
	837	858	-21		127	138	-11
	844	863	-19	<sup>2</sup> I <sub>13/2</sub>	43686	43672	14
<sup>4</sup> F <sub>7/2</sub>	39454	39460	-6		742	725	17
	537	540	-3		759	750	9
	603	605	-2		770	769	1
	634	630	4		833	815	18
<sup>2</sup> I <sub>11/2</sub>	41237	41211	26		914	898	16
	294	269	25	<sup>4</sup> D <sub>1/2</sub>	-	956	
	313	304	9		-	47347	
	380	352	28	<sup>2</sup> L <sub>15/2</sub>	47891	47891	0
	395	375	20		951	922	29
	493	466	27		-	990	
<sup>2</sup> L <sub>17/2</sub>	41680	41720	-40		-	48007	
	-	801			48071	066	5
	783	822	-39			083	

JCPA-90-3443-63

## Appendix V. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>	
State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C
<sup>2</sup> L <sub>15/2</sub>	-	48168	
	-	199	
<sup>2</sup> H <sub>9/2</sub>	-	48306	
	-	349	
	-	394	
	-	438	
	-	461	
<sup>2</sup> D <sub>5/2</sub>	49223	49178	45
	272	248	24
	357	321	36

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<sup>a</sup>The principal SLJ-component of the state is indicated.

<sup>b</sup>All energies are corrected to vacuum cm<sup>-1</sup>. The energies of the ground <sup>4</sup>I<sub>15/2</sub> state are taken from Ref. 47.

<sup>c</sup>Energy level parameters are given in Table 1.

<sup>d</sup>Not included in the energy level parameter fitting.

Appendix VI.

Experimental and Computed Energy Level Structure for  $\text{Tm}^{3+}:\text{LaF}_3$

SLJ	Model <sup>a</sup> ( $\text{cm}^{-1}$ )	Expt. <sup>b</sup> ( $\text{cm}^{-1}$ )	Calc. <sup>c</sup> ( $\text{cm}^{-1}$ )	O-C	SLJ	Model <sup>a</sup> ( $\text{cm}^{-1}$ )	Expt. <sup>b</sup> ( $\text{cm}^{-1}$ )	Calc. <sup>c</sup> ( $\text{cm}^{-1}$ )	O-C
$^3\text{H}_6$	0	0	-4	4	$^3\text{F}_4$	5585	5615	5613	2
	67	67	66	1		5689	5706	5703	3
	74	-	76			5790	5814	5820	-6
	156	118	131	-13		5813	5826	5838	-12
	204	-	197			5836	5859	5857	2
	235	-	198			5851	5866	5863	3
	272	-	254			5903	-	5905	
	274	-	273			5916	5918	5924	-6
	349	-	339			5929	5958	5941	17
	354	-	346		$^3\text{H}_5$				
	400	-	386			8306	8305	8293	12
	418	-	399			8354	8332	8331	1
	441	-	420						



JCLSA-90-3843-63

## Appendix VI. (cont.)

SLJ	Model <sup>a</sup> (cm <sup>-1</sup> )	Expt. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>3</sup> H <sub>5</sub>	8365	8338	8337	1
	8395	8366	8368	-2
	8451	8400	8415	-15
	8460	-	8442	
	8470	-	8446	
	8481	-	8464	
	8522	-	8499	
	8581	8550	8562	-12
	8589	-	8568	
<sup>3</sup> H <sub>4</sub>	12547	12561	12553	8
	597	570	578	-8
	678	700	690	10
	734	727	719	8

  

SLJ	Model <sup>a</sup> (cm <sup>-1</sup> )	Expt. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>3</sup> H <sub>4</sub>	12784	-	12770	
	826	12825	819	6
	832	-	824	
	880	868	863	5
	909	-	890	
<sup>3</sup> F <sub>3</sub>	14514	14508	14522	-14
	530	-	537	
	534	539	538	1
	550	554	556	-2
	582	588	588	0
	590	596	593	3
	622	-	627	

JCPA-90-3443-63

## Appendix VI. (cont.)

SLJ	Model <sup>a</sup> (cm <sup>-1</sup> )	Expt. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ	Model <sup>a</sup> (cm <sup>-1</sup> )	Expt. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>3</sup> F <sub>2</sub>	15153	15138	15144	-6	<sup>1</sup> G <sub>4</sub>	21511	21519	21512	7
	180	169	171	-2		28022	28021	28024	-3
	200	207	193	14	<sup>1</sup> D <sub>2</sub>	023	034	024	10
	254	240	240	0		041	057	049	8
	266	-	264			074	088	088	0
<sup>1</sup> G <sub>4</sub>	21016	21037	21041	-4	<sup>1</sup> I <sub>6</sub>	100	106	114	-8
	193	196	198	-2		34781	34769	34772	-3
	300	309	319	-10		808	-	795	
	335	349	339	10		906	896	906	-10
	362	366	372	-6		35000	-	997	
	364	380	382	-2		022	-	35015	
	425	-	406			078	-	106	
	508	-	511						

JCPSA-90-3443-63

## Appendix VI. (cont.)

SLJ	Model <sup>a</sup> (cm <sup>-1</sup> )	Expt. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ	Model <sup>a</sup> (cm <sup>-1</sup> )	Expt. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>1</sup> I <sub>6</sub>	35079	35107	35109	-2	<sup>3</sup> P <sub>1</sub>	36549	36587	36575	12
	149	160	143	17		588	-	624	
	201	-	184						
	216	-	226		<sup>3</sup> P <sub>2</sub>	38225	38250	38244	6
	217	-	234			266	291	290	1
	257	-	253			296	336	326	10
	272	-	270			415	414	427	-13
<sup>3</sup> P <sub>0</sub>	35588	35604	35624	-20		426	451	464	-13
<sup>3</sup> P <sub>1</sub>	36502	36531	36525	6	<sup>1</sup> S <sub>0</sub>	75158	-	75025	

<sup>a</sup>Ref. 13.<sup>b</sup>Ref. 49 (cm<sup>-1</sup> vac).<sup>c</sup>Energy level parameters are given in Table 1.

JCPA-90-3443-63

## Appendix VII.

Experimental and Computed Energy Level Structure for  $\text{Ho}^{3+}:\text{LaF}_3$ 

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
$^5\text{I}_8$	0	-2	2	$^5\text{I}_7$	5287	5291	-4
	4.5	3	1		296	293	3
	42	29	13		309	300	9
	50	54	-4		314	303	11
	69	67	2	$^5\text{I}_6$	8726	8722	4
	122	130	-8		730	723	7
	145	151	-6		733	732	1
	201	221	-20		735	735	0
	215	222	-7		747	740	7
	227	232	-5		753	754	-1
	(261) <sup>d</sup>	298			761	767	-6
	307	307	-0		773	776	-3
	322	324	-2		783	778	5
	349	339	10		786	791	-5
	387	388	-1		814	812	2
	398	391	7		-	817	
	409	410	-1		834	839	-5
$^5\text{I}_7$	-	5182		$^5\text{I}_5$	11304	11298	6
	5192	182	10		306	303	3
	-	242			308	303	5
	-	243			311	314	-3
	-	244			-	315	
	246	248	-2		321	319	2
	250	250	0		332	333	-1
	-	256			-	338	
	264	268	-4		363	360	3
	273	276	-3				
	280	276	4				

JCPSA-90-3443-63

## Appendix VII. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>		SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>	
State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C	State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C
<sup>5</sup> I <sub>5</sub>	-	11369		<sup>5</sup> S <sub>2</sub>	18603	18602	1
	11386	392	-6		620	620	0
<sup>5</sup> I <sub>4</sub>	-	13260		<sup>5</sup> F <sub>4</sub>	18677	18677	0
	13286	285	1		688	683	5
	362	382	-20		709	719	-10
	380	388	-8		720	728	-8
	-	394			737	749	-12
	-	419			753	760	-7
	-	455			-	767	
	-	477			776	793	-17
	-	607			814	812	2
<sup>5</sup> F <sub>5</sub>	15576	15587	-11	<sup>5</sup> F <sub>3</sub>	20744	20725	19
	593	603	-10		754	750	4
	608	615	-7		796	789	7
	625	629	-4		799	791	8
	641	637	4		826	821	5
	659	661	-2		832	823	9
	-	681			866	861	5
	-	712		<sup>5</sup> F <sub>2</sub>	21238	21228	10
	-	714			249	232	17
	708	717	-9		265	260	5
	730	734	-4		275	281	-6
<sup>5</sup> S <sub>2</sub>					286	287	-1
	18590	18597	-7	<sup>3</sup> K <sub>8</sub>	21411	21405	6
	600	598	2		419	424	-5
	603	601	2				

JLPSA - 90 - 3443-63

## Appendix VII. (cont.)

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>3</sup> K <sub>8</sub>	21423	21427	-4	<sup>5</sup> F <sub>1</sub>	-	22504	
	432	426	6		22508	504	4
	440	449	-9		-	535	
	451	457	-6	<sup>5</sup> G <sub>5</sub>	24112	24123	-11
	461	458	3		116	130	-14
	-	468			125	136	-11
	481	479	2		146	165	-19
	495	480	15		-	167	
	514	507	7		170	173	-3
	527	514	13		182	180	2
	532	546	-14		-	185	
	550	552	-2		196	194	2
	566	564	2		-	222	
	-	573			247	222	25
	579	574	5				
<sup>5</sup> G <sub>6</sub>	22220	22238	-18	<sup>5</sup> G <sub>4</sub>	25985	25982	3
	235	250	-15		26008	980	28
	263	260	3		037	26051	-14
	283	303	-20		054	057	-3
	328	331	-3		-	058	
	346	342	4		084	059	25
	361	348	13		096	096	0
	374	360	14		-	155	
	389	380	9	<sup>3</sup> K <sub>7</sub>	161	169	-8
	407	395	12		26255	26261	-6
	424	423	1		-	262	
	438	429	9		-	266	
	454	479	-25				

JCPA-90. 3443-63

## Appendix VII. (cont.)

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>3</sup> K <sub>7</sub>	26266	26267	-1	<sup>5</sup> G <sub>5</sub> , <sup>3</sup> H <sub>6</sub>	27945	27948	-3
	277	282	-5		-	973	
	-	287			-	984	
	288	287	1		-	991	
	293	298	-5		997	28000	-3
	-	299			-	020	
	298	299	-1		-	076	
	312	312	0		28092	077	15
	320	314	6		.		
	-	324		<sup>5</sup> F <sub>2</sub>	28426	28433	-7
	328	331	-3		-	450	
	328	332	-4		-	479	
<sup>5</sup> G <sub>5</sub> , <sup>3</sup> H <sub>6</sub>					-	492	
					-	506	
	27749	27746	3	<sup>5</sup> G <sub>3</sub> , <sup>3</sup> L <sub>9</sub>	-	28956	
	758	751	7		28981	996	-15
	804	788	16		29011	29017	-6
	-	814			020	019	1
	815	814	1		032	020	12
	-	819			035	028	7
	-	820			039	036	3
	825	826	-1		-	049	
	839	840	-1		-	051	
	-	846			068	052	16
	854	851	3		-	094	
	869	859	10		-	094	4
	879	882	-3		-	095	
	-	926			102	100	2
	-	927					
	932	928	4				

JCPA-90-3443-63

## Appendix VII. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>		SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>	
State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C	State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C
$^5G_3, ^3L_9$	29122	29125	-3	$^3F_4, ^3K_6$	-	30267	
	-	127			-	288	
	-	128			30292	306	-14
	-	146			-	322	
	161	160	1		-	325	
	-	164			330	331	-1
	-	166					
	187	174	13	$^5G_2$	-	30997	
	-	220			31002	31006	-4
	230	220	10		020	008	12
	-	303			-	026	
	292	303	-11		062	072	-10
$^3F_4, ^3K_6$	-	30023		$^3D_3$	-	33313	
	-	027			-	330	
	30058	058	0		-	346	
	078	072	6		-	360	
	094	101	-7		-	382	
	101	105	-4		-	412	
	-	114			-	437	
	116	122	-6				
	-	140		$^3P_1$	-	33554	
	157	155	2		-	560	
	186	187	-1		-	564	
	-	197					
	197	198	-1	$^3M_{10}, ^3L_8$	34022	34033	-11
	213	218	-5		-	040	
	-	228			-	048	
	234	231	3		061	057	4



JCPSA-90-3443-63

## Appendix VII. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>		SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>	
State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C	State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C
<sup>3</sup> M <sub>10</sub> , <sup>3</sup> L <sub>8</sub>	-	34105		<sup>5</sup> D <sub>4</sub>	36058	36040	18
	34116	122	-6		070	071	-1
	-	138			086	085	1
	-	166			100	090	10
	-	191			111	140	-29
	205	205	0		-	221	
	-	212			-	251	
	-	221			244	252	-8
		(34234-34542) <sup>e</sup>			-	270	
<sup>5</sup> G <sub>4</sub>	-	34967		<sup>3</sup> P <sub>0</sub>	-	36318	
	-	978				(36450-36703) <sup>f</sup>	
	-	978					
	34994	984	10	<sup>3</sup> H <sub>5</sub>	36852	36868	-16
	-	998			869	875	-6
	35003	35002	1		894	909	-15
	023	024	-1		-	935	
	-	024			-	965	
	049	032	17		37001	990	11
<sup>3</sup> F <sub>3</sub>	35335	35327	8		-	37021	
	-	343			034	032	2
	369	368	1		-	032	
	424	415	9		-	045	
	-	435			-	066	
	489	491	-2			(37975-38237) <sup>g</sup>	
	-	530					

JCPSA - 90-3443-63

## Appendix VII. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup>	Calc. <sup>c</sup>	
State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C
<sup>3</sup> I <sub>7</sub>	-	38560	
	-	568	
	38570	571	-1
	-	585	
	-	590	
	-	590	
	599	597	2
	-	612	
	-	614	
	-	620	
	-	621	
	-	624	
	38638 <sup>h</sup>	646	
	-	647	
	-	652	

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<sup>a</sup>The principal SLJ-component of the state is given.

<sup>b</sup>The energies quoted as observed are primarily from ref. 52 as confirmed in the present study. In some instances the band energies reported are those found in the present work where no corresponding observations were quoted in (52); there were also cases in which more crystal-field components than would be allowed for a given J-value were quoted in (52). The present model crystal-field calculations were used as the basis for excluding the extra levels. Units of cm<sup>-1</sup> vac.

<sup>c</sup>Energy level parameters are given in Table 1.

<sup>d</sup>Not included in the energy level parameter fitting.

## Appendix VII. (cont.)

JLPSA 90-344363

<sup>e</sup>There are 24 crystal-field components belonging principally to the  $^3M_{10}$  and  $^3L_8$  states computed in the energy range between 34234 and 34542  $\text{cm}^{-1}$ . No structure was observed in this range.

<sup>f</sup>There are 22 crystal-field components belonging principally to the  $^3F_2$  and  $^1L_8$  states computed in the energy range 36450-36703  $\text{cm}^{-1}$ . No structure was observed.

<sup>g</sup>There are 20 crystal-field components belonging principally to the  $^3P_2$  and  $^3L_7$  states computed in the energy range 37975-38237  $\text{cm}^{-1}$ . No structure was observed.

<sup>h</sup>No structure attributable to f+f transitions was observed at energies  $>36638 \text{ cm}^{-1}$ .

JCVSA-90-3443-63

## Appendix VIII.

Experimental and Computed Energy Level Structure of  $\text{Dy}^{3+}:\text{LaF}_4$ 

SLJ <sup>a</sup>	Obsd. <sup>b</sup> ( $\text{cm}^{-1}$ )	Calc. <sup>c</sup> ( $\text{cm}^{-1}$ )	O-C	Fry et al. <sup>d</sup> Obs. ( $\text{cm}^{-1}$ )	SLJ <sup>a</sup> State	Obsd. <sup>b</sup> ( $\text{cm}^{-1}$ )	Calc. <sup>c</sup> ( $\text{cm}^{-1}$ )	O-C	Fry et al. <sup>d</sup> Obs. ( $\text{cm}^{-1}$ )
$6\text{H}_{15/2}$	0	0	0	0	$6\text{H}_{13/2}$	3645	3639	6	3645
	17	28	-11	17		-	678		-
	69	76	-7	69		701	681	20	695
	124	126	-2	124					
	184	188	-4	184		5883	5875	8	5882
	208	209	-1	208		908	912	-4	909
$6\text{H}_{13/2}$	-	296			$6\text{H}_{11/2}$	924	918	6	925
	307	316	-9	307		945	934	11	945
						976	973	3	977
	3503	3502	1	3502		6021	6024	-3	6024
	575	568	7	576					
	621	602	19	618		7632	7630	2	7633
$6\text{F}_{11/2}$	628	624	4	630	$6\text{F}_{11/2}$	664	673	-9	665

## Appendix VIII. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	Fry et al. <sup>d</sup> Obs. (cm <sup>-1</sup> )	SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	Fry et al. <sup>d</sup> Obs. (cm <sup>-1</sup> )
State					State				
${}^6H_{9/2}$	7726	7728	-2	7727	${}^6H_{7/2}$	9181	9185	-4	9179
${}^6F_{11/2}$	756	776	-20	758	${}^6F_{9/2}$	234	238	-4	235
	812	828	-16	803		282	265	17	279
	837	832	5	813		343	330	13	343
	840	841	-1	842		435	435	0	438
	854	862	-8	887					
	930	927	3	933	${}^6H_{5/2}$	10222	10220	2	10222
	996	998	-2	8019		285	284	1	284
	8075	8065	10	075		345	346	-1	344
${}^6H_{7/2}$	8992	8996	-4	8990	${}^6F_{7/2}$	11037	11038	-1	11044
${}^6F_{9/2}$	9074	9085	-11	9071		108	099	9	116
	087	091	-4	085		138	138	0	159
	144	139	5	141		152	142	10	206

## Appendix VIII. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	Fry et al. <sup>d</sup> Obs. (cm <sup>-1</sup> )	SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	Fry et al. <sup>d</sup> Obs. (cm <sup>-1</sup> )
State					State				
<sup>6</sup> F <sub>5/2</sub>	12456	12466	-10	12456	<sup>4</sup> I <sub>15/2</sub>	22022	21996	26	22020
	502	501	1	501		132	121	11	126
	514	517	-3	520		175	168	7	169
<sup>6</sup> F <sub>3/2</sub>	13271	13288	-17	13271		189	185	4	190
	285	296	-11	284		213	211	2	214
						292	297	-5	290
<sup>6</sup> F <sub>1/2</sub>	-	13839		-		342	328	14	342
						379	352	27	380
<sup>4</sup> F <sub>9/2</sub>	21057	21058	-1	21059	<sup>4</sup> G <sub>11/2</sub>	23468	23460	8	23468
	142	131	11	141		497	504	-7	501
	159	147	12	159		513	525	-12	513
	205	190	15	175		537	542	-5	534
	-	358		218		551	555	-4	550

JCPSA-90-3443-63

JCPSA - 90.3843-63

Appendix VIII. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
State				State			
$^4G_{11/2}$	-	23611		$^4I_{13/2}$	-	25626	
$^4M_{21/2}$	24984	24971	13	$^4F_{7/2}$	25661	674	-13
	25001	998	3	$^4K_{17/2}$	691	722	-31
	067	25070	-3		740	742	-2
	090	092	-2		748	759	-11
	-	172			778	814	-36
	187	185	2		-	829	
	-	186			824	837	-13
	226	223	3		-	845	
	-	273			849	861	-12
	303	307	-4		867	892	-25
	341	333	8		-	894	
					-	912	
					903	919	-16

## Appendix VIII. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
State				State			
$4I_{13/2}$	25918	25929	-11	$4M_{19/2}$	26509	26528	-19
$4F_{7/2}$	-	935			571	552	19
$4K_{17/2}$	940	952	-12		583	563	20
	953	962	-9				
	-	981		$6P_{3/2}$	27476	27493	-17
	990	982	8		529	545	-16
$4M_{19/2}$	-	26242		$6P_{5/2}$	27574	27580	-6
	-	251			616	611	5
	26260	257	3		658	660	-2
	-	291					
	-	397		$4I_{11/2}$	27912	27903	9
	448	445	3		-	984	
	-	475			982	991	-9

JCPSA-90-3843-63



## Appendix VIII. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>4</sup> I <sub>11/2</sub>	-	28036		<sup>4</sup> M <sub>15/2</sub>	28819	28808	11
	28030	046	-16	<sup>6</sup> P <sub>7/2</sub>	834	835	-1
	068	072	-4				
<sup>4</sup> M <sub>15/2</sub>	-	28492		<sup>4</sup> F <sub>5/2</sub>	29527	29517	10
<sup>6</sup> P <sub>7/2</sub>	536	523	13	<sup>4</sup> I <sub>9/2</sub>	630	614	16
	572	575	-3		660	658	2
	605	607	-2		676	683	-7
	630	634	-4		746	725	21
	651	641	10		780	783	-3
	666	673	-7		851	842	9
	-	676			884	883	1
	703	698	5	<sup>4</sup> G <sub>9/2</sub>	-	29960	
	726	727	-1	<sup>4</sup> M <sub>17/2</sub>	29980	986	-6

JCPA-90-3443-63

JCPSA - 90-3443-63

Appendix VIII. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
State				State			
<sup>4</sup> G <sub>9/2</sub> '	-	29997		<sup>6</sup> P <sub>3/2</sub>	30879	30862	17
<sup>4</sup> M <sub>17/2</sub>	-	30020			914	898	16
	-	025					
	-	041		<sup>4</sup> K <sub>15/2</sub> '	31119	31105	14
30073		081	-8	<sup>4</sup> L <sub>19/2</sub>	134	148	-14
	-	092			170	169	1
	-	106			195	190	5
139		151	-12		214	218	-4
	-	194			226	245	-19
241		224	17		262	266	-4
	-	263			282	285	-3
301		296	5		294	298	-4
					-	316	
					-	350	

JCPA - 90. 3443-63

Appendix VIII. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
$4K_{15/2}$	-	31356		$4D_{5/2}$	-	32087	
$4L_{19/2}$	31369	370	-1	$4D_{1/2}$	-	152	
	-	375		$4D_{5/2}$	-	168	
	-	389					
	-	415		$4K_{13/2}$	-	33148	
	443	456	-13		-	180	
	-	462			33185	185	0
					-	197	
$4G_{7/2}$	31571	31565	6		205	203	2
	651	648	3		221	206	15
	-	698			239	219	20
	707	710	-3				
$4D_{5/2}$	-	32062		$4H_{13/2}$	-	33485	

JCPSA-90-3443-63

Appendix VIII. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
State				State			
<hr/>							
<sup>4</sup> H <sub>13/2</sub>	-	33497		<sup>4</sup> H <sub>11/2</sub>	34227	34237	-10
	33500	500	0	<sup>4</sup> L <sub>17/2</sub>	240	241	-1
	508	506	2	<sup>4</sup> F <sub>5/2</sub>	-	260	
	537	518	19	<sup>4</sup> H <sub>9/2</sub>	278	274	4
	552	553	-1		293	285	8
	600	566	34		-	292	
					-	298	
<sup>4</sup> F <sub>3/2</sub>	33628	33632	-4		-	324	
	642	639	3		-	338	
					346	348	-2
<sup>4</sup> D <sub>7/2</sub>	34009	34021	-12		-	355	
	020	030	-10		-	358	
	031	041	-10		-	370	
	070	069	1		373	381	-8

JCPSA. 90-3443-63

Appendix VIII. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
State				State			
$^4H_{11/2}$	34398	34383	15	$^4H_{11/2}$	34933	34934	-1
$^4L_{17/2}$	406	400	6		969	990	-21
$^4F_{5/2}$	-	420					
$^4H_{9/2}$	430	436	-6	$^4K_{11/2}$	-	35776	
	445	448	-3	$^4G_{7/2}$	-	818	
	-	457			-	902	
	-	470			35936	948	-12
	-	472			961	971	-10
	505	493	12		36002	36005	-3
					022	014	8
$^4H_{11/2}$	34847	34846	1		051	056	-5
	869	874	-5		077	100	-23
	902	891	11		-	153	
	910	910	0				

JCPA-90-3443-63

## Appendix VIII. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>4</sup> L <sub>13/2</sub>	36484	36480	4	<sup>4</sup> L <sub>13/2</sub>	-	36645	
<sup>4</sup> G <sub>5/2</sub>	498	500	-2	<sup>4</sup> G <sub>5/2</sub>	36653	660	-7
<sup>4</sup> L <sub>15/2</sub>	-	505		<sup>4</sup> L <sub>15/2</sub>	672	664	8
	522	533	-11		686	692	-6
	-	553					
	-	558		<sup>4</sup> G <sub>9/2</sub>	36752	36746	6
	-	574			780	781	-1
	-	579			-	803	
	590	588	2		-	833	
	-	597			-	846	
	-	606					
	614	611	3	<sup>4</sup> G <sub>7/2</sub>	-	37649	
	-	624		<sup>4</sup> P <sub>1/2</sub>	-	674	
	633	627	6	<sup>4</sup> G <sub>7/2</sub>	-	682	

## Appendix VIII. (cont.)

SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup>	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
State				State			
<sup>4</sup> G <sub>7/2</sub>	-	3775		<sup>2</sup> L <sub>15/2</sub>	-	38366	
	-	789			-	451	
					-	502	
<sup>4</sup> F <sub>3/2</sub>	37933	37921	12	<sup>4</sup> F <sub>5/2</sub>	38926	38911	15
	962	952	10		997	989	8
<sup>2</sup> L <sub>15/2</sub>	-	38047			39085	39077	8
	-	084					
	-	170		<sup>4</sup> F <sub>3/2</sub>	39159	39163	-4
	-	264			182	185	3
	-	274				(39185-50000) <sup>e</sup>	

<sup>a</sup>The leading component of the eigenvector is given.<sup>b</sup>The components of the ground state are from Ref. 54. All values in cm<sup>-1</sup> vac.<sup>c</sup>Energy level parameters are given in Table I.<sup>d</sup>Ref. 54.<sup>e</sup>At >39185 cm<sup>-1</sup>, a large number of crystal-field components is computed over the energy range to 50000 cm<sup>-1</sup>; however, there are five intervals of > 650 cm<sup>-1</sup> in which no energy levels are computed. These are 39185-40531 (Δ = 1346) cm<sup>-1</sup>, 43977-44798 (Δ = 821) cm<sup>-1</sup>, 45073-46225 (Δ = 1152) cm<sup>-1</sup>, 46471-47462 (Δ = 991) cm<sup>-1</sup>, and 48618-49406 (Δ = 788) cm<sup>-1</sup>.

## Appendix IX.

Experimental and Computed Energy Level Structure of  $\text{Tb}^{3+}:\text{LaF}_3$ 

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
$^7\text{F}_6$	0	-6	6	$^7\text{F}_4$	-	3281	
	6	0	-6		-	293	
	-	13			-	383	
	-	20			-	396	
	44	26	18		-	397	
	49	58	-9		-	441	
	80	86	-6		-	446	
	-	88			-	506	
	-	108			-	506	
	-	119			-	685	
	-	162					
	-	233		$^7\text{F}_3$	4329	4331	-2
	-	244			413	407	6
					421	415	6
$^7\text{F}_5$	-	2035			429	425	4
	-	043			440	442	-2
	-	063			461	448	13
	-	076			487	473	14
	-	082		$^7\text{F}_2$	5016	5041	-25
	-	131			038	045	-7
	-	133			-	161	
	-	167			166	164	2
	-	261			197	200	-3
	-	263		$^7\text{F}_1$	5502	5522	-20
	-	313			568	586	-18
					617	632	-15



JCPSA - 90-3443-63

## Appendix IX. (cont.)

<u>SLJ<sup>a</sup></u> <u>State</u>	<u>Obsd.<sup>b</sup></u> <u>(cm<sup>-1</sup>)</u>	<u>Calc.<sup>c</sup></u> <u>(cm<sup>-1</sup>)</u>	<u>O-C</u>	<u>SLJ<sup>a</sup></u> <u>State</u>	<u>Obsd.<sup>b</sup></u> <u>(cm<sup>-1</sup>)</u>	<u>Calc.<sup>c</sup></u> <u>(cm<sup>-1</sup>)</u>	<u>O-C</u>
<sup>7</sup> F <sub>0</sub>	5819	5806	13	<sup>5</sup> G <sub>6</sub>	-	26578	
					-	609	
<sup>5</sup> D <sub>4</sub>	-	20504			26631	634	-3
	20507	506	1		-	680	
	534	533	1				
	534	534	0	<sup>5</sup> L <sub>10</sub>	-	26946	
	-	539			26962	949	13
	-	548			-	966	
	555	560	-5		-	966	
	569	568	1		981	972	9
	580	588	-8		994	981	13
					-	27012	
<sup>5</sup> D <sub>3</sub>	26270	26263	7		27029	015	14
	274	266	8		048	041	7
	-	281			078	075	3
	-	285			142	152	-10
	296	302	-6		161	154	7
	325	318	7		183	166	17
	346	344	2		-	201	
					225	215	10
<sup>5</sup> G <sub>6</sub>	26405	26410	-5		-	234	
	415	423	-8		251	249	2
	454	462	-8		-	274	
	482	494	-12		-	278	
	493	503	-10		-	286	
	-	536			322	306	16
	532	537	-5				
	549	556	-7	<sup>5</sup> G <sub>5</sub>	-	27829	
	-	564			-	833	

JCP 5A-90-3443-63

## Appendix IX. (cont.)

<u>SLJ<sup>a</sup></u> <u>State</u>	<u>Obsd.<sup>b</sup></u> <u>(cm<sup>-1</sup>)</u>	<u>Calc.<sup>c</sup></u> <u>(cm<sup>-1</sup>)</u>	<u>O-C</u>	<u>SLJ<sup>a</sup></u> <u>State</u>	<u>Obsd.<sup>b</sup></u> <u>(cm<sup>-1</sup>)</u>	<u>Calc.<sup>c</sup></u> <u>(cm<sup>-1</sup>)</u>	<u>O-C</u>
<sup>5</sup> G <sub>5</sub>	27833	27833	0	<sup>5</sup> G <sub>4</sub> ,	28480	28483	-3
	839	837	2	<sup>5</sup> L <sub>9</sub>	491	496	-5
	856	872	-16		514	510	4
	882	883	-1		540	542	-2
	-	891			-	552	
	903	905	-2		-	563	
	910	916	-6		-	581	
	930	926	4		604	598	6
	989	972	17		618	614	4
<sup>5</sup> D <sub>2</sub>					-	626	
	28197	28215	-18		-	633	
	206	222	-16		-	663	
	-	240			-	665	
	233	241	-8		-	671	
	262	260	2		-	678	
<sup>5</sup> G <sub>4</sub> , <sup>5</sup> L <sub>9</sub>	-	28316		<sup>5</sup> G <sub>3</sub>	29030	29019	11
	28336	344	-8		032	029	3
	-	345			037	038	-1
	-	350			045	039	6
	348	351	-3		-	050	
	364	367	-3		068	051	17
	-	375			090	087	3
	378	376	2				
	392	392	0	<sup>5</sup> L <sub>8</sub> ,	-	29183	
	428	411	17	<sup>5</sup> L <sub>7</sub> ,	29216	220	-4
	-	459		<sup>5</sup> G <sub>2</sub> ,	234	230	4
	460	460	0	<sup>5</sup> L <sub>6</sub>	-	246	
	-	479			-	249	

JCPSA- 90-3443-63

## Appendix IX. (cont.)

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>5</sup> L <sub>8</sub> ,	29274	29279	-5	<sup>5</sup> D <sub>0</sub>	-	31391	
<sup>5</sup> L <sub>7</sub> ,	-	284		<sup>5</sup> H <sub>7</sub>	-	31399	
<sup>5</sup> G <sub>2</sub> ,	-	291			31402	402	0
<sup>5</sup> L <sub>6</sub>	295	295	0		-	403	
	336	329	7		-	452	
	-	348			-	459	
	360	354	6		494	496	-2
	-	370			-	506	
	392	399	-7		509	506	3
	-	406			-	522	
	-	412			-	528	
	-	413			533	535	-2
	430	426	4		-	545	
	-	434			-	592	
	465	447	18		613	608	5
	-	481			637	628	9
	503	502	1				
	-	504		<sup>5</sup> H <sub>6</sub>	32889	32894	-5
	520	521	-1		918	929	-11
	552	542	10		941	942	-1
	-	565			982	992	-10
	-	572			-	998	
	-	592			999	999	0
	(29598-30057) <sup>d</sup>				-	33025	
<sup>5</sup> D <sub>1</sub>	30765	30755	10		33027	028	-1
	774	770	4		-	031	
	800	788	12		047	038	9
					-	102	

JCPA - 90-3443-63

## Appendix IX. (cont.)

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>5</sup> H <sub>5</sub>	33114	33104	10	<sup>5</sup> F <sub>5</sub> ,	35021	35030	-9
	146	119	27	<sup>5</sup> H <sub>3</sub> ,	044	053	-9
	-	817		<sup>5</sup> I <sub>8</sub>	-	060	
	-	838			072	062	10
	-	850			-	068	
	-	878			-	085	
	-	882			-	090	
	887	885	2		-	094	
	909	919	-10		-	102	
	-	923			-	117	
	-	924			139	137	2
	-	927			167	168	-1
	939	937	2		-	176	
					179	178	1
<sup>5</sup> H <sub>4</sub>	-	34435			-	183	
	-	442			203	214	-11
	-	452			211	228	-17
	34452	455	-3		-	229	
	-	461			237	235	2
	-	462			-	243	
	-	482			-	246	
	-	485			256	250	6
	488	489	-1		274	261	13
					-	309	
<sup>5</sup> F <sub>5</sub> ,	-	34958			-	313	
<sup>5</sup> H <sub>3</sub> ,	-	960			-	315	
<sup>5</sup> I <sub>8</sub>	-	986			316	316	0
	34980	987	-7		-	323	
	35005	990	15		-	327	
					348	330	18

JCLSA-90-3443-63

## Appendix IX. (cont.)

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>5</sup> F <sub>4</sub>	35479	35474	5	<sup>5</sup> F <sub>3</sub> ,	-	36737	
	-	505		<sup>5</sup> I <sub>7</sub>	-	739	
	-	510			36741	748	-7
	-	510			-	750	
	-	523			-	764	
	-	533			-	766	
	555	546	9		-	766	
	-	581			773	774	-1
	588	588	0		-	783	
					786	787	-1
					-	796	
<sup>5</sup> F <sub>3</sub> ,	-	36587		<sup>5</sup> F <sub>2</sub>	-	37226	
<sup>5</sup> I <sub>7</sub>	-	588			-	230	
	36619	599	20		-	256	
	-	635			-	278	
	-	663			-	280	
	-	670					
	679	682	-3	<sup>5</sup> F <sub>1</sub>	-	37527	
	-	723			-	555	
	-	729			-	579	
	731	735	-4				
	731	736	-5				
	348	330	18				

(37652-38193)<sup>e</sup>

JCPA-90-3443-63

## Appendix IX. (cont.)

SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C	SLJ <sup>a</sup> State	Obsd. <sup>b</sup> (cm <sup>-1</sup> )	Calc. <sup>c</sup> (cm <sup>-1</sup> )	O-C
<sup>5</sup> K <sub>9</sub> ,	39210	39221	-11		-	410	
<sup>5</sup> D <sub>2</sub>	-	224			-	450	
	-	226	11		-	454	
	-	233			-	475	
	-	246			-	480	
	-	269			-	489	
	265	280	-15		-	502	
	-	303			-	503	
	-	305			-	513	
	356	374	-18		-	521	
	-	378			-	521	
	383	399	-16				
	-	405				(39522-50000) <sup>f</sup>	

<sup>a</sup>The leading component of the eigenvector is given.

<sup>b</sup>Units of cm<sup>-1</sup> vac.

<sup>c</sup>The energy level parameters are given in Table 1.

<sup>d</sup>There are 22 levels belonging principally to the <sup>5</sup>L<sub>7</sub>, <sup>5</sup>D<sub>2</sub>, and <sup>5</sup>L<sub>6</sub> states in the interval 29598-30059 cm<sup>-1</sup>.

<sup>e</sup>There are 33 levels belonging principally to the <sup>5</sup>I<sub>6</sub>, <sup>5</sup>I<sub>4</sub>, and <sup>5</sup>I<sub>5</sub> states in the interval 37657-38193 cm<sup>-1</sup>. No structure was observed.

<sup>f</sup>At >39521 cm<sup>-1</sup> the density of computed levels is high. Energy gaps in the range 39522-50000 cm<sup>-1</sup>, i.e., regions of >650 cm<sup>-1</sup> where no crystal-field components are computed, are as follows: 39522-40253 (Δ=731) cm<sup>-1</sup>, 43645-44415 (Δ=770) cm<sup>-1</sup>, 44568-45281 (Δ=713) cm<sup>-1</sup>, and 48392-49112 (Δ=720) cm<sup>-1</sup>.

JCPSA-90-3443-63

## Appendix X.

Experimental and Computed Energy Level Structure for  $\text{Gd}^{3+}:\text{LaF}_3$ 

SLJ	Expt. <sup>a</sup>	Calc. <sup>b</sup>		SLJ	Expt. <sup>a</sup>	Calc. <sup>b</sup>		
State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C	State	(cm <sup>-1</sup> )	(cm <sup>-1</sup> )	O-C	
<sup>8</sup> S <sub>7/2</sub>	0	19.6	-20	<sup>6</sup> I <sub>17/2</sub>	36340	36351	-11	
		19.7			342	351	-9	
		19.8			346	352	-6	
		19.9			351	354	-3	
		354			355	-1		
<sup>6</sup> P <sub>7/2</sub>	32176	32169	7		363	357	6	
	185	177	8		370	360	10	
	199	194	5		377	362	15	
	226	224	2		384	364	20	
<sup>6</sup> P <sub>5/2</sub>	32771	32774	-3	<sup>6</sup> I <sub>11/2</sub>	36549	36554	-5	
	791	780	11			561	563	-2
	808	802	6			571	572	-1
						584	585	-1
<sup>6</sup> P <sub>3/2</sub>	33352	33368	-16		592	590	2	
	370	386	-16		611	606	5	
<sup>6</sup> I <sub>7/2</sub>	35923	35934	-11	<sup>6</sup> I <sub>15/2</sub>	36659	36671	-12	
	945	945	0		<sup>6</sup> I <sub>13/2</sub>	668	680	-12
	968	964	4			677	683	-6
	996	979	17			687	696	-9
				698		699	-1	
<sup>6</sup> I <sub>9/2</sub>	36274	36277	-3		701	707	-6	
	285	286	-1		710	713	-3	
	305	303	2		712	714	-2	
	313	311	2		717	715	2	
	332	323	9		722	724	-2	

JCPA 90-3443-63

## Appendix X. (cont.)

SLJ State	Expt. <sup>a</sup> (cm <sup>-1</sup> )	Calc. <sup>b</sup> (cm <sup>-1</sup> )	O-C	SLJ State	Expt. <sup>a</sup> (cm <sup>-1</sup> )	Calc. <sup>b</sup> (cm <sup>-1</sup> )	O-C
<sup>6</sup> I <sub>15/2</sub> ,	36731	36725	6	<sup>6</sup> G <sub>7/2</sub>	240	243	3
<sup>6</sup> I <sub>13/2</sub>	736	729	7		298	284	14
	749	747	2				
	760	753	7	<sup>6</sup> G <sub>11/2</sub> ,	49533	49545	-12
	769	760	9	<sup>6</sup> G <sub>9/2</sub> ,	560	556	4
				<sup>6</sup> G <sub>5/2</sub>	604	623	-19
<sup>6</sup> D <sub>9/2</sub>	39667	39647	20		638	654	-16
	686	681	5		651	661	-10
	719	709	10		680	688	-8
	742	731	11		-	696	
	758	747	11		-	711	
					-	731	
<sup>6</sup> D <sub>1/2</sub>	-	40620			740	741	-1
					-	757	
<sup>6</sup> D <sub>7/2</sub>	40734	40734	0		-	810	
	740	737	3		824	823	1
	744	741	3		-	860	
	751	753	-2				
				<sup>6</sup> G <sub>3/2</sub>	-	50486	
<sup>6</sup> D <sub>3/2</sub>	-	40876			-	568	
	-	905					
				<sup>6</sup> G <sub>13/2</sub>	-	51310	
<sup>6</sup> D <sub>5/2</sub>	-	41003			-	357	
	-	045			-	382	
	-	059			-	402	
					-	414	
<sup>6</sup> G <sub>7/2</sub>	49170	49160	10		-	436	
	49221	49225	-4		-	483	

<sup>a</sup>Experimental results from Refs. 68 and 69, cm<sup>-1</sup> vac.<sup>b</sup>The parameter values used in this calculation are given in Table 1.