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Energy Level Structure and Transition Probabilities in the Spectra of the Trivalent Lanthanides in LaF_3

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FOREWORD

The spectroscopic investigations of lanthanide doped LaF_3 crystals and their theoretical interpretation reported here are the result of an extensive joint effort of the Argonne National Laboratory and The Johns Hopkins University over the last decade. It had its roots in similar studies at both laboratories of other crystal hosts, particularly $LaCl_3$, for which a summary is also given in an appendix to this report. This work was supported at Argonne by the United States Atomic Energy Commission and the United States Energy Research and Development Administration, and at Hopkins by the United States Army Research Office and the National Science Foundation. An identical report is being issued under separate cover by each institution.

I. Introduction

The low-temperature absorption spectra of trivalent lanthanide compounds reveal the sharp-line structure characteristic of transitions between states within the $4f^N$-configuration, induced by the ionic environment. These transitions can be directly represented as upper-state energy levels. In some cases, notably ions in $LaCl_3$ host crystals, the empirical levels have been interpreted in terms of a model which exhibits in detail the structure of the $4f^N$ electronic configuration itself. The atomic parameters derived from these studies vary slowly and systematically across the lanthanide series and in fact are depressed from corresponding values derived from atomic and ionic vapor spectra.

G. H. Dieke has given a definitive review of the spectra of lanthanides in crystals including a comprehensive summary of the data in $LaCl_3$ host crystals, Dieke (1968). The early interpretive papers concentrated on analysis of the crystal-field parameters. More recently, the emphasis has been on developing models which include structural details of the $4f^N$ configurations themselves with simultaneous diagonalization of the complete Hamiltonian rather than a perturbation-theory treatment. The most recent analyses have been given in a series of papers, Crosswhite et al. (1976), Carnall et al. (1976), Crosswhite et al. (1977). These include effective two-body and three-body operators approximating the electrostatic effects of configuration-mixing interactions, plus two-body double-vector effective operators which allow for the variation of spin-orbit interactions with spectroscopic term and for the spin-other-orbit corrections for relativistic effects. The present analysis of spectroscopic data for the lanthanides in single-crystal LaF_3 employs the most recent model.

As a crystal matrix in which to study the absorption spectra of lanthanide ions, LaF_3 has several advantageous features. In addition to being a transparent host over a wide region of the spectrum, it is chemically inert so that the crystals can be handled in air. Thus even though the site symmetry of the metal ion is low, the commercial availability of the crystals in a wide range of dopings has encouraged extensive experimental studies.

We report here two types of correlation with experimental results. For even-f-electron systems we have computed a center of gravity based on the energies of the observed states, and calculated optimized sets of atomic energy level parameters. For odd-electron systems we have performed complete crystal-field calculations in which the parameters of both the atomic and crystal-field parts of the interaction have been adjusted to experimental data. Trends in the free-ion parameters over the series have been examined and in some cases further restrictions on their values are set, based on observed parametric regularities across the periodic series. The crystal field parameters for the odd-f-electron ions have also been compared and regularities over the series are noted. The end result of this effort is a set of eigenvectors for all of the ionic states in each configuration. We then turn to the interpretation of intensities of absorption bands and develop the basis for computing transition probabilities using a semi-empirical theory of induced electric dipole transitions. Finally, we apply the results of the analysis of absorption spectra at room temperature to the related process of excited state relaxation, and provide the basis for computing the radiative lifetime for any given state in any member of the series.

Spectroscopic results for all lanthanides doped into LaF_3 ($Ln^{3+}:LaF_3$) except Pm^{3+} and Eu^{3+} are reported. Since the crystals were obtained from commercial sources, the fact that the only isotope of Pm available in macro

amounts is ^{147}Pm which is β^--unstable with a relatively short half-life, excluded it from consideration. The tendency of EuF_3 to reduce to EuF_2 at high temperatures even in the presence of F_2 vapors, and the very strong broad band structure associated with Eu^{2+} in the visible and ultraviolet range due to $4f^7 \rightarrow 4f^6 5d$ transitions, made it impossible to obtain the requisite experimental data for the Eu-system. The energy level schemes for $Pm^{3+}:LaF_3$ and $Eu^{3+}:LaF_3$ were therefore calculated using parameters obtained by interpolation.

Some of the experimental results utilized in the analyses represent as yet unpublished work done over a period of years in the Chemistry Division of Argonne National Laboratory with the help of senior thesis students and guest scientists. These results were obtained using several different instruments. Spectra in the range $\sim$4000-15000 cm^{-1} were recorded using a Cary Model 14R (crystal-grating - 0.5 meter) recording spectrophotometer. In the region 15000-50000 cm^{-1}, both a 1-meter Hilger-Engis Model 1000 spectrograph equipped with an EMI 9558 Q photomultiplier, and the Argonne 30' Paschen-Runge spectrograph (in second order) were used. Observations were made at $\sim$298, 77, and 4 K. Crystals of LaF_3 doped with selected lanthanides in various concentrations were obtained from Optovac Inc., North Brookfield, Mass. 01535.

There continues to be a wide interest in lanthanide-doped crystals and glasses as laser materials. In some cases quantitative intensity calculations have been carried out and related to the fluorescing properties in a given host. The most extensive calculations have been limited to the $f^2(f^{12})$ and $f^3(f^{11})$ members of the series since the matrix elements of the tensor operators connecting the states of interest required in the intensity analysis for more complex systems have not been published. We report here a consistent set of the matrix elements for all $4f^N$-configurations based on the systematic atomic parameters generated in this work.

II. Physical and Crystallographic Properties of LaF_3

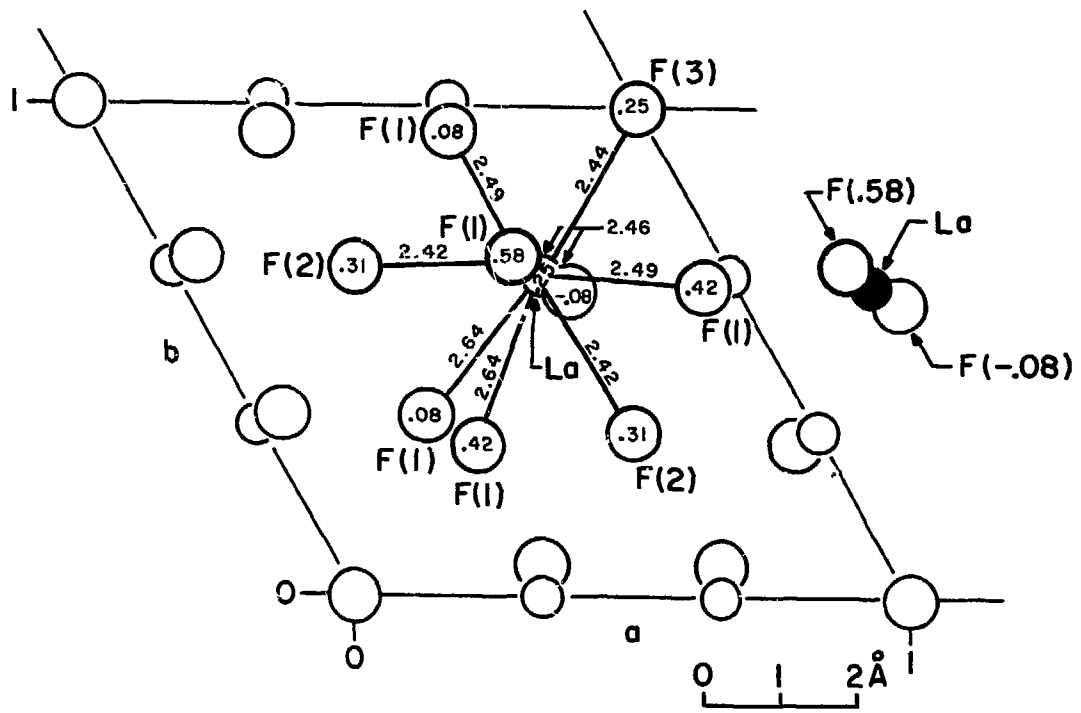
There have been conflicting reports suggesting both C_{2V}, Oftedal (1929, 1931) and D_{3h}, Schlyter (1953), site symmetries of the La^{3+} ions in LaF_3. More recent studies, Mansmann (1964, 1965), Zalkin et al. (1966), Lowndes et al. (1969), indicate that the nine nearest-neighbor F^- ions present a sufficiently distorted environment so that the symmetry is D_{3d}^4 ($P\bar{3}c1$) with a C_2 site symmetry, Fig. 1. A recent powder neutron-diffraction study of LaF_3 and CeF_3, Cheetham et al. (1976), provided additional confirmation of the latter structure. Isostructural members of the series are LaF_3, CeF_3, PrF_3, and NdF_3; SmF_3 and the heavier trifluorides are dimorphic. They also crystallize in the orthorhombic YF_3 lattice where each Y^{3+} has 8-F^- at 2.3 Å and one at 2.6 Å, Zalkin and Templeton (1953).

The crystallographic evidence for a low site symmetry in LaF_3 is consistent with the results of an early spectroscopic study of PrF_3 in which Sayre and Freed (1955) pointed out that the number of lines observed at low temperature for electronic transitions associated with several excited states excluded a site symmetry higher than C_{2V}. The Raman spectrum of LaF_3 has been interpreted in terms of a C_2 site symmetry of the La^{3+}, but these results also emphasize that the deviation of the symmetry from more symmetric models is very small indeed, Bauman and Porto (1967). Spectroscopic evidence for hidden selection rules in the polarized spectrum of Nd^{3+}:LaF_3 is also suggestive of an approach to a symmetry higher than C_2, Wong et al. (1963b), Kumar et al. (1976).

A recent investigation of the normal and vacuum ultraviolet absorption bands of trivalent lanthanides doped into LaF_3 has provided evidence that LaF_3 is transparent down to the normal ultraviolet limit of ~2000 Å, Heaps et al. (1976).

Fig. 1

LaF_3 STRUCTURE VIEWED DOWN THE c-AXIS



$a_0 = 7.185 \pm 0.001$ Å

$c_0 = 7.351 \pm 0.001$ Å

Space Group

$D^4_{3d} - P\bar{3}C1$

Site symmetry C_2

A. Zalkin, D.H. Templeton, J.E. Hopkins
Inorg. Chem. 5, 1466 (1966)

Refractive index (n) measurements using films of LaF_3, CeF_3, and NdF_3, Haas et al. (1959), provided the following values in the 0.25-2.0 μ range:

λ(μ)	n	λ(μ)	n
2.0	1.57	0.45	1.60
1.2	1.575	0.40	1.61
0.8	1.58	0.30	1.625
0.6	1.585	0.27	1.65

For single-crystal LaF_3, the expression obtained for the variation of the refractive index (ordinary ray) with wavelength in the visible-near ultraviolet, Wirich (1966), was

$$n_o = 1.57376 + \frac{153.137}{\lambda(\text{Å}) - 686.2}$$

λ(Å)	n_o(obs)	n_o(calc)
2536.5	1.65587	1.65652
3131.5	-	1.63639
3663.3	-	1.62520
4046.5	1.61797	1.61933
4358.3	1.61664	1.61546
5460.7	1.60597	1.60583

The M.P. of LaF_3 is 1493°C and its density is 5.94 gm/cm^3, Brown (1958).

III. Treatment of Experimental Data

In recent years there have been numerous reports of the spectroscopic properties of different lanthanides in host LaF_3, and many of these investigations have included low-temperature spectra. Consequently, the energies of the crystal-field components associated with many of the free-ion states have been recorded. The extensive data available led us to begin a systematic theoretical analysis of the $4f^N$ energy level structures over the series.

Part of the motivation to undertake a systematic analysis of the data stemmed from the results described in two papers by Onopko (1968a,b) in which he pointed out that the energies of crystal-field components of several of the lowest-lying free-ion states in $Nd^{3+}:LaF_3$ and $Er^{3+}:LaF_3$ could be computed in reasonably good agreement with experiment by assuming that the site symmetry approaches D_{3h}. The approximation also appeared to be justified in treating the crystal-field levels in $Gd^{3+}:LaF_3$, Schwiesow and Crosswhite (1969). We had already developed computer programs that allow a complete diagonalization of the atomic and crystal-field Hamiltonian for the $4f^3(4f^{11})$ case in D_{3h}-symmetry. We had also determined the atomic parameters for both $Nd^{3+}:NdF_3$ and $Er^{3+}:LaF_3$. We therefore extended the analysis using Onopko's crystal-field parameters. The initial results confirmed the validity of Onopko's analysis by providing a computed set of crystal-field levels that were in reasonably good agreement with experiment throughout the spectral range to $\sim$50,000 cm^{-1}.

The analysis was extended by assigning the experimentally observed energy to those crystal-field states identified by the initial computation. This permitted a least-squares adjustment of the original crystal-field parameters. Additional assignments were made based entirely on the correlation

between the optimized crystal-field parameter calculations and observed levels. We then proceeded to perform a similar crystal-field calculation for other lanthanides using the optimized values for Nd^{3+} and Er^{3+} as the basis for beginning the analysis.

For odd-electron systems the crystal field will split a level into J + 1/2 separate components in all site symmetries except cubic and octahedral. The number of possible components therefore is the same for C_2 and D_{3h}, and because D_{3h} appears to be a good approximation to the actual one, it is not difficult to correlate the experimental and computed levels.

On the contrary, in even-electron systems such as $Pr^{3+}(4f^2)$, crystal-field calculations based on D_{3h} symmetry do not remove the degeneracy of the $\mu = \pm 1, \pm 2$ states. It has been pointed out that the number of lines observed in the spectrum of $Pr^{3+}:LaF_3$ implies a low site symmetry consistent with the complete removal of symmetry-related degeneracy in the indicated levels. Sayre and Freed (1955), Carnall et al. (1969). This leads to ambiguities in making the necessary crystal-field correlations. We have therefore attempted complete crystal-field analyses only for odd-electron systems. For the even-electron cases we have made the approximation of fitting the centers of the crystal groups to the free-ion Hamiltonian only.

The basic theory used to interpret the structure observed experimentally in lanthanide crystal spectra has been considerably refined in recent years. A semi-empirical approach has been employed in which the attempt is made to identify those effective interactions operating within the f^N-configuration that reproduce the observed structure. Judd (1963), Wybourne (1965), Judd et al. (1968), Crosswhite et al. (1968). Based on this method of interpretation, the total Hamiltonian of the system can be written:

$$E = E_F + E_{CF}$$

where E_F is the atomic part of the interaction:

$$E_F = \sum_{k=0,2,4,6} F^k(nf,nf)f_k + \zeta_{4f}A_{SO} + \alpha L(L+1) + \beta G(G_2) + \gamma F(R_7)$$

$$+ \sum_{i=2,3,4,6,7,8} T^i t_i + \sum_{k=0,2,4} M^k m_k + \sum_{k=2,4,6} P^k p_k$$

The F^k, ζ_{4f}, α, β, γ, T^i, M^k and P^k are parameters and their associated terms are the corresponding operators. E_{CF} represents the crystal-field interaction. Following Onopko (1968a,b) we assumed that the symmetry of the lanthanide site in LaF_3 was approximately hexagonal (D_{3h}), that is, that the hexagonal terms in the crystal-field expansion are dominant.

$$E_{CF} = \sum_{k,q} B^k_q C^{(k)}_q = B^2_0 C^{(2)}_0 + B^4_0 C^{(4)}_0 + B^6_0 C^{(6)}_0 + B^6_6 [C^{(6)}_6 + C^{(6)}_{-6}]$$

The above interactions which constitute the model used in this investigation are discussed in detail in Appendix I with reference to the similar treatment of the more extensive data for $Ln^{3+}:LaCl_3$.

For odd-f-electron systems the total Hamiltonian can be separated into three submatrices and all three of them diagonalized simultaneously. The methods of truncating the very large matrices that occur for ions in the middle of the series have been discussed previously, Carnall et al. (1976). The results of the diagonalizations--which eventually included variation of most of the parameters in the systems, are given in Appendix II.

Onopko (1968a,b) quoted his original results in the Stevens operator (β_{kq}) normalization and subsequently extended the analysis to $Er^{3+}:LaF_3$,

Onopko (1969). The corresponding crystal-field parameters in the tensor operator normalization (B_q^k) used in the present study, Wybourne (1965), are given below:

$Nd^{3+}:LaF_3$		$Er^{3+}:LaF_3$	
$\beta_{20} = 138\ cm^{-1}$	$B_0^2 = 276\ cm^{-1}$	$\beta_{20} = 141\ cm^{-1}$	$B_0^2 = 282\ cm^{-1}$
$\beta_{40} = 176$	$B_0^4 = 1408$	$\beta_{40} = 145$	$B_0^4 = 1160$
$\beta_{60} = 100$	$B_0^6 = 1600$	$\beta_{60} = 48.3$	$B_0^6 = 773$
$\beta_{66} = 645$	$B_6^6 = 679$	$\beta_{66} = 430$	$B_6^6 = 453$

The crystal-field parameters obtained from the $Nd^{3+}:LaF_3$ data in this investigation are compared with those for $Nd^{3+}:LaCl_3$, Crosswhite et al. (1976), where the symmetry is hexagonal, below:

$Nd^{3+}:LaF_3$ (D_{3h} Approximation)	$Nd^{3+}:LaCl_3$ (C_{3h} Symmetry)
$B_0^2 = 216\ cm^{-1}$	$B_0^2 = 163\ cm^{-1}$
$B_0^4 = 1225$	$B_0^4 = -336$
$B_0^6 = 1506$	$B_0^6 = -713$
$B_6^6 = 770$	$B_6^6 = 462$
$\sigma = 17\ cm^{-1}$	$\sigma = 8.1\ cm^{-1}$
139 levels fitted	101 levels fitted

It has been demonstrated that ab initio calculations of crystal-field parameters based on an ionic model are not able to reproduce the values obtained semi-empirically. However, serious efforts are being made to develop suitable models for the LaF_3 crystal, Newman and Curtis (1969), Stedman and Newman (1971), and attempts have also been made to treat the low-symmetry LaF_3 lattice case by actually using the appropriate number of terms in the potential, Matthies and Welsch (1975).

The experimental results of the present efforts should provide a useful testing ground for further theoretical treatments. Systematic trends in the values of the crystal field parameters for $Ln^{3+}:LaF_3$ are compared with those for $Ln^{3+}:LaCl_3$ which are much better established experimentally, in Fig. 2.

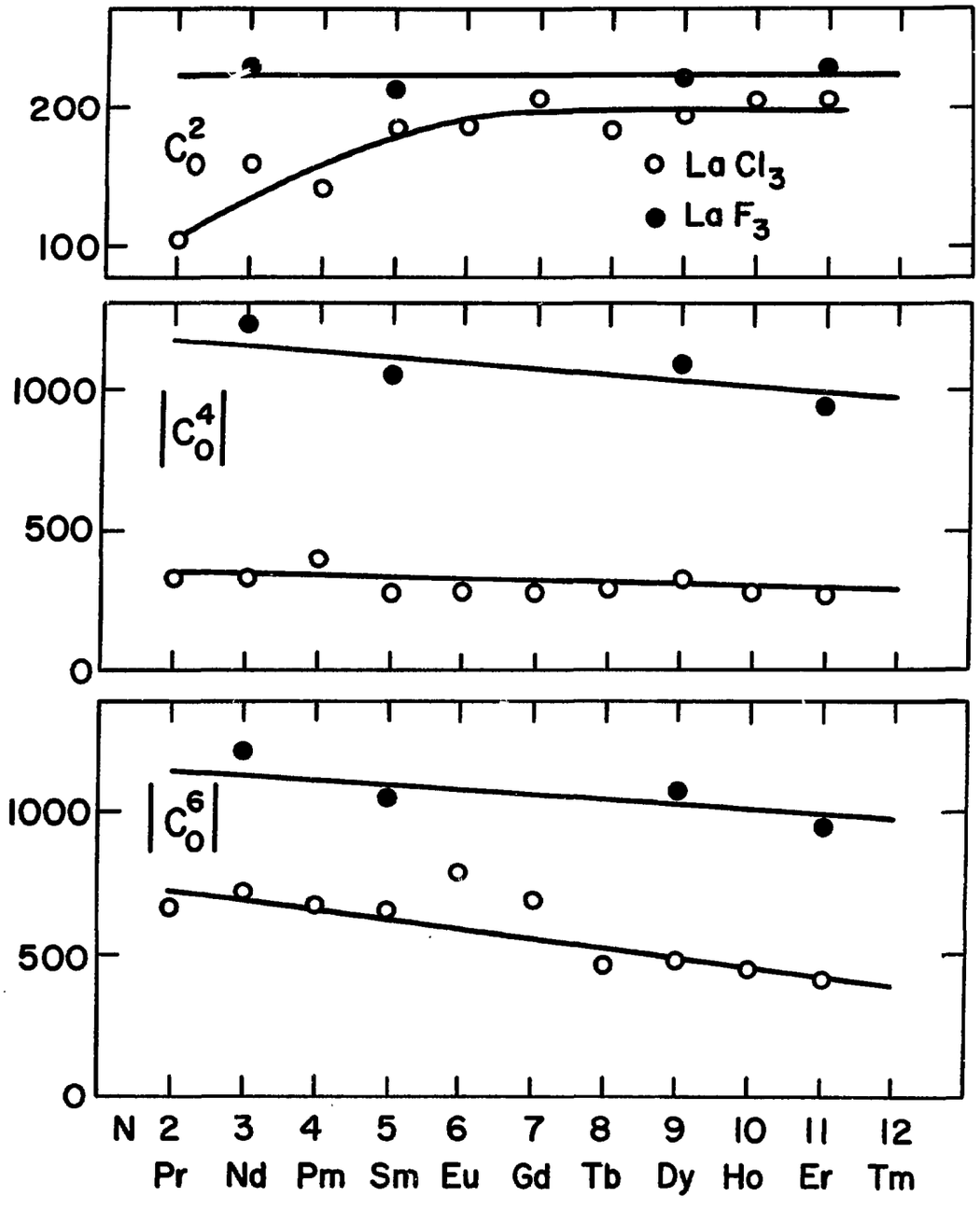


Fig. 2. Crystal-field Parameters for Ln^{3+}:$LaCl_3$ and Ln^{3+}:LaF_3.

IV. Energy Level Correlations - Survey of Experimental Data

1. $4f^2(f^{12})$

The energy level structure in $Pr^{3+}:LaF_3$ has been examined experimentally in moderate to high resolution by several groups. Wong et al. (1963a), Yen et al. (1964), Caspers et al. (1965a), Carnall et al. (1969). Free-ion level energies are recorded in Appendix III together with the corresponding computed levels using parameters given in Appendix II. The weak point in the theoretical analysis is the assumption of a center of gravity for the $^1I_6$ and for the $^3P_1$ transitions.

Most of the possible crystal-field components in the spectrum of $Tm^{3+}:LaF_3$ have been observed, Carnall et al. (1970), and the centers of gravity of these groups are compared to the calculated free-ion levels in Appendix XIII.

2. $4f^3(f^{11})$

There are extensive published reports, Wong et al. (1963b), Caspers et al. (1965b), of the structure observed in the low-temperature absorption and fluorescence spectra of $Nd^{3+}:LaF_3$. These data have been extended by previously unpublished work at ANL to provide as complete a set of crystal-field components as possible. Of the 182 levels in the f^3 configurations, 139 have been assigned. The results are included in Appendix IV, and can be compared to those obtained in the recent extensive investigation of the spectrum of $Nd^{3+}:LaCl_3$, Crosswhite et al. (1976). Kumar et al. (1976) have examined the absorption and fluorescence spectra of $Nd^{3+}:LaF_3$ at 77 K, the latter excited using the 3371 Å line of a N_2-laser. They reported several transitions not observed in previous investigations. Some of these are consistent with band energies observed in the present study but there are discrepancies. In general, there is a small shift in energy between observations at 77 K and those

reported here which refer to 4 K. The assignments made to the fluorescence spectrum serve to further establish the energies of the lower-lying states which had been reported earlier. The components of the $^4I_{15/2}$ state reported by Voron'ko et al. (1973) from observations made at 77 K are in good agreement with the unpublished results recorded in Table 1, Appendix IV.

The present theory of intensities of f → f transitions treats the composite free-ion states rather than transitions between individual crystal-field components (see Section V). A number of investigators are presently concerned with extending the theory to the crystal-field case. In order to provide a basis for testing the results of such calculations we include in Figs. 3-22, Appendix IV, a set of absorption spectra of Nd^{3+}:LaF_3 taken at ∿4 K covering most of the levels observed in the f^3-configuration. No attempt was made to preserve a constant resolution since two different instruments were used, and several different crystals of varying concentrations and path lengths were employed. However, in any one group, the relative intensities of the components are clearly evident.

The absorption and fluorescence spectra of Er^{3+}:LaF_3 measured at 77 K and including levels up to ∿39500 cm^{-1} were reported by Krupke and Gruber (1963, 1964, 1965). Several higher-energy transitions were also tentatively identified. A subsequent investigation, Carnall et al. (1972), included measurements at ∿4 K in the range 6000-50000 cm^{-1}. Additional spectroscopic measurements at low temperature have been made, so that the levels recorded in Appendix XII represent a composite and in a number of cases a reevaluation of results appearing in the literature. In addition to a discrepancy in the calibration standards applied to a number of groups originally reported by Carnall et al. (1972), the comparison of experimental energies with those computed based on

the crystal-field interpretation used here suggested a possible vibronic origin for some of the states previously identified as crystal-field components.

3. $4f^4(f^{10})$

The absorption spectrum of $Pm^{3+}:LaF_3$ has not been reported, but an extensive investigation of the absorption and fluorescence spectra of $Pm^{3+}:LaCl_3$ has been published, Carnall et al. (1976). We have therefore used the regularities in the energy level parameters for $Ln^{3+}:LaF_3$ as the basis for interpolation and assignment of approximate parameters for $Pm^{3+}:LaF_3$. The corresponding computed free-ion levels are given in Appendix V. The chemical shifts observed on comparing free-ion levels in $Nd^{3+}:LaF_3$ and $Nd^{3+}:LaCl_3$ are similar to those found in comparing the computed results for $Pm^{3+}:LaF_3$ with the experimental states of $Pm^{3+}:LaCl_3$.

An extensive investigation of the absorption and fluorescence spectra of $Ho^{3+}:LaF_3$ has been reported by Caspers et al. (1970). Additional experiments have been conducted at ANL, but only minor additions or modifications of the published data were indicated. In many cases, the number of observed components of free-ion groups is less than allowed theoretically based on C_2 site symmetry, but the centers of gravity of these levels appear to provide the basis for calculation of a consistent set of energy level parameters, as recorded in Appendix XI.

4. $4f^5(f^9)$

The observation and analysis of the absorption and fluorescence spectra of $Sm^{3+}:LaF_3$ in the range 0-11000 cm^{-1} was reported by Rast et al. (1967), and the line list was extended to ~32000 cm^{-1} in a tabulation given in Dieke (1968). The number of observed lines was further extended in the present investigation, and a composite tabulation based primarily on recent work at ANL is given in Appendix VI.

Absorption and fluorescence spectra of $Dy^{3+}:LaF_3$ including levels up to $\sim$32000 cm^{-1} have been reported in the literature by Fry et al. (1968). A number of new levels including groups at higher energies were recorded in the course of the present investigation. The results are presented in Appendix X.

5. $\underline{4f^6(f^8)}$

Crystals of LaF_3 doped with EuF_3 are found to contain some Eu^{2+} which makes it difficult to observe the Eu^{3+} transitions in absorption in the near-ultraviolet. Weber (1967a) observed fluorescence in $Eu^{3+}:LaF_3$ from the excited states $^5D_0$, $^5D_1$, $^5D_2$, and $^5D_3$ using pulsed selective excitation. The energy level scheme for the low-lying ^5D and ^7F states that can be deduced from these measurements shows the expected red shift with respect to the corresponding levels observed in $Eu^{3+}:LaCl_3$, Dieke (1968), and is consistent with the results given in Appendix VII. The latter were computed based on energy level parameters deduced from systematic trends over the series.

The energy levels of Tb^{3+} in single-crystal TbF_3 have been studied in absorption and fluorescence by Krupka and Guggenheim (1960). From this data the centers of gravity of the $^5D_4$ and the ground term ^7F multiplet components could be determined. The results are in agreement with the moderately extensive study of the low-temperature absorption spectrum of $Tb^{3+}:LaF_3$ which was part of the present investigation. The free-ion levels of $Tb^{3+}:LaF_3$ are given in Appendix IX.

6. $\underline{4f^7}$

The energy levels of the ^6P and ^6I groups in $Gd^{3+}:LaF_3$ were reported by Schwiesow and Crosswhite (1969) who also performed a crystal-field analysis assuming an approximate hexagonal site symmetry. The experimental results were subsequently extended to include the ^6D states in the 40000-50,000 cm^{-1} range,

Carnall et al. (1971). The data recorded in Appendix VIII are a composite of the indicated published results.

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V. Theoretical Interpretation of Excited State Relaxation

A. Theoretical Treatment of Absorption Spectra

1. General Concepts

The quantitative treatment of the intensities of trivalent lanthanide absorption bands relates an experimentally determined quantity, a normalized band envelope, P_{EXPT}, to a theoretical model based on the mechanisms by which radiation can be absorbed. The terms oscillator strength or transition probability are applied interchangeably to the symbol P. There is some magnetic dipole character in a few transitions ($P_{M.D.}$), but an induced electric-dipole mechanism ($P_{E.D.}$) must be invoked to account for the intensities of most lanthanide absorption bands. The term induced or forced electric dipole is used to emphasize that true electric dipole transitions require the initial and final states to be of different parity, whereas no parity change is involved in transitions within a configuration. In contrast, magnetic dipole transitions within a configuration are (parity) allowed. The weak intra-f^N transitions are accounted for by assuming that a small amount of the character of higher-lying opposite-parity configurations is mixed into the f^N states via the odd terms in the potential due to the ligand field, Wybourne (1965). We neglect higher multipole mechanisms, (electric quadrupole, etc.), and write:

$$P_{EXPT} = P_{E.D.} + P_{M.D.}$$

In expressing $P_{E.D.}$ in terms of a theoretical model, Judd (1962) and Ofelt (1962) summed over the intensities of the individual crystal-field components of a given state. As a consequence, the model applies to spectra observed at room temperature or above since it is assumed that all of the crystal-field

components of the ground state are equally populated. Some attempts have been made to avoid this summation and thus treat the intensities of transitions between the lowest crystal-field level of the ground state and excited crystal-field states, Axe (1963). However, the intensity calculations reported in the present summary deal only with composite levels. Thus the appropriate expression for P_{EXPT}, which represents the number of classical oscillators in one ion, more commonly referred to as the probability for absorption of radiant energy, Hoogschagen (1946), is:

$$P_{EXPT} = \frac{2303\ mc^2}{N\pi e^2} \int \varepsilon_i(\sigma)d\sigma = 4.32 \times 10^{-9} \int \varepsilon_i(\sigma)d\sigma$$

where ε_i is the molar absorptivity of a band at the energy σ_i (cm^{-1}), and the other symbols have their usual meaning. P is here a dimensionless quantity. The molar absorptivity at a given energy is computed from the Beer-Lambert law:

$$\varepsilon = \frac{1}{c\ell} \log I_o/I \qquad (1)$$

where c is the concentration of the lanthanide ion in moles/1000 cm^3, ℓ is the light path in the crystal (cm), and log I_o/I is the absorptivity or optical density. The expression for P_{EXPT} is identical to that for f defined by Krupke (1966) in his treatment of lanthanide spectra in LaF_3.

In view of our interest in both absorption and fluorescence processes, there is an advantage in pointing out the basic role of the Einstein coefficient in expressing the transition probability due to dipole radiation:

$$A(i,f) = \frac{64\pi^4\sigma^3}{3h} |\langle i|D|f\rangle|^2 \qquad (2)$$

where i and f signify the initial and final states, A is the (spontaneous) transition probability per unit time, $\sigma(cm^{-1})$ is the energy difference between

the states, and $\underset{\sim}{D}$ is the dipole operator, Condon and Shortley (1957).

In addressing the problem of the absorption of energy, Broer et al. (1945) expressed eq. (2) in terms of oscillator strength using the relationship $P = Amc/8\pi^2\sigma^2e^2$. The factor $2J + 1$ was added since the matrix elements of $\underset{\sim}{D}$ are summed over all components of the initial state i. A refractive index correction χ was also included giving:

$$P = \frac{8\pi^2 mc\sigma}{3he^2(2J+1)} [\chi\bar{F}^2 + n\bar{M}^2] \qquad (3)$$

where $\bar{F}^2$ and $\bar{M}^2$ represent the matrix elements of the electric dipole and magnetic dipole operators, respectively, joining an initial state J to the final state J', $\chi = \frac{(n^2 + 2)^2}{9n}$, and n is the refractive index of the medium.

2. Induced Electric-Dipole Transitions

Judd (1962) and Ofelt (1962) independently derived expressions for the oscillator strength of induced electric dipole transitions within the f^N configuration. Since their results are similar, and were published simultaneously, the basic theory has become known as the Judd-Ofelt theory. However, Judd's expression, eq. (4), was cast in a form that could be directly related to oscillator strengths derived from lanthanide absorption spectra taken at 25°C or above:

$$P_{E.D.} = \sum_{\lambda=2,4,6} T_\lambda \nu(\psi J||U^{(\lambda)}||\psi' J')^2 \qquad (4)$$

where $\nu(sec^{-1})$ is the mean frequency of the transition $\psi J \rightarrow \psi' J'$, $\underset{\sim}{U}^{(\lambda)}$ is a unit tensor operator of rank λ, the sum running over the three values $\lambda = 2,4,6$, and the T_λ are three parameters which can be evaluated from experimental data. These parameters involve the radial parts of the $4f^N$ wave functions, the wave functions of perturbing configurations such as $4f^{N-1}5d$, and the interaction

between the central ion and the immediate environment.

Typically, several excited states are encompassed by a single complex absorption envelope, and the matrix elements of $\underset{\sim}{U}^{(\lambda)}$ are summed over these states. The energy in this case becomes that of the center of gravity of the envelope. Those investigators who have studied lanthanide intensities in crystals have followed an alternate parametrization, Axe (1963), Krupke (1966), which has clear advantages in describing both the absorption and fluorescence processes in terms of a single set of adjustable parameters.

The expression for T_λ given by Judd in eq. (4) was:

$$T_\lambda = \frac{8\pi^2 m}{3h(2J+1)} \left[\frac{(n^2+2)^2}{9n}\right](2\lambda+1)\sum_t (2t+1)B_t \Xi^2(t,\lambda) \qquad (5)$$

Substituting $\nu = c\sigma$ and eq. (5) into eq. (4) gives

$$P_{E.D.} = \frac{8\pi^2 mc\sigma}{3h(2J+1)} \left[\frac{(n^2+2)^2}{9n}\right] \sum_{\lambda=2,4,6} \Omega_\lambda (\psi J||U^{(\lambda)}||\psi' J')^2 \qquad (6)$$

where $\Omega_\lambda = (2\lambda+1)\sum_t (2t+1)B_t \Xi^2(t,\lambda)$, Axe (1963), and in terms of $\bar{F}^2$, eq. (3),

$$\bar{F}^2 = e^2 \sum_{\lambda=2,4,6} \Omega_\lambda (\psi J||U^{(\lambda)}||\psi' J')^2 \qquad (7)$$

The matrix elements of eq. (6) are calculated in the SL basis using the relation:

$$(f^N \alpha SLJ||U^{(\lambda)}||f^N \alpha' S'L'J') = \delta(S,S')(-1)^{S+L'+J+\lambda}[(2J+1)(2J'+1)]^{1/2} \begin{Bmatrix} J & J' & \lambda \\ L' & L & S \end{Bmatrix} (f^N \alpha SL||U^{(\lambda)}||f^N \alpha' SL') \qquad (8)$$

Selection rules imposed by the nature of the mechanism assumed are discussed by Ofelt (1962). The reduced matrix elements on the right side of eq. (8) have been tabulated by Nielson and Koster (1963). The matrix elements as

computed must be transformed from the SL basis to intermediate coupling before being squared and substituted into eq. (6).

The intermediate-coupling eigenvectors, $|f^N\psi J\rangle$, are expressed in terms of SL basis states, $|f^N\alpha SLJ\rangle$, by:

$$|f^N\psi J\rangle = \sum_{\alpha,S,L} c(\alpha,S,L)|f^N\alpha SLJ\rangle$$

where $c(\alpha,S,L)$ are the numerical coefficients resulting from the simultaneous diagonalization of the atomic parts of the Hamiltonian. The matrix elements of $\underset{\sim}{U}^{(\lambda)}$, eq. (8), have been calculated for transitions between various excited states as well as between the ground and excited states of the whole series of lanthanide ions using the energy level parameters given in Appendix II. The results are tabulated in Appendices III-XII.

3. Magnetic Dipole Transitions

Following the results of Condon and Shortly (1957), the magnetic dipole operator is given as $\bar{M} = -e/2mc \sum_i (L_i+2S_i)$. The matrix elements of the operator $\bar{M}^2$ in eq. (3) can then be written,

$$\bar{M}^2 = e^2/4m^2c^2(\psi J||L+2S||\psi'J')^2 \qquad (9)$$

The non-zero matrix elements will be those diagonal in the quantum numbers α, S, and L. The selection rule on J, $\Delta J = 0,\pm 1$, restricts consideration to three cases:

1) $J'=J$ $\quad (\alpha SLJ||L+2S||\alpha SLJ') = g\hbar[J(J+1)(2J+1)]^{1/2}$ (10)

where $g = 1 + \dfrac{J(J+1) + S(S+1) - L(L+1)}{2J(J+1)}$

2) $J'=J-1$

$$(\alpha SLJ||L+2S||\alpha SLJ-1) = \hbar\left[\frac{(S+L+J+1)(S+L+1-J)(J+S-L)(J+L-S)}{4J}\right]^{1/2} \qquad (11)$$

3) $J'=J+1$

$$(\alpha SLJ||L+2S||\alpha SLJ+1) = \hbar\left[\frac{(S+L+J+2)(S+J+1-L)(L+J+1-S)(S+L-J)}{4(J+1)}\right]^{1/2} \qquad (12)$$

The matrix elements calculated in eqs. (10)-(12) must be transformed into the intermediate coupling scheme before computation of the magnetic dipole contribution represented by eq. (9).

Values of the quantity $P' > 0.015 \times 10^{-8}$ where $P_{M.D.} = P'n$ and n is the refractive index of the medium, have been tabulated for transitions of the trivalent lanthanide ions between the ground states and all excited free-ion states, Carnall et al. (1968a).

4. Comparison of Calculated and Observed Transition Probabilities

A number of authors have determined the Ω_λ intensity parameters from a least squares fitting procedure using band envelopes for $Ln^{3+}:LaF_3$ observed at ~25°C and available sets of the matrix elements of $\underset{\sim}{U}^{(\lambda)}$. Krupke (1966) was the first to show that transition probabilities in good agreement with experiment could be computed for $Pr^{3+}:LaF_3$ and $Nd^{3+}:LaF_3$. A summary of parameter values, Ω_λ, for $Ln^{3+}:LaF_3$ is presented in Table 1, Appendix XIV. The parameters for $Sm^{3+}:LaF_3$, $Dy^{3+}:LaF_3$, and $Tm^{3+}:LaF_3$ were checked against results obtained in the present investigation, and those for Dy^{3+} and Tm^{3+} were modified from the values originally reported. While the values of the matrix elements of $\underset{\sim}{U}^{(\lambda)2}$ given in Appendices III-XIII differ slightly from those in the literature, these differences are not sufficient to affect the reported values of Ω_λ.

B. Relaxation of Excited States

1. General Considerations

A great deal of progress has been made in analyzing the mechanisms of excited state relaxation of lanthanides in crystal hosts. Two modes of

relaxation can be recognized: radiative and non-radiative processes. Axe (1963) addressed the problem of expressing the radiative process in quantitative terms using the Judd-Ofelt theory. Non-radiative relaxation was already being formulated in terms of multiphonon processes in the early 1960's. Barasch and Dieke (1965), Riseberg and Moos (1967,1968). Such processes become less probable as the energy gap between an excited state and the next lower energy state increases.

2. Radiative Relaxation

In treating the fluorescence process, the Einstein coefficient, eq. (2) is used directly to express the rate of relaxation of an excited state (ψJ) to a particular final state ($\psi' J'$). Following Axe (1963), the counterpart of eq. (3) becomes

$$A(\psi J,\psi' J') = \frac{64\pi^4\sigma^3}{3J(2J+1)} [\chi' \bar{F}^2 + n^3 \bar{M}^2] \qquad (13)$$

where $\sigma(cm^{-1})$ represents the energy gap between states (ψJ) and ($\psi' J'$), $\chi' = \frac{n(n^2+2)^2}{9}$, and n is the refractive index of the medium. As in the absorption process, there is an implicit assumption that all crystal-field components of the initial state are equally populated. In principal, if fluorescence can be detected, the lifetime of the state is long compared to the rate at which it is populated in the excitation process, so thermal equilibrium at the temperature of the system can be achieved prior to emission.

The matrix elements of the electric and magnetic dipole operators, $\bar{F}^2$ and $\bar{M}^2$, are identical to those in eq. (7) and eq. (9), respectively. However, the form of the refractive index correction in eq. (13) is not the same as for the absorption process, eq. (3). Equation (13) can be evaluated using parameters Ω_λ established from measurement of the absorption spectrum of the lanthanide ion in a crystal lattice identical to that studied in fluorescence.

Since excited state relaxation generally involves transitions to several lower-lying states, we define a total radiative relaxation rate, $A_T(\psi J)$

$$A_T(\psi J) = \sum_{\psi' J'} A(\psi J, \psi' J') \tag{14}$$

where the sum runs over all states lower in energy than the fluorescing state.

It is useful to define in addition the radiative branching ratio, β_R, from the relaxing state (ψJ) to a particular final state $(\psi' J')$

$$\beta_R(\psi J, \psi' J') = \frac{A(\psi J, \psi' J')}{A_T(\psi J)} \tag{15}$$

and the radiative lifetime of a state

$$\tau_R(\psi J) = [A_T(\psi J)]^{-1} \tag{16}$$

The principal fluorescing states of the lanthanides in crystal hosts are indicated in Fig. 3. However, fluorescence from many of these levels is only observed at low temperatures since rapid relaxation of an excited state by non-radiative processes competes strongly with the radiative mode unless the energy gap to the next lower level is large, as discussed in the next section.

Since the parameters Ω_λ have been determined for a number of the lanthanides in LaF_3 host, Table 1, Appendix XIV, we can compute the radiative lifetime of any excited state using eqs. 13, 14 and 16. For those states with large energy gaps to the next lower level, the observed and computed radiative lifetimes would be expected to be in approximate agreement. Weber (1967b) has pointed out that such agreement is observed for excited states in Er^{3+}:LaF_3 where the energy gaps are in excess of 3000 cm^{-1}:

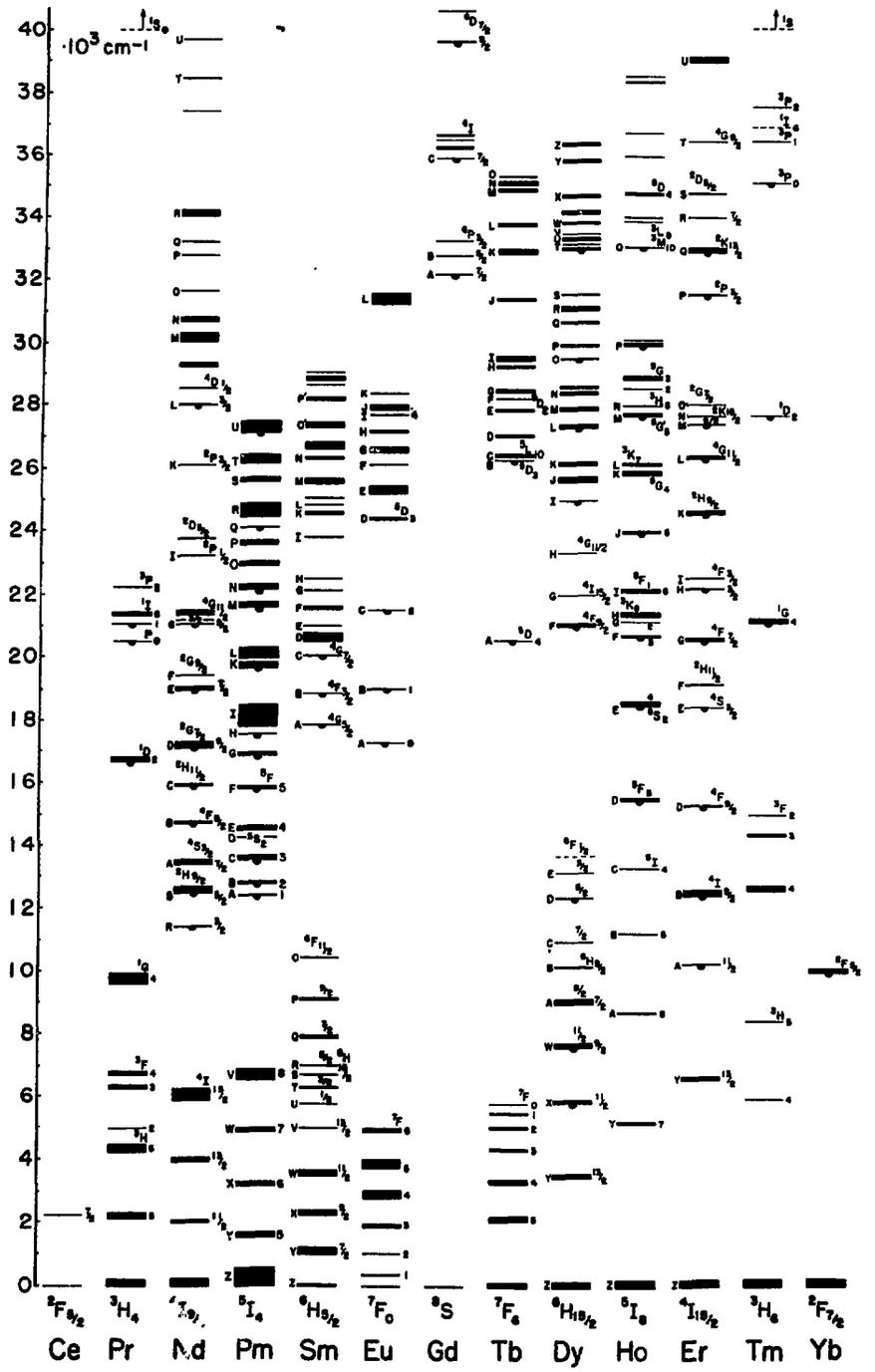

Fig. 3. Energy Level Diagrams for $Ln^{3+}:LaCl_3$.

Transition	τ_R (msec)	Observed Lifetime (msec)
$^4I_{13/2} \rightarrow {}^4I_{15/2}$	10.9	13
$^4I_{11/2} \rightarrow$	11.6	11
$^2P_{3/2} \rightarrow$	0.43	0.29

3. Non-radiative Relaxation

Following the excitation of a lanthanide ion in a crystal lattice, the relaxation of excited states may occur by a purely radiative process, or more generally, may occur by the transfer of some energy to lattice vibrations. It was known experimentally for a number of years before any quantitative theory of non-radiative processes was developed that fluorescence was not observed at 25°C from $Ln^{3+}:LaCl_3$ if the energy gap between the excited state and that next lower in energy was < 1000 cm^{-1}, Barasch and Dieke (1965). In a systematic investigation of multiphonon orbit-lattice relaxation of lanthanide excited states, Riseberg and Moos (1968) have given an explicit expression for the temperature dependent transition rate in LaF_3, $LaCl_3$ and $LaBr_3$. The energy-gap dependence of the multiphonon process is treated phenomenologically by assuming that the appropriate phonon energy is that corresponding to the cut-off in the phonon states. For LaF_3 this is $\sim$350 cm^{-1}, while for $LaCl_3$ it is $\sim$260 cm^{-1}. In terms of the $\sim$1000 cm^{-1} energy gap cited earlier, it is apparent that a 3-4 phonon emission process is a relatively efficient mode of relaxation at 25°C. However, as the gap increases, demanding the simultaneous emission of a large number of phonons, the process rapidly decreases in probability such that radiative decay can efficiently compete as a relaxation mechanism.

Since in the usual case both radiative and non-radiative processes operate to relax an excited state, we can express the total fluorescence lifetime of the

state as

$$(\tau_T)^{-1} = A_T(\psi J) + W_T(\psi J) \qquad (17)$$

where A_T is the radiative rate and $W_T(\psi J)$ is the sum of the rates of the various non-radiative processes.

The dependence of the relaxation rate on energy gap alone, W(o) can be expressed as a simple exponential, Moos (1970),

$$W(o) = Ce^{\alpha\Delta E}$$

where C and α are parameters characteristic of the host material, not of the lanthanide ion. For LaF_3, $C = 6.6 \times 10^8$ (sec^{-1}) and $\alpha = -5.6 \times 10^{-3}$, Riseberg and Weber (1976).

Adding the temperature dependence, Riseberg and Moos (1967,1968), results in the expression

$$W(\psi J) = W(o)\{[e^{\hbar\omega_i/kT} - 1]^{-1} + 1\}^{\Delta E/\hbar\omega_i}$$

which can be rewritten

$$W(\psi J) = Ce^{\alpha\Delta E}[1 - e^{-\hbar\omega_i/kT}]^{-\Delta E/\hbar\omega_i} \qquad (18)$$

where $\hbar\omega_i$ is the maximum phonon energy, taken as 350 cm^{-1} for LaF_3, Riseberg and Weber (1976). Since k = 0.695, kT = 207 cm^{-1} at room temperature and the corresponding expression is:

$$W(\psi J) = Ce^{\alpha\Delta E}(.8155)^{-\Delta E/350}$$

For example, the radiative lifetime of the $^4I_{9/2}$ state of Er^{3+}:LaF_3 at $\sim$12000 cm^{-1} has been computed to be 20.7 msec but observed to be $\sim$0.15 msec, Weber (1967b). Since ΔE between $^4I_{9/2}$ and the next lower $^4I_{11/2}$ state is

2000 cm^{-1}, $W(\psi J) = \sim 10^4$ sec^{-1}. Thus the non-radiative lifetime of ~0.1 msec is rate determining.

4. Comparison of Computed Excited-State Lifetimes with Those Observed Experimentally

Experimental measurements of excited-state lifetimes for a number of lanthanides in LaF_3 have been reported, and in many instances these values have been compared to those computed using eq. (13), (17) and (18). Although the results of the computations were reported, the availability of the relevant matrix elements of $\underset{\sim}{U}^{(\lambda)}$ interconnecting the excited states in the various configurations is very limited. The only tabulation that includes all members of the series is restricted to matrix elements that join excited states to the ground state, Carnall et al. (1968b). As a consequence, the results presented in Appendices III-XIII represent the first systematic effort to make interconnecting matrix elements of $\underset{\sim}{U}^{(\lambda)}$ available for the whole series and thus enable calculation of a wide range of lifetimes. Some minor corrections to values reported in the earlier tables have also been made. Calculated radiative lifetimes and observed lifetimes for some of the prominent fluorescing states in $Ln^{3+}:LaF_3$ are given in Table 2, Appendix XIV. An example of the complete calculation of the lifetimes associated with the radiative relaxation of two states in Tb^{3+}, showing branching ratios to all lower-lying states, is given in Table 3, Appendix XIV. The strong radiative coupling of the $^5D_4$ to the $^5D_3$ state is clearly indicated. Recently Page et al. (1976) reported lifetimes in the 100 μsec range for the $^5D_4$ state in $Tb^{3+}:LaF_3$ at 300 K, with little change, as expected, on cooling to 77 K. However, these values are a factor of ten shorter than would have been predicted, see Table 2, Appendix XIV, and must be regarded as questionable. In $Tb^{3+}:LaCl_3$ at 300 K the lifetimes of the $^5D_3$ states were 570 and 1220 μsec, respectively, in good agreement with the calculated values for the LaF_3 host, Barasch and Dieke (1965).

5. Comments on the Use of the Tables

(A) Atomic (free-ion) states

As discussed in the introduction, detailed crystal-field calculations were only carried out for odd-f-electron systems. For the even-f-electron systems a center of gravity was computed from the experimentally observed crystal-field components of each state. These "free-ion" states are recorded in the appendices and were used as the basis for computing the energy level parameters. Similar tabulations of the free-ion state energies have been included for the odd-f-electron systems in order to facilitate use of the tables of U(K)*2. In these latter cases the computation was made using the atomic parameter values given in Appendix I with the crystal-field parameters set equal to zero. In all the tabulations of free-ion levels the state designation corresponds to the largest component of the eigenvector.

(B) Tables of $(U^{(K)})^2$

The entries in these tables are arranged in order of increasing J-value for the initial state. Entries are not repeated. For example, the matrix element between an initial J = 9/2 and a final J = 3/2 state is identical to the J = 3/2 → J = 9/2 entry. Only the latter is given. If the entry is missing from the table, the matrix elements are zero. The following partial tabulation of matrix elements of U(K)*2 for Nd^{3+}:LaF_3 joining the ground ($^4I_{9/2}$) state with several excited states taken from Appendix IV serves as an illustration and may be compared with results given for Nd^{3+}(aquo) in Carnall et al. (1968b).

State	2J	$E(cm^{-1})$	U(2)*2	U(4)*2	U(6)*2
4I	9	235	---	---	---
4I	11	2114	.0194	.1072	1.1639
4I	13	4098	0	.0135	.4549
4I	15	6148	0	0	.0452
4F	3	11621	0	.2283	.0554
4F	5	12660	.0006	.2337	.3983
2H	9	12768	.0095	.0082	.1195

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APPENDIX I

Appendix I

As a result of the correspondence between the energy levels of lanthanides in $LaCl_3$ and LaF_3, it is convenient to summarize the present status of the theory applied to the host $LaCl_3$ in order to facilitate the LaF_3 discussion. The basic experimental work on trivalent lanthanide spectra in $LaCl_3$ crystals has been described by G. H. Dieke, Dieke (1968), who also gave a comprehensive historical review and a brief discussion of early efforts at theoretical analysis. Most of the subsequent extensions of the latter have been based on the same data, and no attempt will be made to reproduce them here.

The effect of the crystalline neighborhood on the electronic orbitals of the rare earth ion is appreciable, but is nevertheless small compared with the atomic electron interactions, and to a large extent can be treated in terms of a model whose basis states are the free-ion orbitals themselves, without need for specific structural detail of the electronic involvement with ligand ions. Because of the dominance of the atomic forces it is important to have an atomic Hamiltonian which is detailed enough to accurately describe the observed crystal level groupings. In the process we have incidently learned much about the structure of the atomic energy levels themselves.

In a pure $4f^N$ configuration the only interactions to be evaluated would be the four Slater integrals $F^{0,2,4,6}$ and the spin-orbit integral, ζ, plus relativistic correction terms representing spin-other-orbit and spin-spin interactions. Ab initio evaluations for each of these can be carried out; however, the latter values are not quite in agreement with experimental ones. This is not because they are inaccurate in themselves but because there are additional contributions due to ignored inter-configuration interactions which have the

same angular dependence and are therefore lumped with the former in any empirical fitting. The experimental values are therefore only effective ones, although we conventionally continue to give them the original names. These same interactions will in addition produce completely new effective-Hamiltonian operators, namely: $\alpha L(L+1)$, Trees (1951, 1952, 1964); $\beta G(G_2)$ and $\gamma G(R_7)$, Racah (1949) and Rajnak and Wybourne (1963); $T^i t_i$, the three-body electrostatic effective operators discussed by Rajnak and Wybourne (1963), Rajnak (1965), Judd (1966,1972) and Crosswhite et al. (1968); and $A_i z_i$, the generalized two-body double-vector operators, Judd et al. (1968) and Crosswhite and Judd (1970).

Fortunately, not all of the theoretically possible operators are needed in the analysis, and those that are (including the F^k and ζ corrections) are all either constant or slowly varying functions of the atomic number Z. For instance, of the fourteen possible $T^i t_i$, only those six which have non-zero matrix elements in second-order perturbation theory are retained. Furthermore, these results are in good agreement with ab initio calculations, Newman and Taylor (1971,1972), Balasubramanian et al. (1975). A review of the whole question of crystal energy level parametrization was given by Newman (1971).

There are thirteen generalized two-body double-vector operators, eight having rank one in each of the spin and orbital angular momentum spaces. (An additional one has matrix elements exactly proportional to those of the spin-orbit interaction and can be ignored). Five have rank two in each of the spaces. The principal contribution to the latter comes from the spin-spin interaction and can be estimated by ab initio calculations of the Marvin integrals $M^{0,2,4}$, Marvin (1947). The former appears to be dominated by spin-other-orbit effects, parametrized by the same Marvin integrals, and another effect arising from the fact that there are spin-orbit matrix elements connecting $4f^N$

with configurations of the type $4f^{N-1}n'f$. Rajnak and Wybourne (1964) have called these "electrostatically-correlated spin-orbit" effects. Matrix elements have been given by Judd et al. (1968). Their essential role is to allow for effective spin-orbit variations with spectroscopic term and are parametrized by the quantities $P^{2,4,6}$. Ab initio calculations have been given by Newman and Taylor (1972).

A summary of the parameters derived from $LaCl_3$ crystal studies is given in Table 1, Crosswhite (1977). As a rule of thumb for estimating atomic parameters appropriate for the LaF_3 case, the $LaCl_3$ F^K and ζ values reported in Table 1 should be increased slightly: 1.8% for F^2, 1.1% for F^4, 0.8% for F^6 and 0.5% for ζ. More extensive details are given elsewhere; Crosswhite et al. (1976), Carnall et al. (1976), Crosswhite et al. (1977), Crosswhite and Crosswhite (1977). For the major parameters we have found on comparison with ab initio calculations that the required corrections are remarkably uniform. Computations with a Hartree-Fock program containing an approximate relativistic correction, Cowan and Griffin (1976), are given in Table 2, and differences of these and experimental F^k and ζ values are shown in Figs. 1 and 2. The two-body electrostatic correction parameters α, β and γ show similar slow variations across the series; the T^i are essentially constant; and the P^k can be taken proportional to ζ. The M^k(spin-other-orbit) are shown in Fig. 2.

The crystalline environment can in principle make contributions to each of these terms in addition to new ones specific to the particular point-group symmetry. However, experimentally we find that there is a great similarly between the parameters for the $LaCl_3$-doped spectra and those of the few free ion cases for which experimental data are complete enough to permit full parametrization (La II, Ce III and Pr IV $4f^2$ and Pr III $4f^3$). Systematic values can

APPENDIX I - TABLE 1

Parameters for $Ln^{3+}:LaCl_3$ [a]

	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er
E_{ave}	9928	24186	36805	47190	64542	87538	68200	55894	48193	35490
F^2	68368	71866	75808	78125	84399	85200	90012	92750	95466	98203
F^4	50008	52132	54348	56809	60343	60399	64327	65699	67238	69647
F^6	32743	35473	38824	40091	41600	44847	42951	45549	46724	49087
Alpha	22.9	22.1	21.0	21.6	16.8	[19]	17.5	17.2	17.2	15.9
Beta	-674	-650	-645	-724	[-640]	[-643]	[-630]	-622	-621	-632
Gamma	[1520]	1586	1425	[1700]	[1750]	1644	[1880]	1881	2092	[2017]
T^2	--	377	302	291	[370]	[315]	[340]	311	300	300
T^3	--	40	45	13	[40]	[44]	[40]	116	37	48
T^4	--	63	34	34	[40]	[40]	[40]	12	98	18
T^6	--	-292	-315	-193	[-330]	[-300]	[-330]	-474	-316	-342
T^7	--	358	554	288	[380]	[325]	[330]	413	440	214
T^8	--	354	[400]	330	[370]	[360]	[380]	315	372	449
Zeta	744	880	1022	1168	1331	[1513]	1707	1920	2137	2370
M^0 [b]	1.76	1.97	2.1	2.4	[2.38]	[2.82]	[3.00]	2.8	3.0	4.5
P^2 [c]	275	255	319	341	245	495	590	591	523	667
B^2_0	107	163	143	186	189	216	185	193	216	216
B^4_0	-342	-336	-395	-270	-287	-272	-291	-328	-284	-271
B^6_0	-677	-713	-666	-623	-801	-688	-457	-470	-448	-411
B^6_6	466	462	448	470	525	474	302	287	294	272

[a] Values in brackets were not freely varied.

[b] Only M^0 was varied; the ratios $M^2/M^0 = 0.56$, $M^4/M^0 = 0.38$ were maintained.

[c] Only P^2 was varied; the ratios $P^4/P^2 = 0.75$, $P^6/P^2 = 0.50$ were maintained.

lated values for the LaF_3 host, Barasch and Dieke (1965).

APPENDIX I - TABLE 2

Relativistic Hartree-Fock Integrals for $4f^N$ IV.

		F^2	F^4	F^6	ζ	M^0	M^2	M^4
$4f^1$	Ce IV	-	-	-	696.41	-	-	-
$4f^2$	Pr IV	98723	61937	44564	820.22	1.991	1.110	0.752
$4f^3$	Nd IV	102720	64462	46386	950.51	2.237	1.248	0.846
$4f^4$	Pm IV	106520	66856	48111	1091.46	2.492	1.391	0.943
$4f^5$	Sm IV	110157	69143	49758	1243.60	2.756	1.540	1.044
$4f^6$	Eu IV	113663	71373	51342	1407.71	3.031	1.694	1.149
$4f^7$	Gd IV	117058	73470	52873	1584.45	3.318	1.855	1.258
$4f^8$	Tb IV	120366	75541	54361	1774.46	3.615	2.022	1.372
$4f^9$	Dy IV	123592	77558	55810	1998.44	3.924	2.195	1.490
$4f^{10}$	Ho IV	126751	79530	57227	2197.06	4.246	2.376	1.612
$4f^{11}$	Er IV	129850	81462	58615	2431.00	4.580	2.563	1.739
$4f^{12}$	Tm IV	132897	83361	59978	2680.97	4.928	2.758	1.872
$4f^{13}$	Yb IV	-	-	-	2947.69	-	-	-

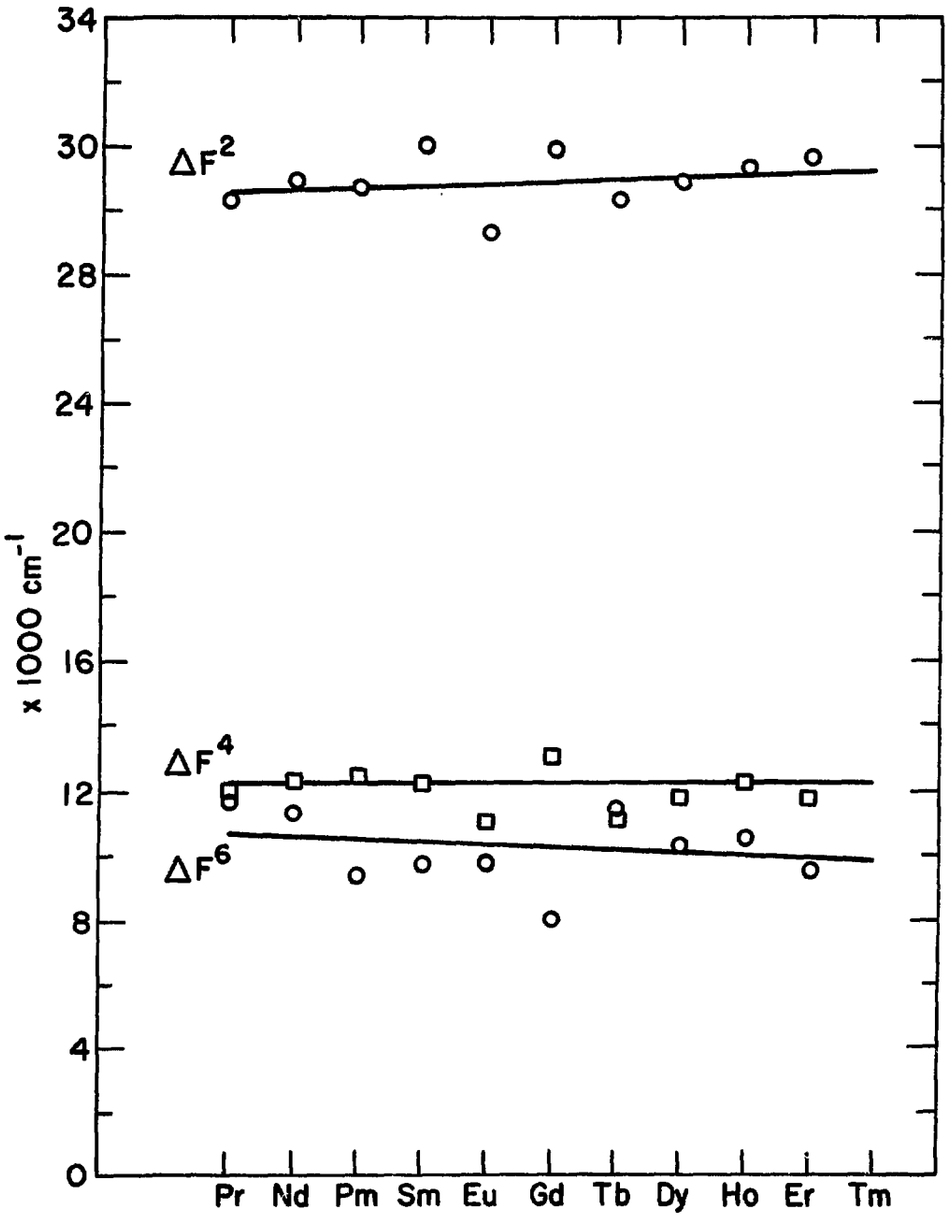

Fig. 1. Variation of the differences between the pseudo relativistic Hartree-Fock (HFR) values of the Slater integrals F^k and those determined experimentally, $F^k(HFR)-F^k(EXP) = \Delta F^k$, with lanthanide atomic number.

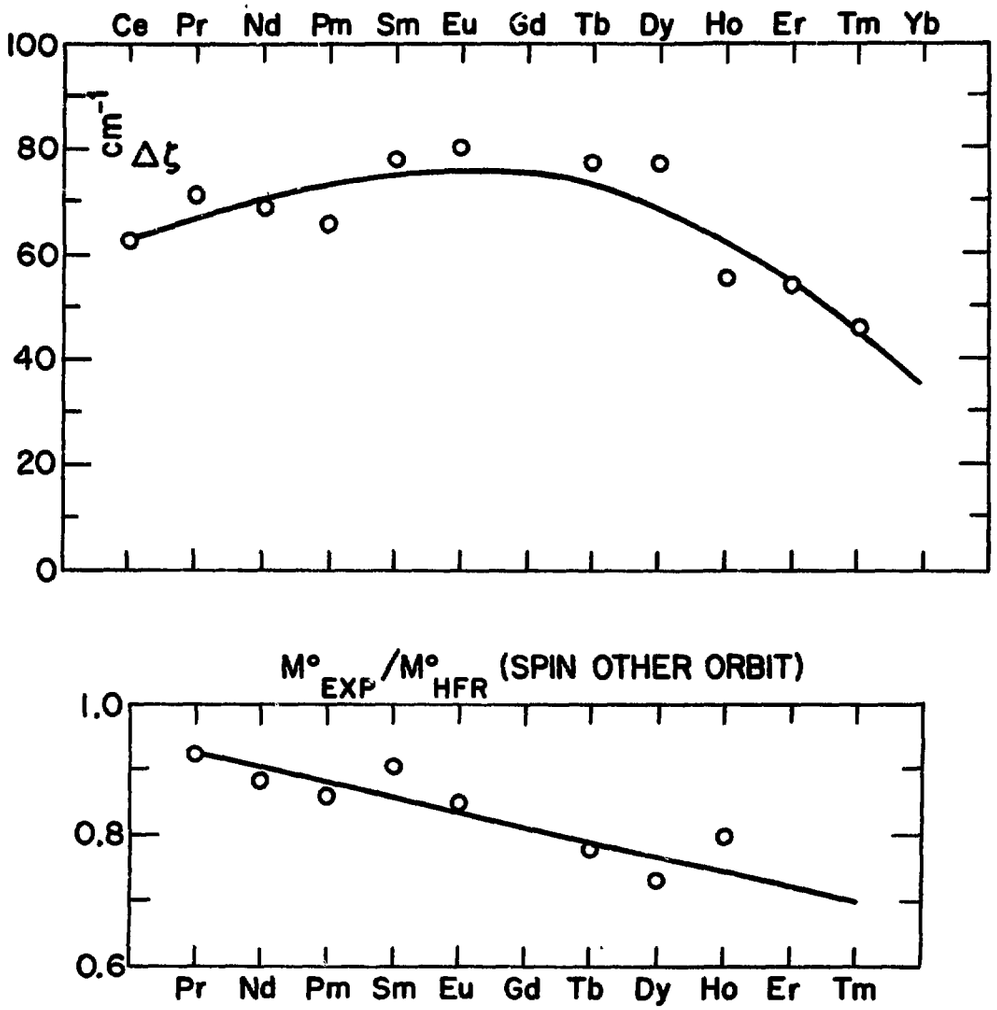

Fig. 2. Variation of the differences between the pseudo relativistic Hartree-Fock (HFR) values of the spin-orbit Slater integral ζ, and those determined experimentally, $\zeta(\text{HFR})-\zeta(\text{EXP}) = \Delta\zeta$; and the ratios of the corresponding spin-other orbit values M^{o}_{EXP}/M^{o}_{HFR} with lanthanide atomic number.

be found for the T^i and a_i (or alternately M^k and P^k) which satisfy all known spectra, whether free ion or crystal, in terms of only a few constants. It follows therefore that the same model can be used for preliminary estimates for other spectra such as LaF_3-doped crystals.

As to the parametrization of the crystal-field itself, the general specification that the number of possible two-particle operators is equal to the number of available independent cells in the Hamiltonian requires 366 additional ones besides the ten single-particle ones (of which only four are formally used). Fortunately, the single-particle model, Judd (1963), Wybourne (1965), Dieke (1968), works very well, although we must recognize that these parameters represent much more complicated effects than the simple Coulomb model visualized by the early theories. Newman and Taylor (1971) give a discussion of the physical significance of these parameters.

APPENDIX II

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APPENDIX II - TABLE 1

Atomic Parameters for $Ln^{3+}:LaF_3$

	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm
EAV	10163.	24490.	(37272)	47760.	(64263)	87847.	68608.	56492.	48453.	35915.	18000.
F^2	69305.	73036	(77000)	79915	(84000)	85587	91220	94877	97025	100274	102459
F^4	50675.	52624	(55000)	57256	(60000)	61361	65798	67470	68885	70555	72424
F^6	32813	35793	(37500)	40424	(42500)	45055	43661	45745	47744	49900	51380
α	(21)	21.28	(21.00)	20.07	(20.)	(20.)	19.81	17.64	18.98	17.88	(17.)
β	-842	-583.	(-560)	-563	(-570)	(-590)	(-600.)	-608	-579	-599	-737
γ	1625	1443	(1400.)	1436	(1450)	(1450)	(1400)	1498	1570	1719	(1700)
ζ	750.8	884.9	(1022.)	1177.2	(1327)	1503.5	1702	1912	2144	2381	2640
T^2	-	306	(330.)	288	(330)	(330)	(+330)	+423	(+330)	+441	
T^3	-	41	(41.5)	36	(41.5)	(+41.5)	(+41.5)	+50	(+41.5)	+42	
T^4	-	59	(62.)	56	(62)	(+62)	(+62)	+117	(+62)	+64	
T^6	-	-283	(-295.)	-283	(-295)	-(295)	-(295)	-334	-(295)	-314	
T^7	-	326	(360)	333	(360)	(+360)	(+360)	+432	(+360)	+387	
T^8	-	298	(310)	342	(310)	(+310)	(+310)	+353	(+310)	+363	
$M^{0(b)}$	(1.99)	(2.237)	(2.49)	(2.76)	(3.03)	(3.32)	(3.61)	(3.92)	(4.25)	(4.58)	(4.93)
$M^{2(b)}$	(1.11)	(1.248)	(1.39)	(1.54)	(1.69)	(1.85)	(2.02)	(2.19)	(2.38)	(2.56)	(2.72)
$M^{4(b)}$	(0.75)	(0.84)	(0.94)	(1.04)	(1.15)	(1.26)	(1.37)	(1.49)	(1.61)	(1.74)	(1.37)
$P^{2(c)}$	(200)	213	(440)	344	(300)	611	583	771	843	852	729.6
$P^{4(c)}$	(150)	160	(330)	258	(200)	458	437	578	632	639	547
$P^{6(c)}$	(100)	106.5	(220)	172	(150)	306	291	386	421	426	364
No. of Levels fit	11	139	-	180	-	64	(26)[d]	201	(27)[d]	117	(12)[d]
σ	41	16.6	-	16.7		9	36	22	32	12.1	76

[a]Values in parenthesis were not freely varied.

[b]Relativistic Hartree-Fock values were assumed.

[c]Only P^2 was varied, the ratios $P_4/P_2 = 0.75$, $P_6/P_2 = 0.5$ were maintained.

[d]Free-ion Hamiltonian only

APPENDIX II - TABLE 2

Crystal-field Parameters for $Ln^{3+}:LaF_3$

	Nd	Sm	Gd	Dy	Er
B_0^2	216	209	(210)	218	229
B_0^4	1225	1042	(1050)	1099	965
B_0^6	1506	1415	(1250)	1129	909
B_6^6	770	659	(600)	553	484

APPENDIX III

APPENDIX III

TABLE 1
PR+3:LAF3 CENTERS OF GRAVITY

OBSERVED	CALC	O-C	STATE
200	191	9	3H4
...	2303	...	3H5
4487	4495	-7	3H6
5215	5196	19	3F2
6568	6595	-26	3F3
7031	7009	22	3F4
10001	10012	-10	1G4
17047	17052	-4	1D2
20927	20935	-7	3P0
21514	21555	-40	3P1
...	21743	...	1I6
22746	22690	56	3P2
46986	46986	0	1S0

APPENDIX III

TABLE 2
U(K)*2 FOR PR+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
0	20931	2	5194	0.2954	0.0	0.0
0	20931	2	17054	0.0152	0.0	0.0
0	20931	4	189	0.0	0.1729	0.0
0	20931	4	7008	0.0	0.1079	0.0
0	20931	6	4499	0.0	0.0	0.0726
1	21552	1	21552	0.1607	0.0	0.0
1	21552	2	5194	0.2685	0.0	0.0
1	21552	2	17054	0.0799	0.0	0.0
1	21552	3	6595	0.5714	0.1964	0.0
1	21552	4	189	0.0	0.1702	0.0
1	21552	4	7008	0.0	0.2636	0.0
1	21552	5	2305	0.0	0.2857	0.0892
1	21552	6	4499	0.0	0.0	0.1246
2	5194	2	5194	0.0618	0.0065	0.0
2	5194	2	17054	0.0140	0.0866	0.0
2	5194	3	6595	0.0209	0.0509	0.0
2	5194	4	189	0.5090	0.4030	0.1173
2	5194	4	7008	0.0014	0.0012	0.0905
2	5194	5	2305	0.0	0.2977	0.6590
2	5194	6	4499	0.0	0.0164	0.3038
2	17054	2	17054	0.3745	0.3295	0.0
2	17054	3	6595	0.0319	0.0177	0.0
2	17054	4	189	0.0027	0.0174	0.0534
2	17054	4	7008	0.6015	0.0000	0.0201
2	17054	5	2305	0.0	0.0019	0.0004
2	17054	6	4499	0.0	0.0686	0.0066
3	6595	3	6595	0.0625	0.0030	0.0625
3	6595	4	189	0.0653	0.3465	0.6982
3	6595	4	7008	0.0252	0.0731	0.0054
3	6595	5	2305	0.6285	0.3467	0.0
3	6595	6	4499	0.0	0.3182	0.8459
4	189	4	189	0.7782	0.4645	0.2642
4	189	4	7008	0.0189	0.0503	0.4889
4	189	5	2305	0.1095	0.2012	0.6115
4	189	6	4499	0.0000	0.0333	0.1392
4	7008	4	7008	0.0146	0.2427	0.0358
4	7008	5	2305	0.0296	0.3116	0.4407
4	7008	6	4499	0.5668	0.6095	0.4623
5	2305	5	2305	0.9192	0.3668	0.1214
5	2305	6	4499	0.1080	0.2327	0.6420
6	4499	6	4499	1.2383	0.7108	0.7878

APPENDIX IV

APPENDIX IV

TABLE 1
ND+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
0	3	-2	4I	9/2	-9/2
45	38	7	4I	9/2	5/2
136	142	-5	4I	9/2	3/2
296	294	2	4I	9/2	1/2
500	500	0	4I	9/2	-7/2
1978	1963	15	4I	11/2	-11/2
2037	2041	-4	4I	11/2	5/2
2068	2075	-6	4I	11/2	3/2
2091	2098	-6	4I	11/2	1/2
2187	2203	-15	4I	11/2	-7/2
2223	2227	-3	4I	11/2	-9/2
3918	3901	17	4I	13/2	13/2
3978	3983	-4	4I	13/2	5/2
4038	4043	-4	4I	13/2	3/2
4076	4102	-25	4I	13/2	1/2
4118	4126	-7	4I	13/2	-7/2
4208	4205	3	4I	13/2	-9/2
4278	4275	3	4I	13/2	-11/2
5816	5820	-3	4I	15/2	15/2
5874	5838	36	4I	15/2	-7/2
5986	5997	-10	4I	15/2	-9/2
6141	6171	-29	4I	15/2	5/2
6167	6187	-19	4I	15/2	1/2
6323	6293	30	4I	15/2	3/2
6454	6420	34	4I	15/2	-11/2
6556	6545	11	4I	15/2	13/2
11592	11596	-3	4F	3/2	1/2
11634	11626	8	4F	3/2	3/2
12596	12585	11	2H2	9/2	-7/2
12614	12589	25	4F	5/2	3/2
12622	12630	-7	4F	5/2	1/2
12676	12678	-1	4F	5/2	5/2
12694	12704	-9	4F	5/2	1/2
12754	12763	-8	2H2	9/2	3/2
12843	12854	-10	2H2	9/2	-9/2
12902	12873	29	2H2	9/2	5/2
13514	13514	0	4F	7/2	3/2
13590	13583	7	4F	7/2	-7/2
13671	13673	-1	4F	7/2	1/2
13676	13693	-16	4S	3/2	1/2
13711	13695	16	4S	3/2	3/2
13715	13711	4	4F	7/2	5/2

APPENDIX IV

TABLE 1
ND+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
14834	14847	-12	4F	9/2	1/2
14861	14861	0	4F	9/2	3/2
14892	14886	6	4F	9/2	3/2
14926	14924	2	4F	9/2	5/2
14959	14957	2	4F	9/2	-7/2
15997	16028	-30	2H2	11/2	5/2
16033	16046	-12	2H2	11/2	-11/2
16060	16059	1	2H2	11/2	3/2
16046	16060	-13	2H2	11/2	-7/2
16100	16095	5	2H2	11/2	1/2
16165	16140	25	2H2	11/2	-9/2
17316	17308	8	4G	5/2	3/2
17306	17311	-4	4G	5/2	1/2
17363	17360	3	4G	5/2	5/2
17510	17491	19	4G	7/2	5/2
17520	17505	15	2G1	7/2	3/2
17571	17564	7	4G	5/2	5/2
17605	17611	-5	4G	5/2	1/2
19147	19139	8	4G	7/2	5/2
19235	19245	-9	4G	7/2	1/2
19252	19271	-18	4G	7/2	3/2
19324	19324	0	4G	7/2	-7/2
19567	19567	0	2K	13/2	13/2
19615	19632	-16	4G	9/2	5/2
19651	19645	6	2K	13/2	1/2
19704	19687	17	4G	9/2	-7/2
19686	19693	-6	4G	9/2	-9/2
...	19737	...	2K	13/2	-11/2
19741	19738	3	4G	9/2	3/2
19799	19790	9	2K	13/2	3/2
19835	19845	-9	4G	9/2	1/2
...	19917	...	2K	13/2	5/2
...	19927	...	2K	13/2	-9/2
19960	19971	-10	2K	13/2	-7/2
21155	21150	5	2G1	9/2	-7/2
21176	21183	-6	2G1	9/2	3/2
21198	21199	0	2G1	9/2	-7/2
21232	21235	-2	2G1	9/2	1/2
21252	21267	-14	2G1	9/2	-9/2
21338	21339	0	2D1	3/2	3/2
21353	21352	1	2D1	3/2	1/2

APPENDIX IV

TABLE 1
ND+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	21535	...	4G	11/2	-7/2
...	21620	...	2K	15/2	15/2
21633	21621	12	4G	11/2	5/2
21718	21731	-12	4G	11/2	-9/2
...	21774	...	4G	11/2	-11/2
...	21779	...	2K	15/2	13/2
...	21790	...	4G	11/2	-9/2
...	21824	...	2K	15/2	1/2
...	21827	...	2K	15/2	5/2
21846	21857	-10	2K	15/2	3/2
...	21901	...	2K	15/2	-11/2
...	21931	...	2K	15/2	-9/2
...	21946	...	2K	15/2	-7/2
21992	21995	-2	4G	11/2	1/2
23473	23455	18	2P	1/2	1/2
...	23996	...	2D1	5/2	3/2
23991	23999	-7	2D1	5/2	1/2
24080	24057	23	2D1	5/2	5/2
26378	26394	-15	2P	3/2	1/2
26426	26416	10	2P	3/2	3/2
28341	28361	-19	4D	3/2	1/2
28374	28369	5	4D	3/2	3/2
...	28495	...	4D	5/2	5/2
28525	28528	-2	4D	5/2	1/2
...	28634	...	2I	11/2	-11/2
28676	28686	-9	4D	5/2	3/2
28962	28938	24	4D	1/2	1/2
29463	29459	4	2I	11/2	-9/2
29489	29475	14	2I	11/2	-7/2
29568	29565	3	2I	11/2	5/2
29644	29659	-14	2I	11/2	3/2
29773	29767	6	2I	11/2	1/2
30275	30271	4	2L	15/2	13/2
...	30346	...	2L	15/2	15/2
...	30411	...	2L	15/2	1/2
...	30451	...	2L	15/2	3/2
...	30533	...	2L	15/2	-11/2
...	30534	...	2L	15/2	5/2
30576	30602	-25	4D	7/2	5/2
...	30615	...	2L	15/2	-9/2
30631	30646	-14	4D	7/2	-7/2
30682	30701	-18	2L	15/2	-7/2
30719	30712	7	4D	7/2	3/2
30807	30792	15	4D	7/2	1/2

experimentally, F^k(HFR)-F^k(EXP) = ΔF^k, with lanthanide atomic number.

APPENDIX IV

TABLE 1
ND+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	30850	...	2I	13/2	-11/2
30893	30895	-1	2I	13/2	-9/2
30933	30955	-21	2I	13/2	-7/2
30994	31002	-7	2I	13/2	13/2
31030	31041	-10	2I	13/2	5/2
31068	31070	-1	2I	13/2	3/2
...	31079	...	2I	13/2	1/2
31781	31767	14	2L	17/2	15/2
31859	31836	23	2L	17/2	17/2
...	31926	...	2L	17/2	1/2
...	31968	...	2L	17/2	3/2
...	31990	...	2L	17/2	13/2
...	32013	...	2L	17/2	5/2
...	32048	...	2L	17/2	-11/2
...	32093	...	2L	17/2	-9/2
...	32126	...	2L	17/2	-7/2
33030	33035	-4	2H1	9/2	-7/2
33107	33137	-29	2H1	9/2	1/2
33181	33168	13	2H1	9/2	-9/2
33228	33226	2	2H1	9/2	5/2
33255	33258	-2	2H1	9/2	3/2
33619	33612	7	2D2	3/2	3/2
33649	33631	18	2D2	3/2	1/2
34292	34274	18	2H1	11/2	-9/2
34380	34374	6	2H1	11/2	1/2
34419	34445	-25	2D2	5/2	5/2
34521	34519	2	2H1	11/2	-7/2
...	34551	...	2H1	11/2	1/2
...	34573	...	2H1	11/2	3/2
34678	34686	-7	2H1	11/2	-11/2
34706	34709	-2	2D2	5/2	3/2
...	34818	...	2H1	11/2	5/2
38690	38723	-32	2F2	5/2	5/2
38735	38778	-42	2F2	5/2	1/2
38841	38815	26	2F2	5/2	3/2
40103	40113	-9	2F2	7/2	-7/2
40155	40126	29	2F2	7/2	3/2
...	40187	...	2F2	7/2	1/2
40288	40254	34	2F2	7/2	5/2

APPENDIX IV

TABLE 1
ND+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	47871	...	2G2	9/2	5/2
47894	47888	6	2G2	9/2	-9/2
47937	47964	-26	2G2	9/2	3/2
47999	48006	-6	2G2	9/2	-7/2
48043	48055	-11	2G2	9/2	1/2
48839	48861	-21	2G2	7/2	-7/2
48908	48869	39	2G2	7/2	3/2
48977	48979	-1	2G2	7/2	5/2
49088	49065	23	2G2	7/2	1/2
...	66548	...	2F1	7/2	5/2
...	66705	...	2F1	7/2	-7/2
...	66793	...	2F1	7/2	3/2
...	66859	...	2F1	7/2	1/2
...	67857	...	2F1	5/2	5/2
...	67858	...	2F1	5/2	3/2
...	68075	...	2F1	5/2	1/2

APPENDIX IV

TABLE 1A
ND+3:LAF3 CENTERS OF GRAVITY

CALC CENTER	STATE
235	4I 9/2
2114	4I11/2
4098	4I13/2
6148	4I15/2
11621	4F 3/2
12660	4F 5/2
12768	2H 9/2
13619	4F 7/2
13691	4S 3/2
14899	4F 9/2
16105	2H11/2
17428	4G 5/2
17469	4G 7/2
19293	4G 7/2
19709	4G 9/2
19785	2K13/2
21425	2D 3/2
21714	4G11/2
21780	2K15/2
23458	2P 1/2
24004	2D 5/2
26424	2P 3/2

TABLE 2
U(K)*2 FOR ND+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
1/2	23458	3/2	11621	0.0131	0.0	0.0
1/2	23458	3/2	13691	0.0175	0.0	0.0
1/2	23458	3/2	21425	0.0291	0.0	0.0
1/2	23458	3/2	26424	0.0056	0.0	0.0
1/2	23458	5/2	12660	0.0101	0.0	0.0
1/2	23458	5/2	17428	0.0346	0.0	0.0
1/2	23458	5/2	24004	0.0260	0.0	0.0
1/2	23458	7/2	13619	0.0	0.0200	0.0
1/2	23458	7/2	17469	0.0	0.0097	0.0
1/2	23458	7/2	19293	0.0	0.0026	0.0
1/2	23458	9/2	235	0.0	0.0396	0.0
1/2	23458	9/2	12768	0.0	0.0871	0.0
1/2	23458	9/2	14899	0.0	0.0033	0.0
1/2	23458	9/2	19709	0.0	0.0010	0.0
1/2	23458	11/2	16105	0.0	0.0	0.1643
1/2	23458	13/2	19785	0.0	0.0	0.1746
3/2	11621	3/2	11621	0.0612	0.0	0.0
3/2	11621	3/2	21425	0.0050	0.0	0.0
3/2	11621	3/2	26424	0.0024	0.0	0.0
3/2	11621	5/2	12660	0.0773	0.0533	0.0
3/2	11621	5/2	17428	0.4856	0.0433	0.0
3/2	11621	5/2	24004	0.0009	0.0007	0.0
3/2	11621	7/2	13619	0.0063	0.0800	0.0
3/2	11621	7/2	17469	0.0735	0.0400	0.0
3/2	11621	7/2	19293	0.1062	0.0629	0.0
3/2	11621	9/2	235	0.0	0.2283	0.0554
3/2	11621	9/2	12768	0.0	0.0149	0.0223
3/2	11621	9/2	14899	0.0	0.0046	0.1115
3/2	11621	9/2	19709	0.0	0.0570	0.1451
3/2	11621	11/2	2114	0.0	0.1423	0.4083
3/2	11621	11/2	16105	0.0	0.0001	0.0081
3/2	11621	11/2	21714	0.0	0.0015	0.0992
3/2	11621	13/2	4098	0.0	0.0	0.2093
3/2	11621	13/2	19785	0.0	0.0	0.0076
3/2	11621	15/2	6148	0.0	0.0	0.0280
3/2	11621	15/2	21780	0.0	0.0	0.0099
3/2	13691	3/2	21425	0.0073	0.0	0.0
3/2	13691	3/2	26424	0.0060	0.0	0.0
3/2	13691	5/2	17428	0.0007	0.1775	0.0
3/2	13691	5/2	24004	0.0071	0.0000	0.0
3/2	13691	7/2	17469	0.0006	0.0731	0.0
3/2	13691	7/2	19293	0.0021	0.2023	0.0
3/2	13691	9/2	235	0.0	0.0025	0.2347
3/2	13691	9/2	12768	0.0	0.0044	0.0001
3/2	13691	9/2	14899	0.0	0.0023	0.0011
3/2	13691	9/2	19709	0.0	0.1922	0.0009
3/2	13691	11/2	2114	0.0	0.0000	0.2099
3/2	13691	11/2	16105	0.0	0.0563	0.0016

TABLE 2
U(K)*2 FOR ND+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
3/2	13691	11/2	21714	0.0	0.3245	0.0004
3/2	13691	13/2	4098	0.0	0.0	0.3295
3/2	13691	15/2	6148	0.0	0.0	0.3306
3/2	13691	15/2	21780	0.0	0.0	0.0030
3/2	21425	3/2	21425	0.0161	0.0	0.0
3/2	21425	3/2	26424	0.0052	0.0	0.0
3/2	21425	5/2	12660	0.0038	0.0000	0.0
3/2	21425	5/2	17428	0.0002	0.0039	0.0
3/2	21425	5/2	24004	0.1744	0.0011	0.0
3/2	21425	7/2	13619	0.0025	0.0001	0.0
3/2	21425	7/2	17469	0.0104	0.0839	0.0
3/2	21425	7/2	19293	0.0206	0.0418	0.0
3/2	21425	9/2	235	0.0	0.0202	0.0001
3/2	21425	9/2	12768	0.0	0.0259	0.0872
3/2	21425	9/2	14899	0.0	0.0003	0.0139
3/2	21425	9/2	19709	0.0	0.0023	0.0325
3/2	21425	11/2	2114	0.0	0.0016	0.0326
3/2	21425	11/2	16105	0.0	0.1078	0.1807
3/2	21425	11/2	21714	0.0	0.0300	0.0003
3/2	21425	13/2	19785	0.0	0.0	0.0860
3/2	21425	15/2	6148	0.0	0.0	0.0083
3/2	21425	15/2	21780	0.0	0.0	0.3482
3/2	26424	3/2	26424	0.0838	0.0	0.0
3/2	26424	5/2	12660	0.0022	0.0033	0.0
3/2	26424	5/2	17428	0.0058	0.0000	0.0
3/2	26424	5/2	24004	0.0074	0.0001	0.0
3/2	26424	7/2	13619	0.0003	0.0007	0.0
3/2	26424	7/2	19293	0.0063	0.0052	0.0
3/2	26424	9/2	235	0.0	0.0010	0.0005
3/2	26424	9/2	12768	0.0	0.0100	0.0813
3/2	26424	9/2	14899	0.0	0.0527	0.0578
3/2	26424	9/2	19709	0.0	0.0601	0.0647
3/2	26424	11/2	2114	0.0	0.0159	0.0005
3/2	26424	11/2	16105	0.0	0.0194	0.0136
3/2	26424	11/2	21714	0.0	0.0043	0.0000
3/2	26424	13/2	4098	0.0	0.0	0.0098
3/2	26424	13/2	19785	0.0	0.0	0.2319
3/2	26424	15/2	6148	0.0	0.0	0.0029
3/2	26424	15/2	21780	0.0	0.0	0.0076
5/2	12660	5/2	12660	0.0462	0.0218	0.0
5/2	12660	5/2	17428	0.2671	0.1301	0.0
5/2	12660	5/2	24004	0.0005	0.0006	0.0
5/2	12660	7/2	13619	0.0655	0.0540	0.0872
5/2	12660	7/2	17469	0.2504	0.0075	0.0750
5/2	12660	7/2	19293	0.2569	0.0009	0.1195
5/2	12660	9/2	235	0.0006	0.2337	0.3983
5/2	12660	9/2	12768	0.0062	0.0308	0.0052

TABLE 2
U(K)*2 FOR ND+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
5/2	12660	9/2	14899	0.0105	0.0508	0.1091
5/2	12660	9/2	19709	0.1912	0.0995	0.0022
5/2	12660	11/2	2114	0.0	0.1698	0.0369
5/2	12660	11/2	16105	0.0	0.0030	0.0239
5/2	12660	11/2	21714	0.0	0.0611	0.1976
5/2	12660	13/2	4098	0.0	0.1817	0.4010
5/2	12660	13/2	19785	0.0	0.0026	0.0048
5/2	12660	15/2	6148	0.0	0.0	0.2300
5/2	12660	15/2	21780	0.0	0.0	0.0051
5/2	17428	5/2	17428	0.0024	0.1883	0.0
5/2	17428	5/2	24004	0.0014	0.0008	0.0
5/2	17428	7/2	13619	0.0382	0.1047	0.1626
5/2	17428	7/2	17469	0.0002	0.1321	0.0845
5/2	17428	7/2	19293	0.0000	0.2391	0.0571
5/2	17428	9/2	235	0.8975	0.4126	0.0346
5/2	17428	9/2	12768	0.0012	0.0134	0.0018
5/2	17428	9/2	14899	0.0026	0.0070	0.1303
5/2	17428	9/2	19709	0.0000	0.1035	0.2477
5/2	17428	11/2	2114	0.0	0.2867	0.0961
5/2	17428	11/2	16105	0.0	0.0002	0.0145
5/2	17428	11/2	21714	0.0	0.0094	0.0914
5/2	17428	13/2	4098	0.0	0.0342	0.0485
5/2	17428	13/2	19785	0.0	0.0018	0.0077
5/2	17428	15/2	6148	0.0	0.0	0.0046
5/2	17428	15/2	21780	0.0	0.0	0.0051
5/2	24004	5/2	24004	0.2977	0.0045	0.0
5/2	24004	7/2	13619	0.0005	0.0171	0.0064
5/2	24004	7/2	17469	0.0064	0.0688	0.1756
5/2	24004	7/2	19293	0.0003	0.0481	0.0558
5/2	24004	9/2	235	0.0000	0.0002	0.0017
5/2	24004	9/2	12768	0.0078	0.1994	0.0791
5/2	24004	9/2	14899	0.0003	0.0110	0.0132
5/2	24004	9/2	19709	0.0000	0.0077	0.0064
5/2	24004	11/2	2114	0.0	0.0001	0.0029
5/2	24004	11/2	16105	0.0	0.2523	0.0184
5/2	24004	11/2	21714	0.0	0.0314	0.0006
5/2	24004	13/2	4098	0.0	0.0037	0.0169
5/2	24004	13/2	19785	0.0	0.0033	0.1828
5/2	24004	15/2	21780	0.0	0.0	0.4889
7/2	13619	7/2	13619	0.1525	0.0082	0.1033
7/2	13619	7/2	17469	0.1267	0.0589	0.0104
7/2	13619	7/2	19293	0.1747	0.0732	0.0023
7/2	13619	9/2	235	0.0011	0.0406	0.4272
7/2	13619	9/2	12768	0.0056	0.0344	0.0040
7/2	13619	9/2	14899	0.0934	0.0912	0.0783
7/2	13619	9/2	19709	0.5548	0.0001	0.0825
7/2	13619	11/2	2114	0.0009	0.2335	0.3076

TABLE 2
U(K)*2 FOR ND+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
7/2	13619	11/2	16105	0.0336	0.0154	0.1287
7/2	13619	11/2	21714	0.1729	0.1623	0.1447
7/2	13619	13/2	4098	0.0	0.3314	0.0001
7/2	13619	13/2	19785	0.0	0.0664	0.0003
7/2	13619	15/2	6148	0.0	0.1553	0.6166
7/2	13619	15/2	21780	0.0	0.0000	0.0077
7/2	17469	7/2	17469	0.0111	0.0002	0.0189
7/2	17469	7/2	19293	0.0633	0.0008	0.0359
7/2	17469	9/2	235	0.0707	0.1720	0.0274
7/2	17469	9/2	12768	0.0088	0.0292	0.1989
7/2	17469	9/2	14899	0.0261	0.0504	0.2665
7/2	17469	9/2	19709	0.0730	0.1395	0.0034
7/2	17469	11/2	2114	0.3996	0.1764	0.0522
7/2	17469	11/2	16105	0.0068	0.0000	0.3593
7/2	17469	11/2	21714	0.0119	0.1233	0.0015
7/2	17469	13/2	4098	0.0	0.0875	0.0345
7/2	17469	13/2	19785	0.0	0.7062	0.0012
7/2	17469	15/2	6148	0.0	0.0010	0.1064
7/2	17469	15/2	21780	0.0	0.0383	0.0122
7/2	19293	7/2	19293	0.0937	0.0433	0.0772
7/2	19293	9/2	235	0.0596	0.1709	0.0566
7/2	19293	9/2	12768	0.0508	0.0543	0.3685
7/2	19293	9/2	14899	0.0006	0.0112	0.0099
7/2	19293	9/2	19709	0.0375	0.1449	0.1417
7/2	19293	11/2	2114	0.6684	0.1075	0.0099
7/2	19293	11/2	16105	0.0011	0.0197	0.1020
7/2	19293	11/2	21714	0.0023	0.0341	0.3811
7/2	19293	13/2	4098	0.0	0.2407	0.0613
7/2	19293	13/2	19785	0.0	0.5179	0.0014
7/2	19293	15/2	6148	0.0	0.0273	0.0045
7/2	19293	15/2	21780	0.0	0.0186	0.0018
9/2	235	9/2	235	0.1195	0.1727	0.6892
9/2	235	9/2	12768	0.0095	0.0082	0.1195
9/2	235	9/2	14899	0.0009	0.0092	0.0406
9/2	235	9/2	19709	0.0044	0.0584	0.0383
9/2	235	11/2	2114	0.0194	0.1072	1.1639
9/2	235	11/2	16105	0.0000	0.0027	0.0104
9/2	235	11/2	21714	0.0000	0.0052	0.0079
9/2	235	13/2	4098	0.0000	0.0135	0.4549
9/2	235	13/2	19785	0.0071	0.0002	0.0330
9/2	235	15/2	6148	0.0	0.0000	0.0452
9/2	235	15/2	21780	0.0	0.0052	0.0149
9/2	12768	9/2	12768	0.1156	0.0016	0.2728
9/2	12768	9/2	14899	0.0487	0.0029	0.0018
9/2	12768	9/2	19709	0.0390	0.0478	0.0982
9/2	12768	11/2	2114	0.0028	0.0004	0.0254

APPENDIX IV

TABLE 2
U(K)*2 FOR ND+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
9/2	12768	11/2	16105	0.0687	0.0037	0.2755
9/2	12768	11/2	21714	0.1796	0.0001	0.0037
9/2	12768	13/2	4098	0.0389	0.0064	0.1217
9/2	12768	13/2	19785	0.1211	0.0063	1.1292
9/2	12768	15/2	6148	0.0	0.2155	0.0775
9/2	12768	15/2	21780	0.0	0.4675	0.4145
9/2	14899	9/2	14899	0.1407	0.0960	0.0003
9/2	14899	9/2	19709	0.1181	0.1593	0.0207
9/2	14899	11/2	2114	0.0001	0.0328	0.3702
9/2	14899	11/2	16105	0.0873	0.0239	0.0172
9/2	14899	11/2	21714	0.9423	0.2060	0.0411
9/2	14899	13/2	4098	0.0029	0.2148	0.5102
9/2	14899	13/2	19785	0.0462	0.0042	0.2931
9/2	14899	15/2	6148	0.0	0.5000	0.4628
9/2	14899	15/2	21780	0.0	0.0003	0.2037
9/2	19709	9/2	19709	0.0042	0.0063	0.0122
9/2	19709	11/2	2114	0.1403	0.3495	0.0505
9/2	19709	11/2	16105	0.0032	0.0308	0.2310
9/2	19709	11/2	21714	0.0521	0.5102	0.1206
9/2	19709	13/2	4098	0.9552	0.3843	0.0157
9/2	19709	13/2	19785	0.0210	0.0440	0.1131
9/2	19709	15/2	6148	0.0	0.1426	0.2398
9/2	19709	15/2	21780	0.0	0.1408	0.0246
11/2	2114	11/2	2114	0.1321	0.1159	0.0673
11/2	2114	11/2	16105	0.0043	0.0094	0.0062
11/2	2114	11/2	21714	0.0044	0.0645	0.0563
11/2	2114	13/2	4098	0.0256	0.1352	1.2376
11/2	2114	13/2	19785	0.0002	0.0000	0.0168
11/2	2114	15/2	6148	0.0000	0.0109	0.4180
11/2	2114	15/2	21780	0.0020	0.0003	0.0039
11/2	16105	11/2	16105	0.0107	0.0009	0.0284
11/2	16105	11/2	21714	0.0009	0.0809	0.0109
11/2	16105	13/2	4098	0.0043	0.0168	0.0029
11/2	16105	13/2	19785	0.0014	0.0044	0.4795
11/2	16105	15/2	6148	0.1293	0.0687	0.0000
11/2	16105	15/2	21780	0.1556	0.0017	1.5224
11/2	21714	11/2	21714	0.0015	0.6344	0.1858
11/2	21714	13/2	4098	0.1283	0.3514	0.1609
11/2	21714	13/2	19785	0.0001	0.0077	0.0233
11/2	21714	15/2	6148	1.5301	0.8915	0.1590
11/2	21714	15/2	21780	0.0099	0.0162	0.0912
13/2	4098	13/2	4098	0.1693	0.1729	0.2331
13/2	4098	13/2	19785	0.0032	0.0001	0.0024
13/2	4098	15/2	6148	0.0195	0.1187	1.4522

APPENDIX IV

TABLE 2
U(K)*2 FOR ND+3

J1	IEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
13/2	4098	15/2	21780	0.0003	0.0003	0.0172
13/2	19785	13/2	19785	1.6237	0.5238	0.0228
13/2	19785	15/2	6148	0.0000	0.0009	0.0064
13/2	19785	15/2	21780	0.0073	0.4138	0.0201
15/2	6148	15/2	6148	0.2332	0.3717	1.9341
15/2	6148	15/2	21780	0.0105	0.0001	0.0231
15/2	21780	15/2	21780	1.9817	0.4265	0.0142

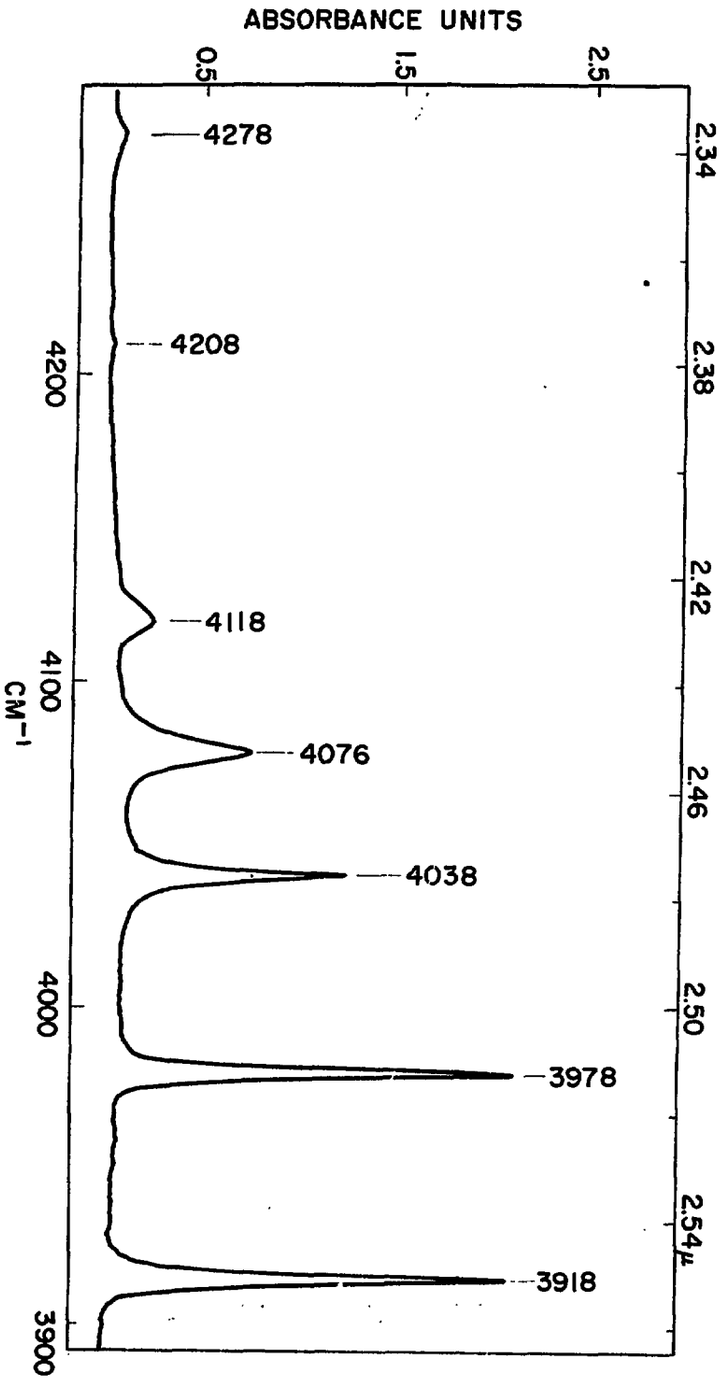

Fig. 1. X Group ($^4I_{13/2}$)

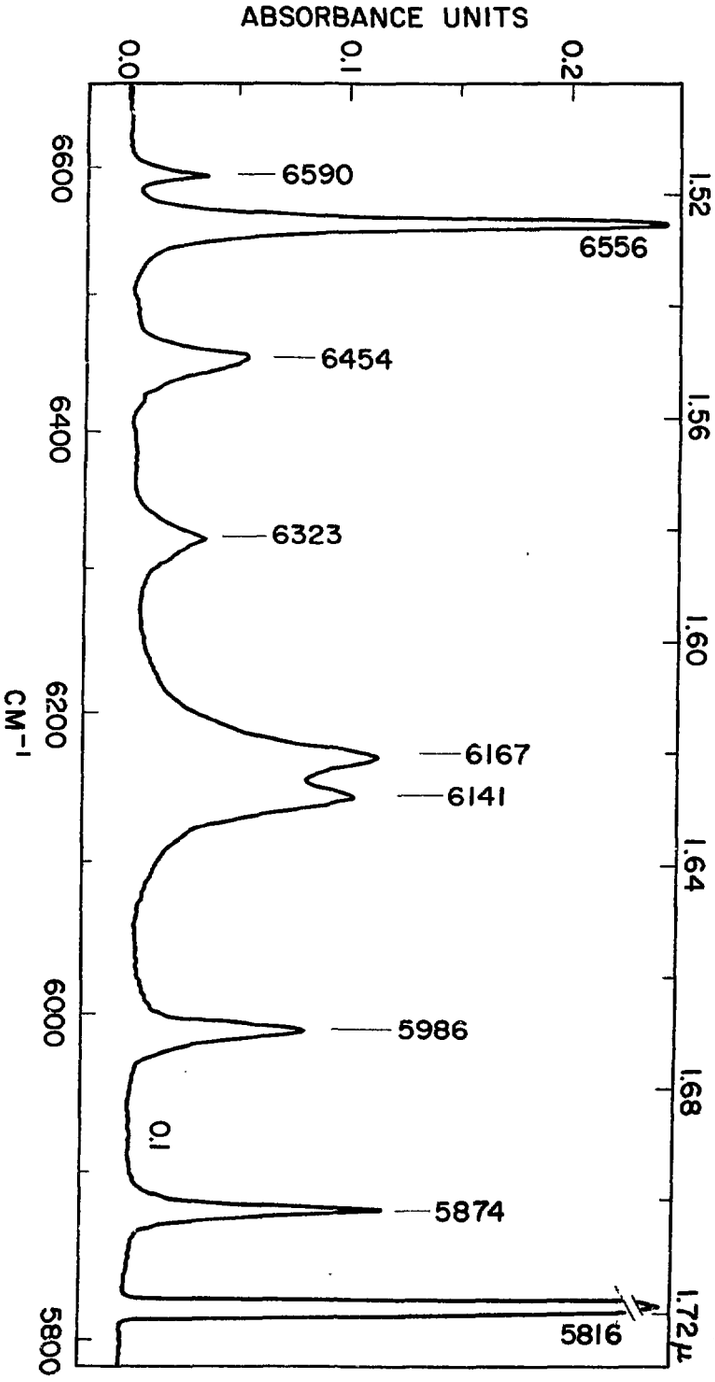

Fig. 2. W Group ($^4I_{15/2}$)

13676	13693	-16	4S	3/2	1/2
13711	13695	16	4S	3/2	3/2
13715	13711	4	4F	7/2	5/2

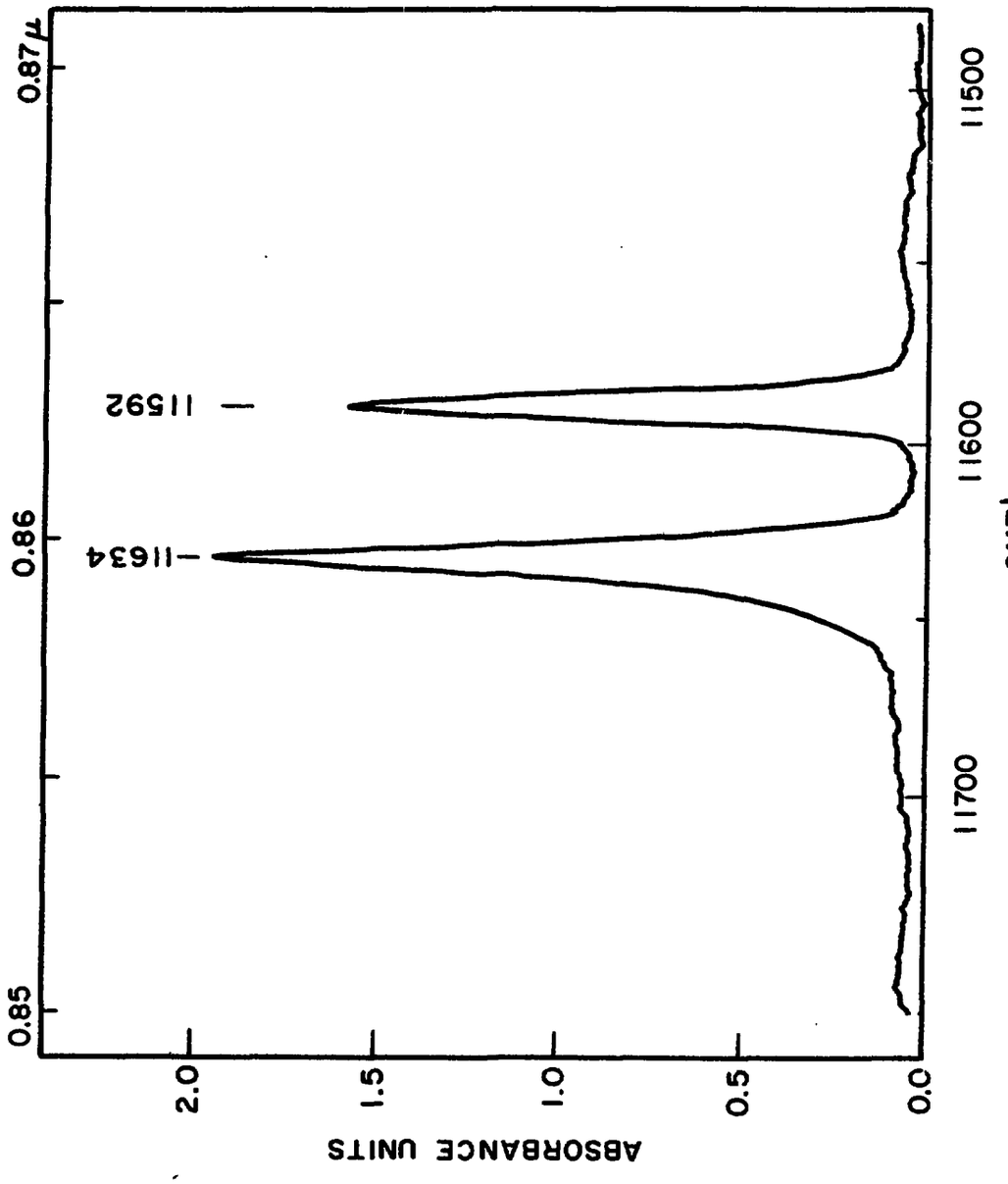

Fig. 3. R Group ($^4F_{3/2}$)

21338	21339	0	2D1	3/2	3/2
21353	21352	1	2D1	3/2	1/2

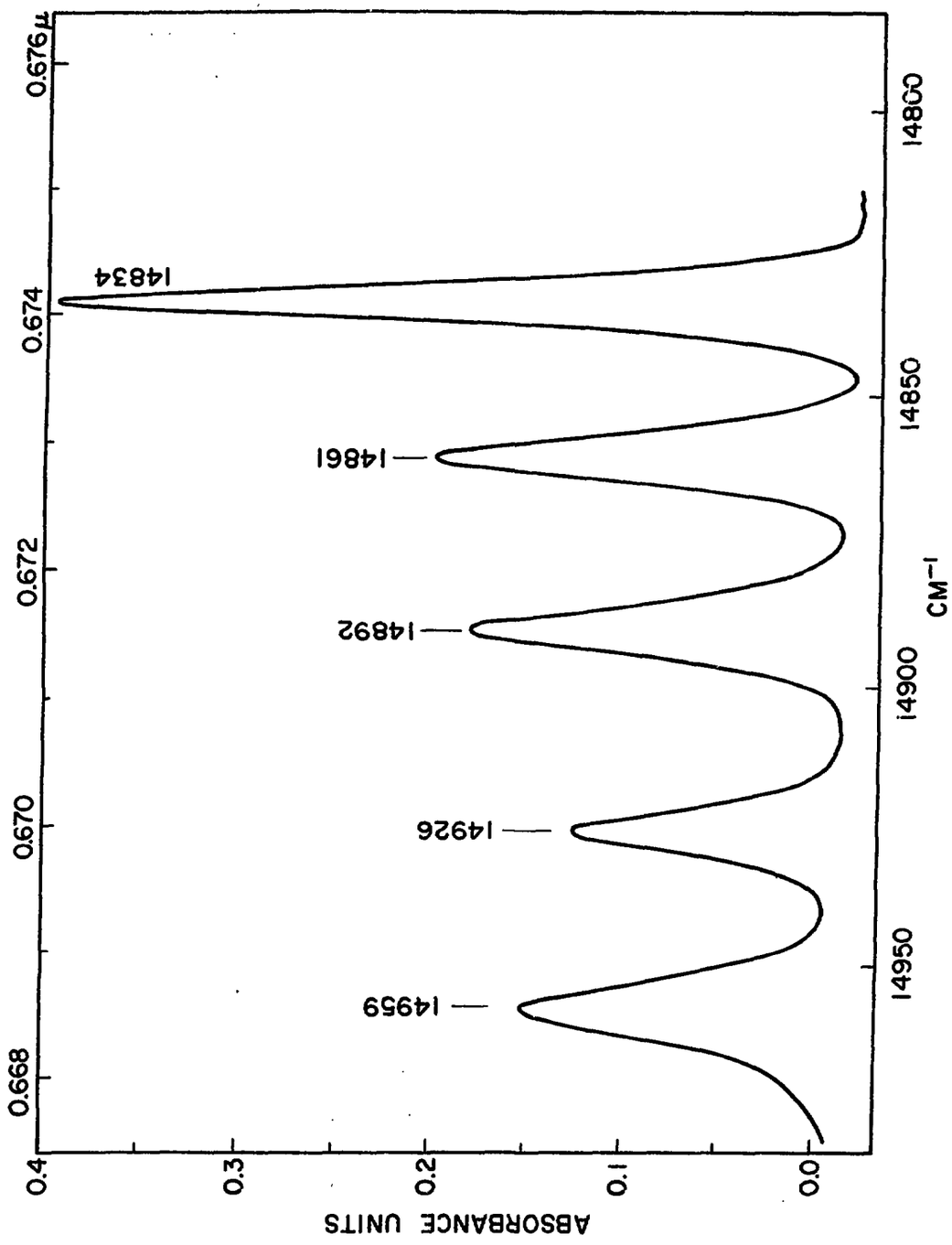

Fig. 6. B Group ($^4F_{9/2}$)

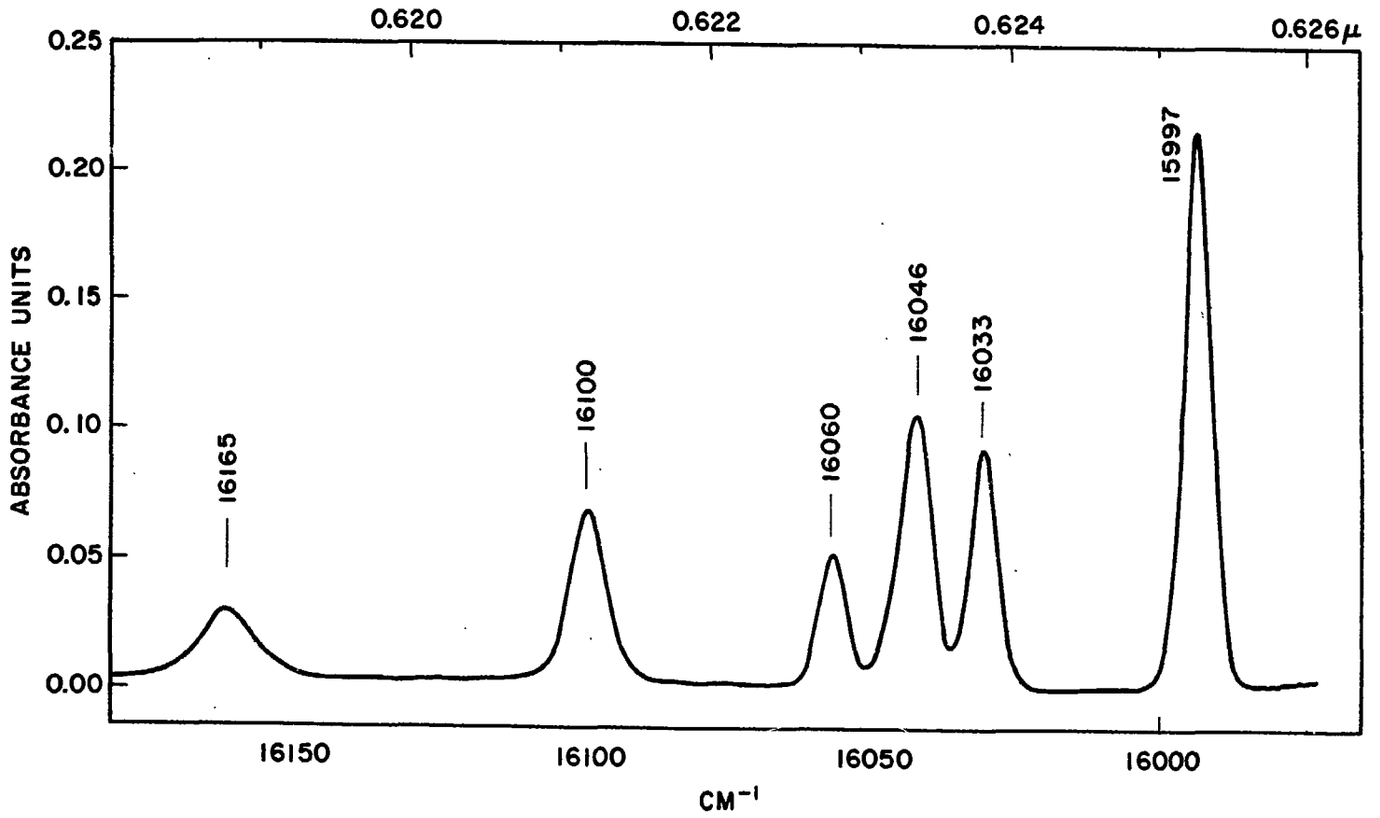

Fig. 7. C Group ($^2H_{11/2}$)

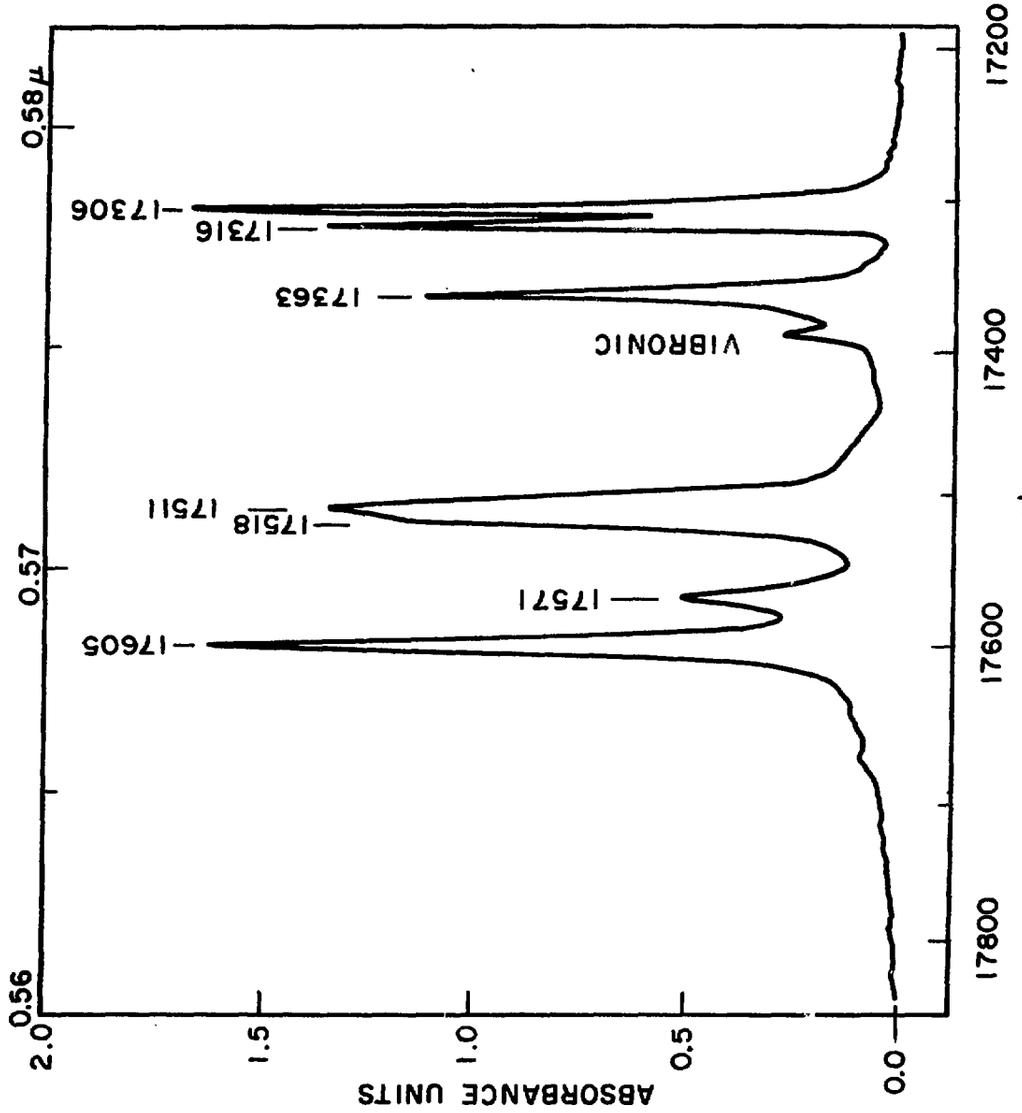

Fig. 8. D Group ($^4G_{7/2} + {}^4G_{5/2}$)

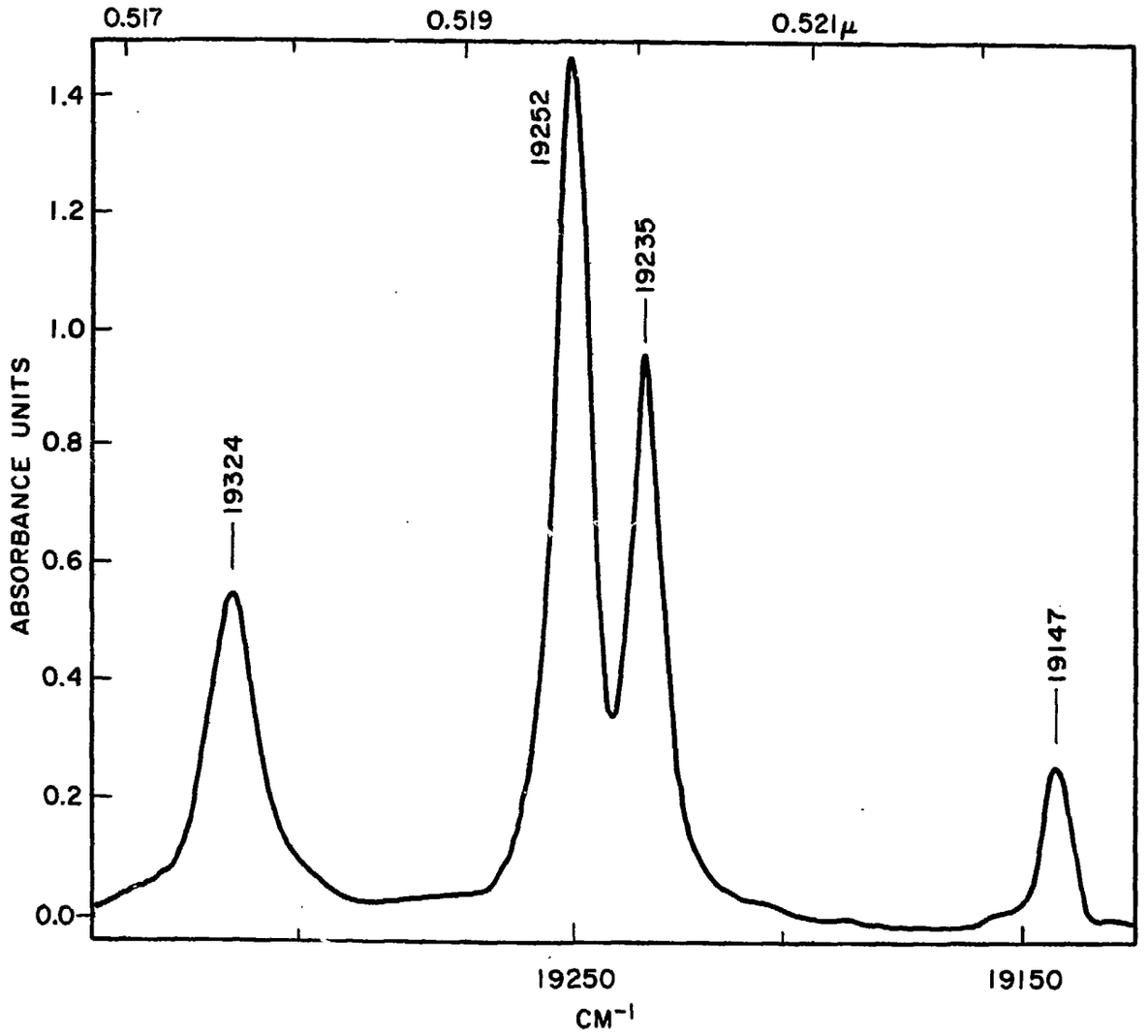

Fig. 9. E Group ($^4G_{7/2}$)

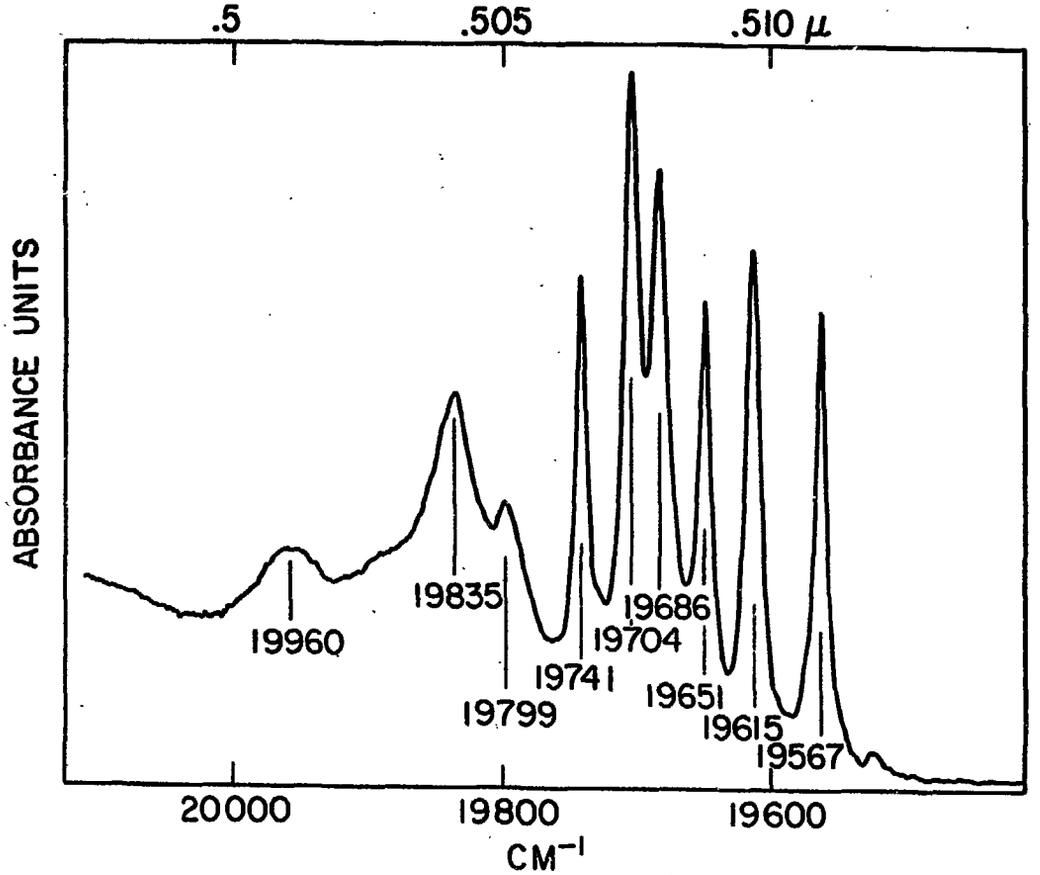

Fig. 10. F Group ($^2K_{13/2} + {}^4G_{9/2}$)

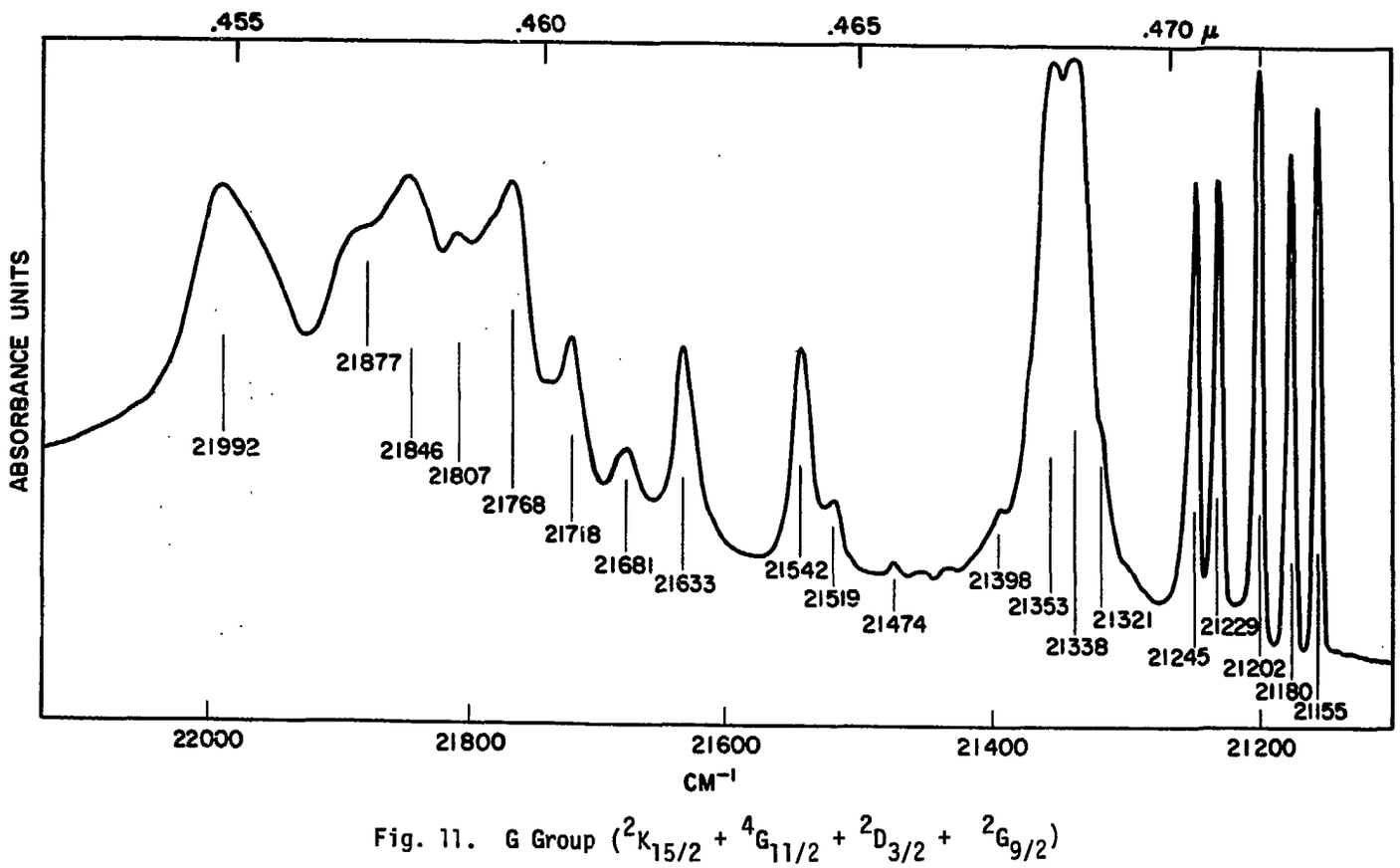

Fig. 11. G Group ($^2K_{15/2} + {}^4G_{11/2} + {}^2D_{3/2} + {}^2G_{9/2}$)

0.06 0.415 0.416 0.417 0.418

7

3/2 13691 11/2 16105 0.0 0.0563 0.0016

5/2	12660	9/2	12768	0.0062	0.0308	0.0052

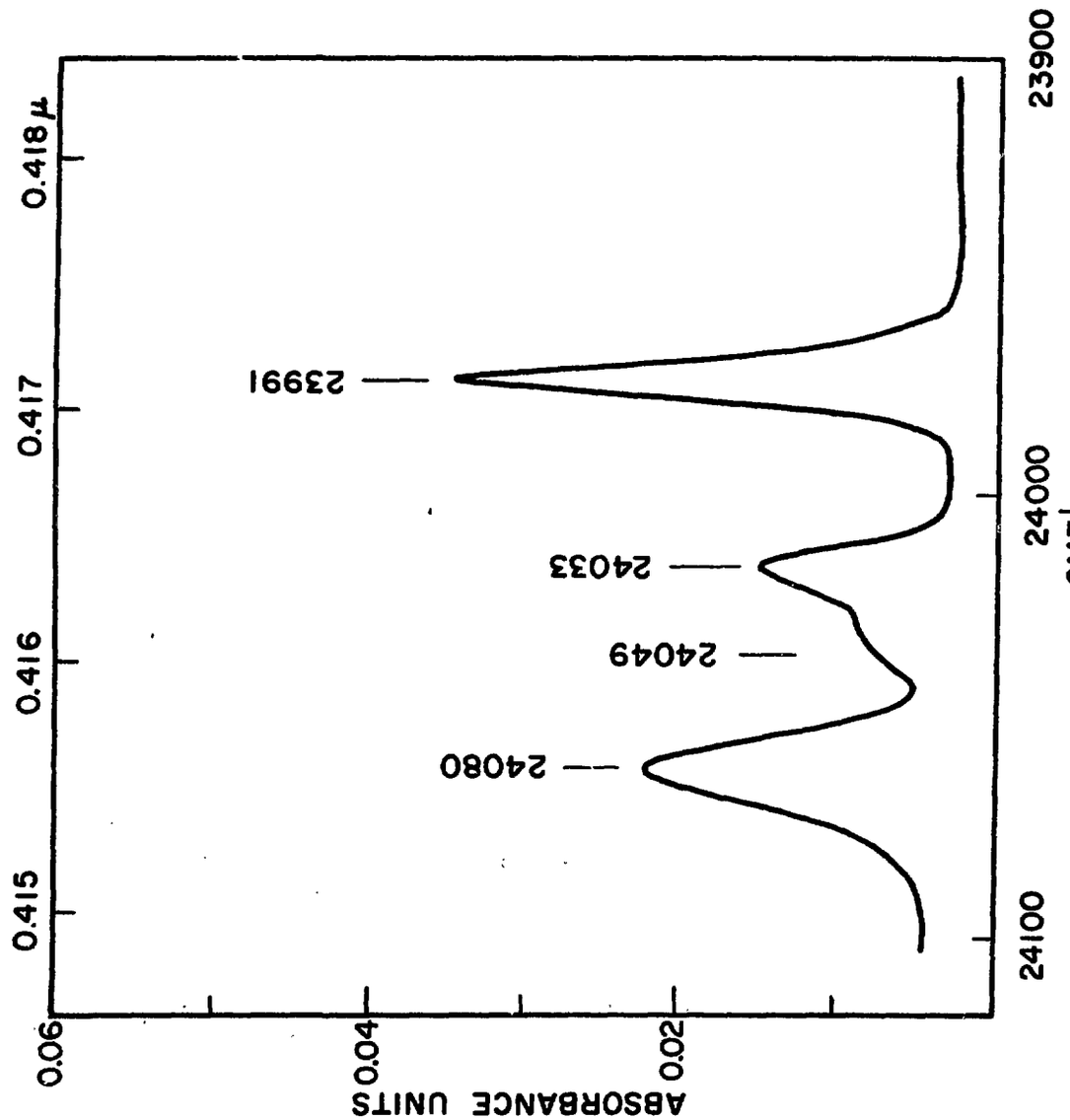

Fig. 12. I Group ($^2D_{5/2} + {}^2P_{1/2}$)

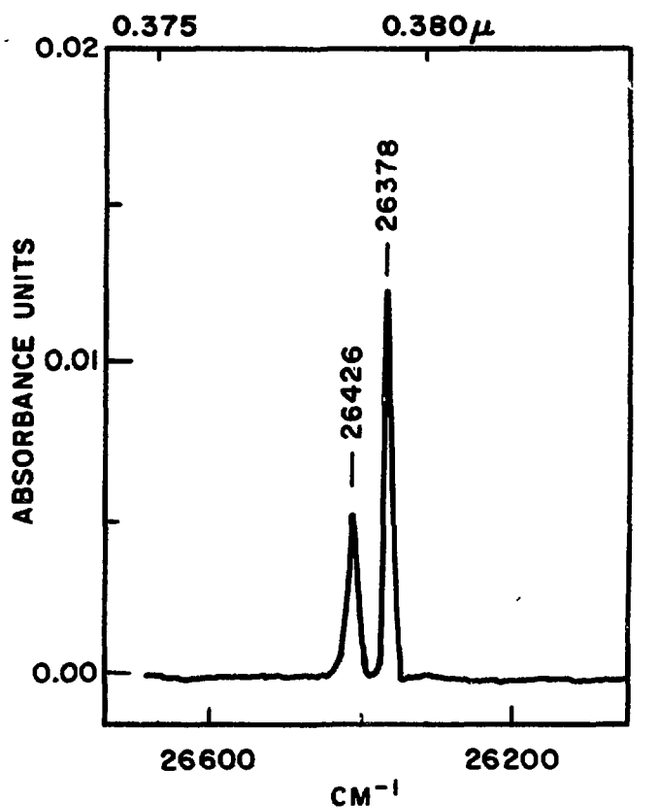

Fig. 13. K Group ($^2P_{3/2}$)

9/2	12768	9/2	19709	0.0390	0.0478	0.0982
9/2	12768	11/2	2114	0.0028	0.0004	0.0254

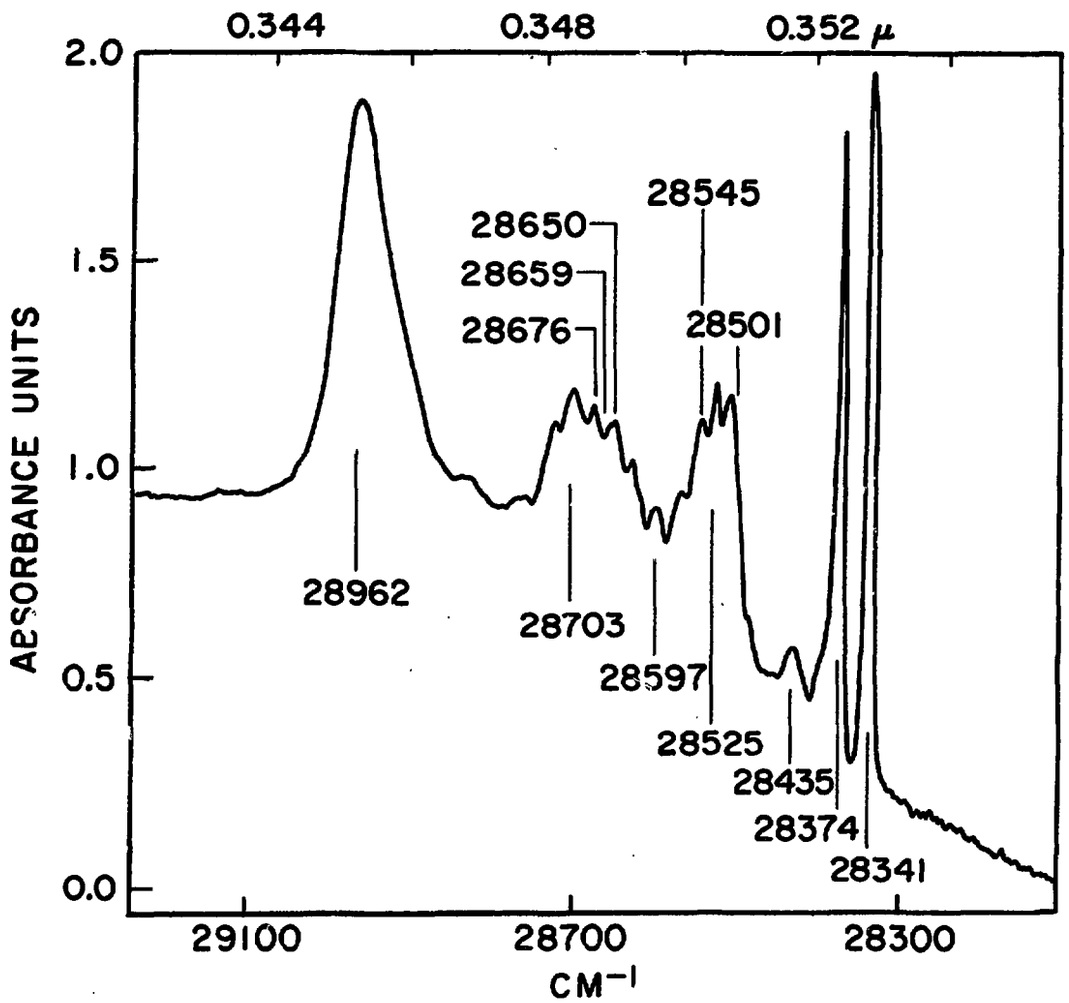

Fig. 14. L Group ($^4D_{1/2}$ + $^4D_{5/2}$ + $^4D_{3/2}$)

		13/2	4098	0.1693	0.1729	0.2331
13/2	4098	13/2	19785	0.0032	0.0001	0.0024
13/2	4098	15/2	6148	0.0195	0.1187	1.4522

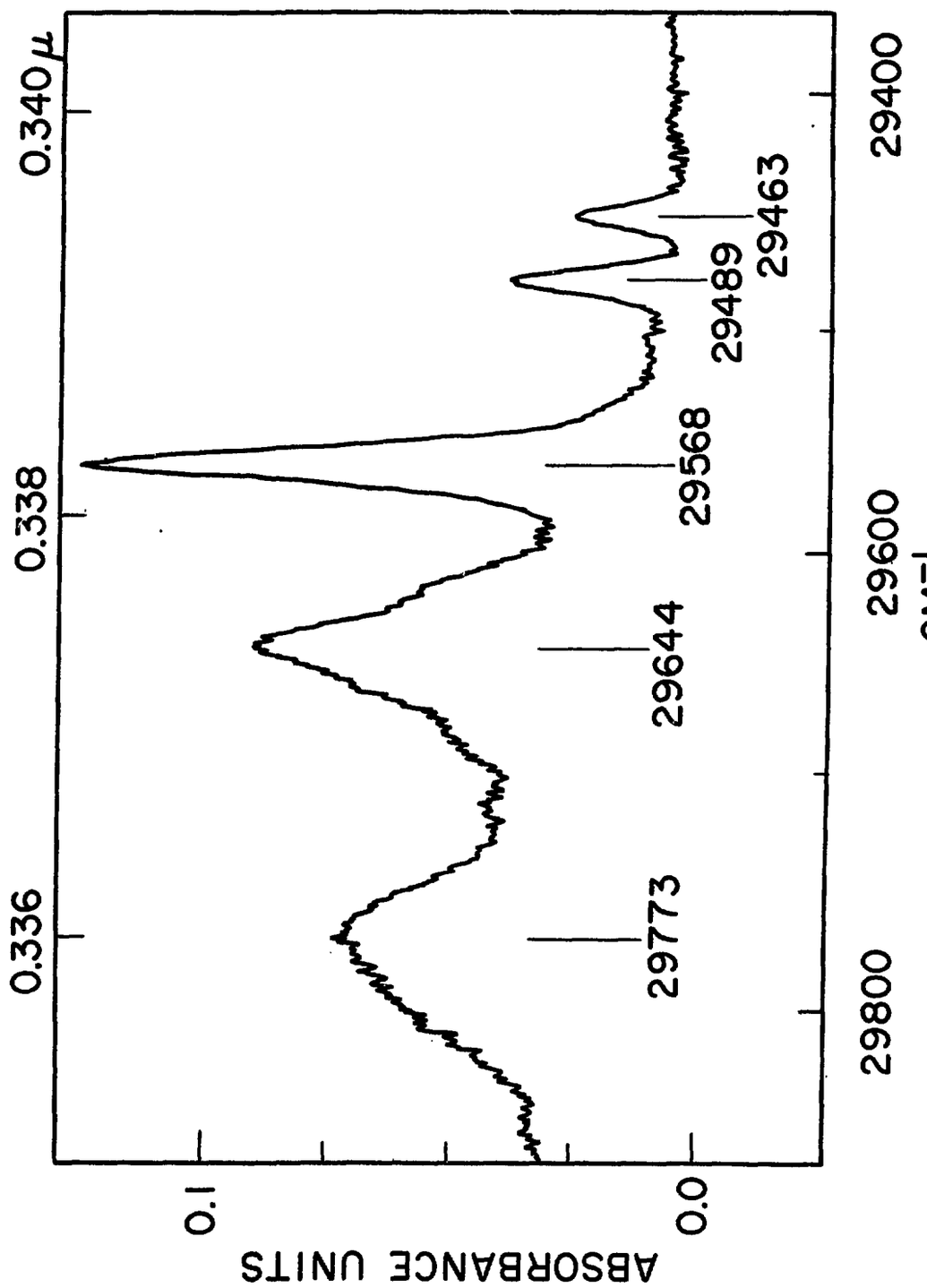

Fig. 15. L. Group ($^2I_{11/2}$)

		/	4098	0.1693	0.1729	0.2551
13/2	4098	13/2	19785	0.0032	0.0001	0.0024
13/2	4098	15/2	6148	0.0195	0.1187	1.4522

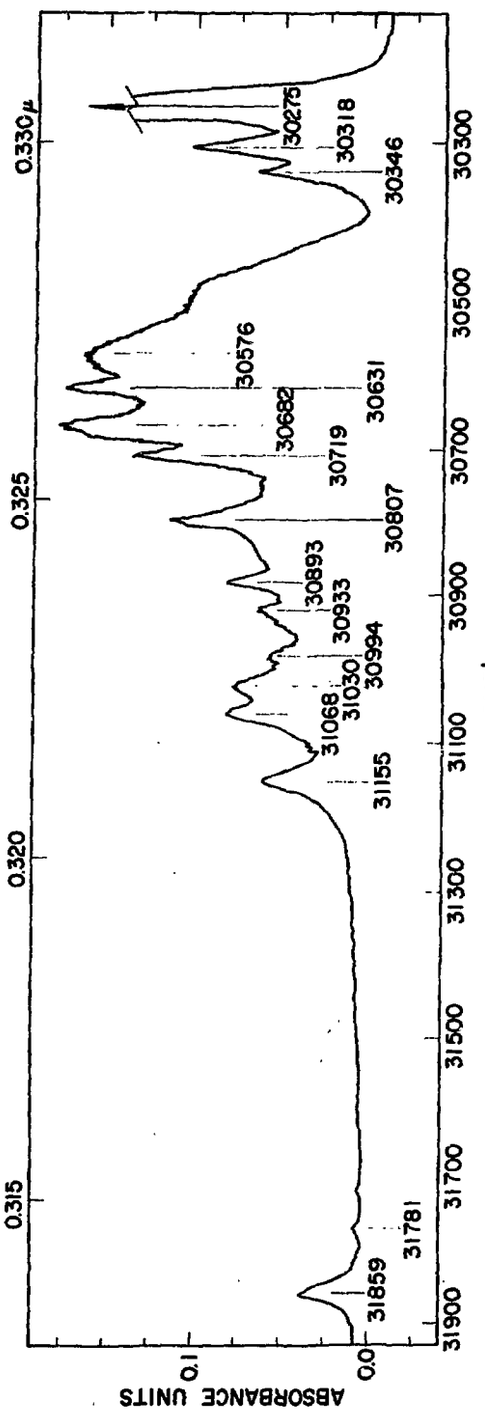

Fig. 16. O,N,M Groups ($^2L_{17/2} + {}^2I_{13/2} + {}^4D_{7/2} + {}^2L_{15/2}$)

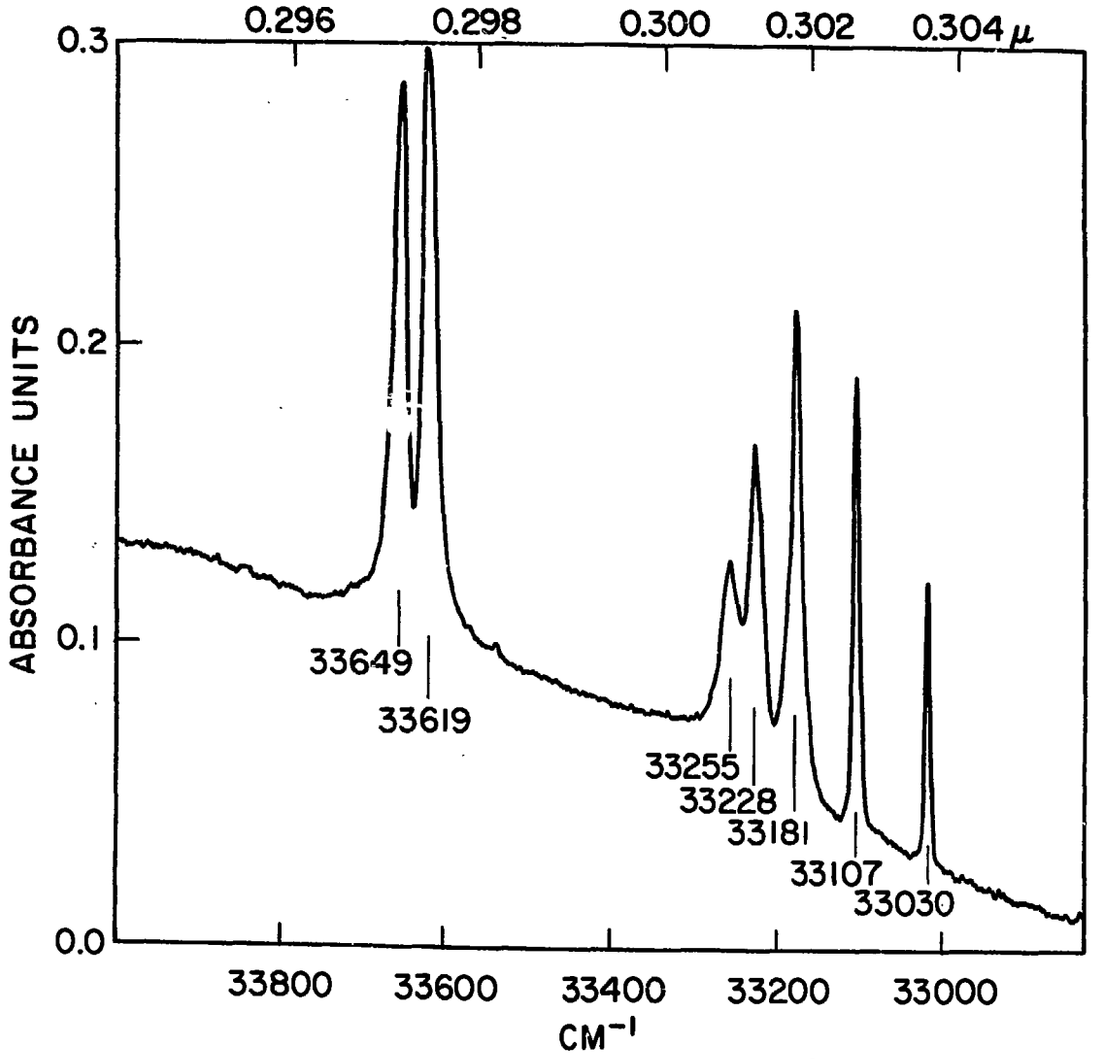

Fig. 17. Q and P Groups ($^2D'_{3/2} + {}^2H'_{9/2}$)

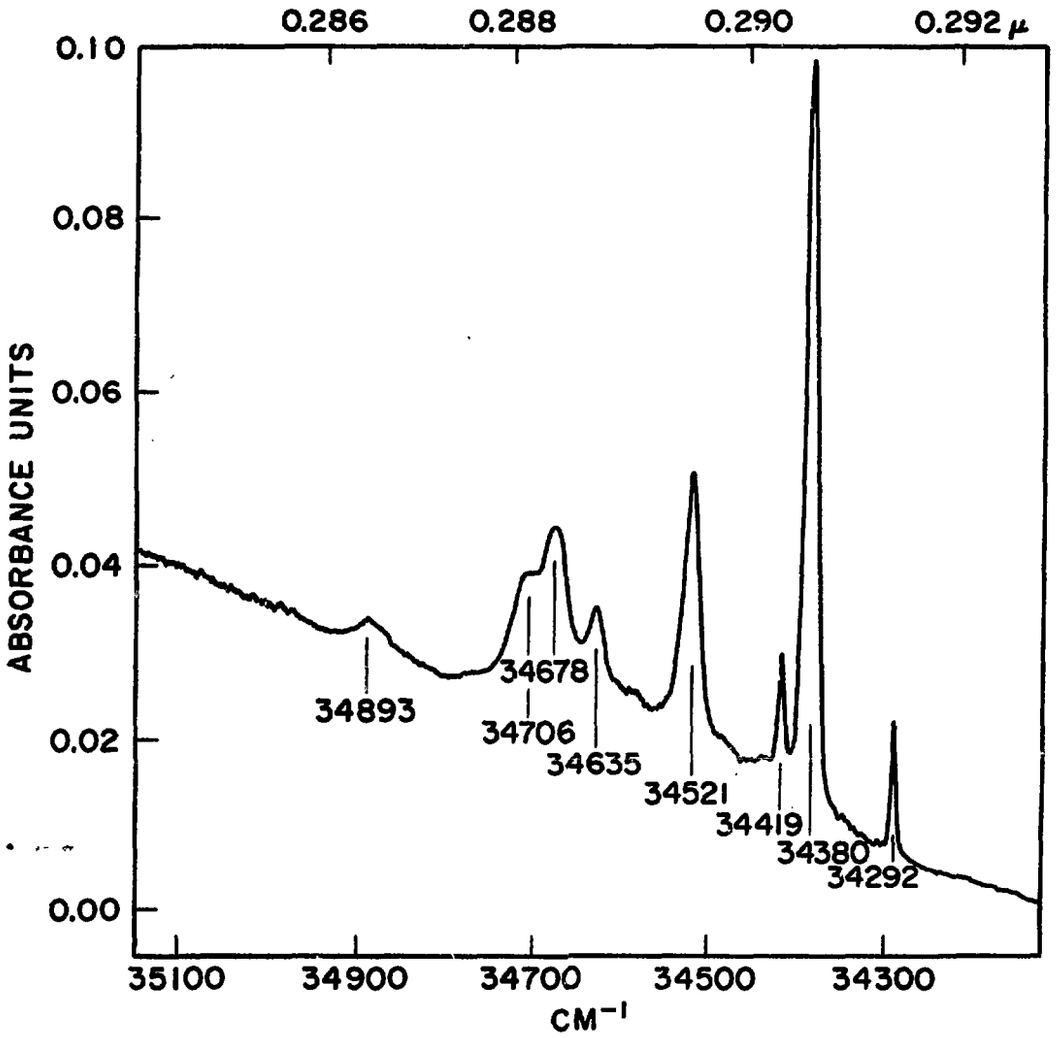

Fig. 18. R' Group ($^2H'_{11/2} + {}^2D'_{5/2}$)

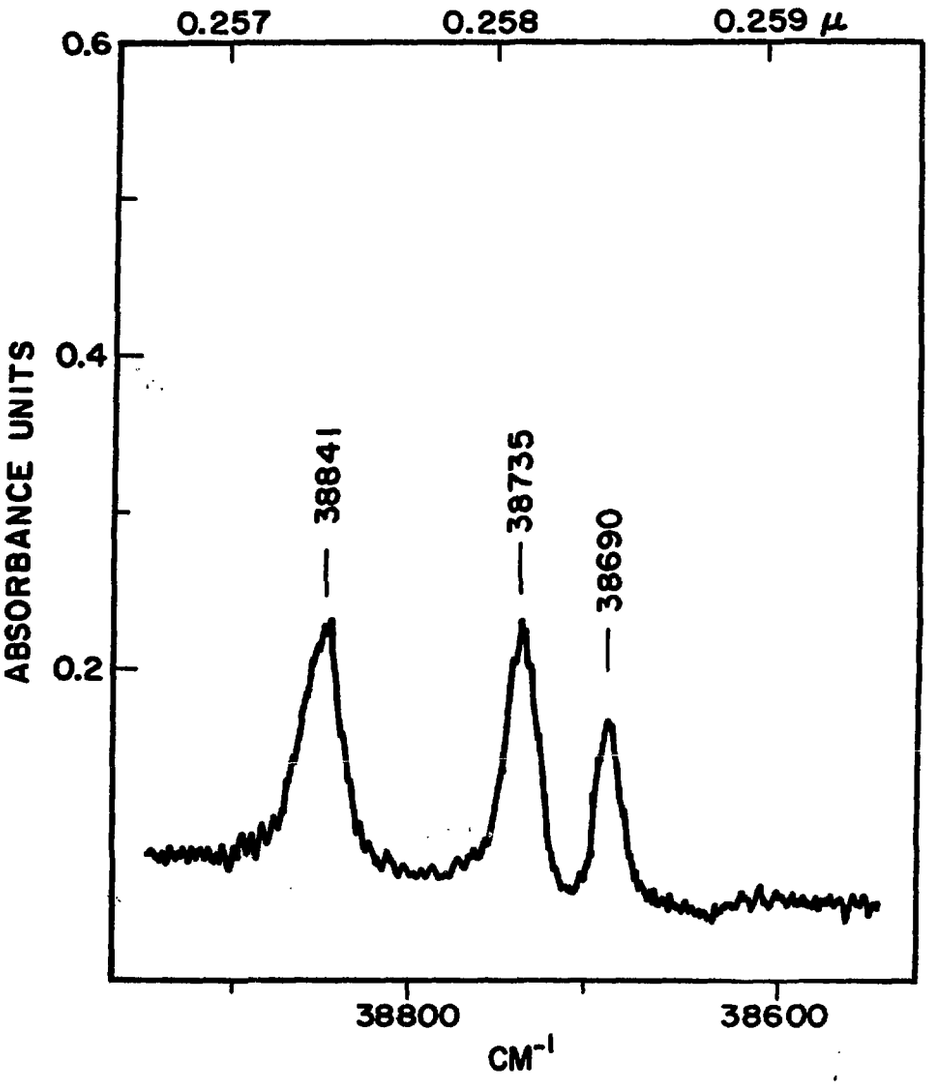

Fig. 19. T Group ($^2F_{5/2}$)

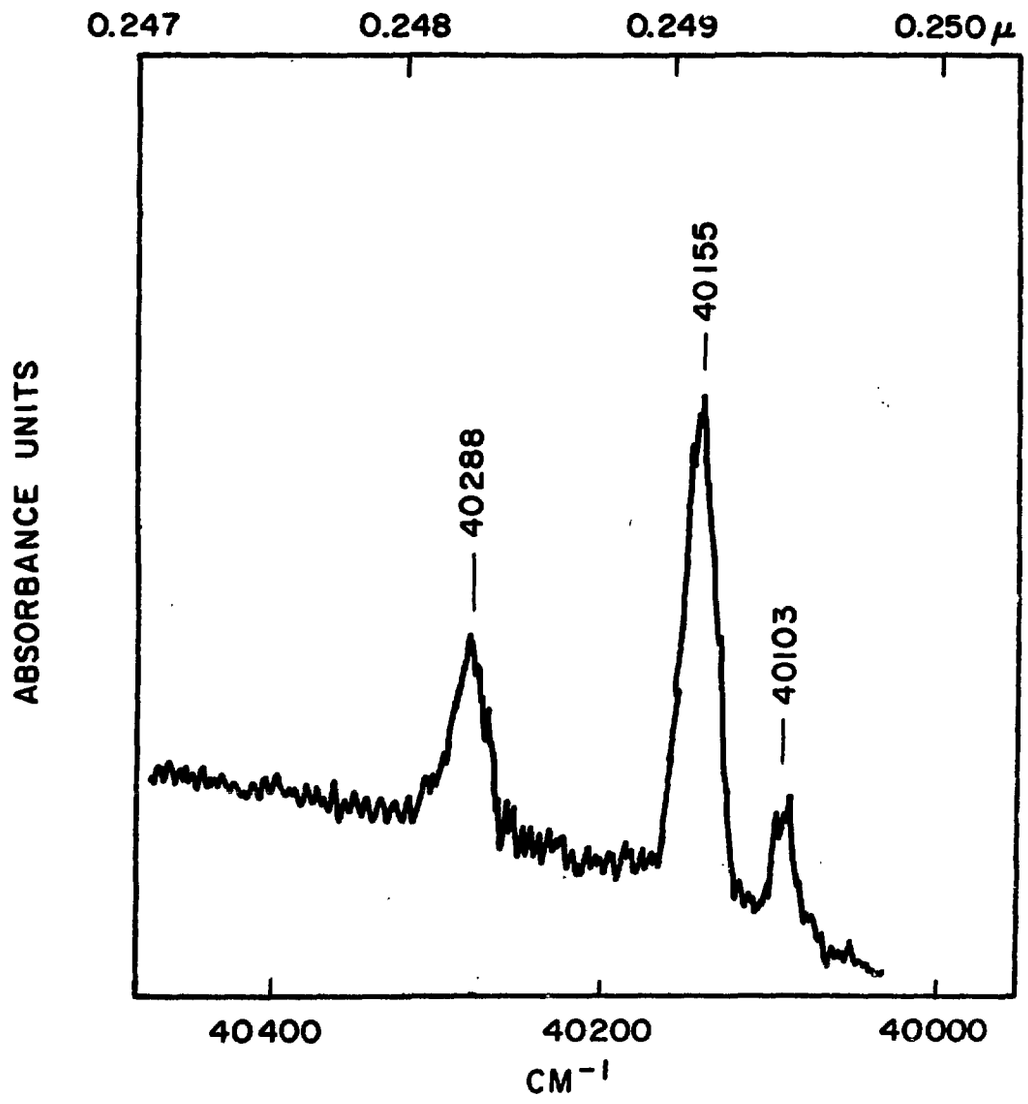

Fig. 20. U Group ($^2F_{7/2}$)

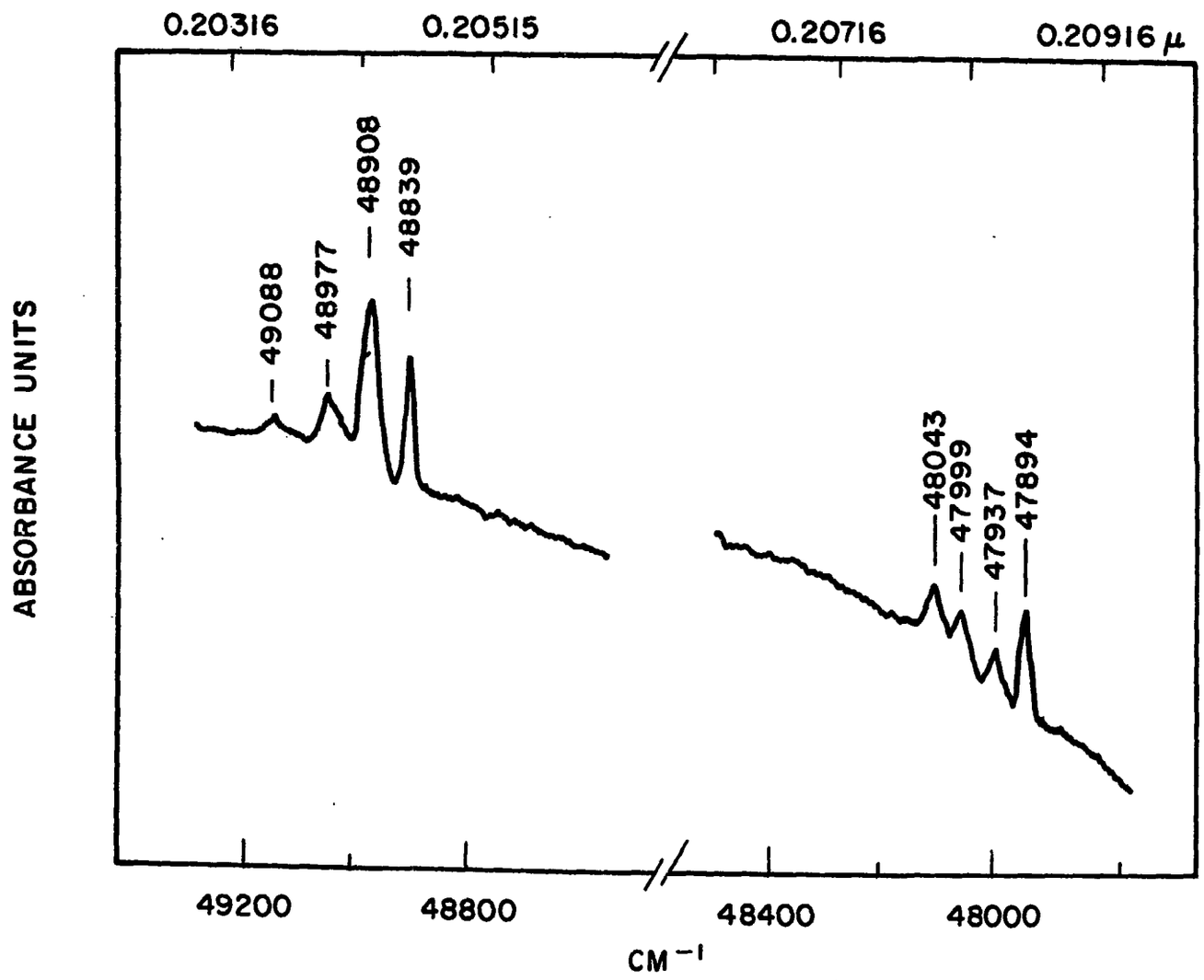

Fig. 21. $^2G_{7/2}$ and $^2G_{9/2}$ Groups

APPENDIX V

APPENDIX V

TABLE 1
PM+3:LAF3 CENTERS OF GRAVITY

OBSERVED	CALC	O-C	STATE
...	120	...	5I4
...	1612	...	5I5
...	3239	...	5I6
...	4951	...	5I7
...	6714	...	5I8
...	12638	...	5F1
...	13080	...	5F2
...	13933	...	5F3
...	14486	...	5S2
...	14887	...	5F4
...	16223	...	5F5
...	16939	...	3K6
...	18053	...	5G2
...	18075	...	3H4
...	18255	...	3K7
...	18565	...	5G3
...	19862	...	3K8
...	20307	...	3H5
...	20554	...	5G4
...	21935	...	3G3
...	22475	...	5G5
...	22807	...	5G6
...	23140	...	3D2
...	23772	...	3L7
...	24216	...	3P1
...	24702	...	3H6
...	24840	...	3G4
...	24907	...	3L8
...	25811	...	3P0
...	25895	...	3D3
...	25907	...	3L9

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TABLE 2
U(K)*2 FOR PM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
0	25810	2	23142	0.0054	0.0	0.0
0	25810	4	14882	0.0	0.0019	0.0
0	25810	4	18083	0.0	0.0142	0.0
0	25810	6	3247	0.0	0.0	0.0037
0	25810	6	16957	0.0	0.0	0.0820
0	25810	6	22787	0.0	0.0	0.0168
1	12658	1	12658	0.0268	0.0	0.0
1	12658	2	13094	0.0529	0.0	0.0
1	12658	2	18070	0.2682	0.0	0.0
1	12658	2	23142	0.0032	0.0	0.0
1	12658	3	13939	0.0177	0.0641	0.0
1	12658	3	18577	0.1965	0.0469	0.0
1	12658	3	21946	0.0225	0.0105	0.0
1	12658	4	161	0.0	0.1405	0.0
1	12658	4	14882	0.0	0.0322	0.0
1	12658	4	18083	0.0	0.0277	0.0
1	12658	4	20565	0.0	0.0604	0.0
1	12658	5	1639	0.0	0.1532	0.1544
1	12658	5	16208	0.0	0.0016	0.1303
1	12658	5	20303	0.0	0.0090	0.0462
1	12658	5	22476	0.0	0.0066	0.0856
1	12658	6	3247	0.0	0.0	0.2986
1	12658	6	22787	0.0	0.0	0.0303
1	12658	7	4937	0.0	0.0	0.0680
1	12658	7	18258	0.0	0.0	0.0046
1	12658	7	23796	0.0	0.0	0.0016
1	24221	2	13094	0.0013	0.0	0.0
1	24221	2	18070	0.0077	0.0	0.0
1	24221	2	23142	0.0082	0.0	0.0
1	24221	3	18577	0.0100	0.0101	0.0
1	24221	3	21946	0.0539	0.0537	0.0
1	24221	4	18083	0.0	0.0137	0.0
1	24221	4	20565	0.0	0.0236	0.0
1	24221	5	1639	0.0	0.0047	0.0132
1	24221	5	20303	0.0	0.0402	0.0121
1	24221	5	22476	0.0	0.0340	0.0054
1	24221	6	3247	0.0	0.0	0.0049
1	24221	6	16957	0.0	0.0	0.0019
1	24221	6	22787	0.0	0.0	0.0654
1	24221	7	4937	0.0	0.0	0.0019
1	24221	7	18258	0.0	0.0	0.2964
2	13094	2	13094	0.0202	0.0794	0.0
2	13094	2	18070	0.2860	0.0722	0.0
2	13094	2	23142	0.0001	0.0011	0.0
2	13094	3	13939	0.0899	0.0003	0.0
2	13094	3	18577	0.1486	0.0370	0.0
2	13094	3	21946	0.0339	0.0127	0.0

TABLE 2
U(K)*2 FOR PM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
2	13094	4	161	0.0016	0.2042	0.1258
2	13094	4	14882	0.0385	0.0705	0.0537
2	13094	4	18083	0.0916	0.0097	0.0174
2	13094	4	20565	0.2071	0.0209	0.0929
2	13094	5	1639	0.0	0.0594	0.2878
2	13094	5	16208	0.0	0.0172	0.1467
2	13094	5	20303	0.0	0.0733	0.0135
2	13094	5	22476	0.0	0.0634	0.0125
2	13094	6	3247	0.0	0.2200	0.0825
2	13094	6	16957	0.0	0.0032	0.0033
2	13094	6	22787	0.0	0.0032	0.1147
2	13094	7	4937	0.0	0.0	0.3057
2	13094	8	6674	0.0	0.0	0.0743
2	13094	8	19845	0.0	0.0	0.0130
2	14486	2	18070	0.0030	0.1411	0.0
2	14486	3	18577	0.0033	0.2032	0.0
2	14486	3	21946	0.0000	0.0308	0.0
2	14486	4	161	0.0000	0.0011	0.2296
2	14486	4	18083	0.0003	0.0794	0.0003
2	14486	4	20565	0.0007	0.2059	0.0022
2	14486	5	1639	0.0	0.0000	0.1908
2	14486	5	16208	0.0	0.0035	0.0004
2	14486	5	20303	0.0	0.1422	0.0014
2	14486	5	22476	0.0	0.1509	0.0023
2	14486	6	3247	0.0	0.0023	0.2394
2	14486	6	22787	0.0	0.3099	0.0037
2	14486	7	4937	0.0	0.0	0.3683
2	14486	8	6674	0.0	0.0	0.3463
2	18070	2	18070	0.0011	0.0345	0.0
2	18070	2	23142	0.0035	0.0013	0.0
2	18070	3	13939	0.0610	0.1119	0.0
2	18070	3	18577	0.0013	0.2434	0.0
2	18070	3	21946	0.0013	0.0203	0.0
2	18070	4	161	0.7293	0.2412	0.0049
2	18070	4	14882	0.0024	0.0212	0.2000
2	18070	4	18083	0.0006	0.1209	0.0081
2	18070	4	20565	0.0027	0.1409	0.1133
2	18070	5	1639	0.0	0.2702	0.0407
2	18070	5	16208	0.0	0.0003	0.0988
2	18070	5	20303	0.0	0.0365	0.0802
2	18070	5	22476	0.0	0.0235	0.0923
2	18070	6	3247	0.0	0.0372	0.0781
2	18070	6	22787	0.0	0.0008	0.0203
2	18070	7	4937	0.0	0.0	0.0203
2	18070	7	18258	0.0	0.0	0.0097
2	18070	7	23796	0.0	0.0	0.0158
2	18070	8	6674	0.0	0.0	0.0013
2	18070	8	19845	0.0	0.0	0.0111

APPENDIX V

TABLE 2
U(K)*2 FOR PM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
2	23142	2	23142	0.0521	0.0830	0.0
2	23142	3	13939	0.0104	0.0000	0.0
2	23142	3	18577	0.0161	0.0078	0.0
2	23142	3	21946	0.0002	0.0066	0.0
2	23142	4	161	0.0044	0.0020	0.0025
2	23142	4	14882	0.0010	0.0045	0.0024
2	23142	4	18083	0.0878	0.0791	0.0127
2	23142	4	20565	0.0067	0.0412	0.0000
2	23142	5	1639	0.0	0.0003	0.0342
2	23142	5	16208	0.0	0.0003	0.0009
2	23142	5	20303	0.0	0.0201	0.1329
2	23142	5	22476	0.0	0.0670	0.0927
2	23142	6	3247	0.0	0.0197	0.0184
2	23142	6	16957	0.0	0.0081	0.0723
2	23142	6	22787	0.0	0.0331	0.0647
2	23142	7	18258	0.0	0.0	0.0126
2	23142	7	23796	0.0	0.0	0.0137
2	23142	8	19845	0.0	0.0	0.4641
3	13939	3	13939	0.0221	0.0589	0.0409
3	13939	3	18577	0.3740	0.0415	0.1223
3	13939	3	21946	0.0344	0.0007	0.0344
3	13939	4	161	0.0001	0.1079	0.4226
3	13939	4	14882	0.1295	0.0349	0.1135
3	13939	4	18083	0.0407	0.0007	0.0040
3	13939	4	20565	0.2248	0.0379	0.0316
3	13939	5	1639	0.0000	0.2429	0.0260
3	13939	5	16208	0.0285	0.0673	0.0810
3	13939	5	20303	0.1819	0.0928	0.0285
3	13939	5	22476	0.1560	0.0595	0.0110
3	13939	6	3247	0.0	0.0777	0.2099
3	13939	6	16957	0.0	0.0056	0.0012
3	13939	6	22787	0.0	0.0727	0.1761
3	13939	7	4937	0.0	0.2488	0.2551
3	13939	7	18258	0.0	0.0046	0.0032
3	13939	7	23796	0.0	0.0008	0.0008
3	13939	8	6674	0.0	0.0	0.3326
3	13939	9	25888	0.0	0.0	0.0094
3	18577	3	18577	0.0000	0.0471	0.0876
3	18577	3	21946	0.0070	0.0000	0.0579
3	18577	4	161	0.1538	0.2855	0.0512
3	18577	4	14882	0.0623	0.0792	0.0156
3	18577	4	18083	0.0184	0.1197	0.0002
3	18577	4	20565	0.0048	0.0922	0.0570
3	18577	5	1639	0.7098	0.0276	0.0173
3	18577	5	16208	0.0011	0.0032	0.2212
3	18577	5	20303	0.0000	0.1907	0.0910
3	18577	5	22476	0.0020	0.0568	0.0397

APPENDIX V

TABLE 2
U(K)*2 FOR PM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
3	18577	6	3247	0.0	0.3298	0.0388
3	18577	6	16957	0.0	0.0008	0.0073
3	18577	6	22787	0.0	0.0238	0.1178
3	18577	7	4937	0.0	0.0533	0.0611
3	18577	7	18258	0.0	0.0245	0.0070
3	18577	7	23796	0.0	0.0606	0.0088
3	18577	8	6674	0.0	0.0	0.0048
3	18577	8	19845	0.0	0.0	0.0105
3	18577	9	25888	0.0	0.0	0.0362
3	21946	3	21946	0.1057	0.0228	0.0094
3	21946	4	161	0.0137	0.0428	0.0056
3	21946	4	14882	0.0108	0.0269	0.0000
3	21946	4	18083	0.0298	0.0264	0.1162
3	21946	4	20565	0.0495	0.1601	0.0046
3	21946	5	1639	0.1623	0.0314	0.0201
3	21946	5	16208	0.0004	0.0100	0.0106
3	21946	5	20303	0.0042	0.0005	0.0163
3	21946	5	22476	0.0224	0.1341	0.0825
3	21946	6	3247	0.0	0.0422	0.0003
3	21946	6	16957	0.0	0.0189	0.0498
3	21946	6	22787	0.0	0.0022	0.0097
3	21946	7	4937	0.0	0.0048	0.0174
3	21946	7	18258	0.0	0.0806	0.0310
3	21946	7	23796	0.0	0.2660	0.1614
3	21946	8	6674	0.0	0.0	0.0086
3	21946	8	19845	0.0	0.0	0.0026
3	21946	9	25888	0.0	0.0	0.0110
4	161	4	161	0.1156	0.1393	0.3495
4	161	4	14882	0.0004	0.0290	0.2400
4	161	4	18083	0.0079	0.0313	0.0278
4	161	4	20565	0.0081	0.0883	0.0764
4	161	5	1639	0.0247	0.1172	0.9702
4	161	5	16208	0.0000	0.0020	0.0341
4	161	5	20303	0.0001	0.0079	0.0102
4	161	5	22476	0.0002	0.0082	0.0330
4	161	6	3247	0.0017	0.0300	0.6891
4	161	6	16957	0.0021	0.0023	0.0101
4	161	6	22787	0.0000	0.0003	0.0016
4	161	7	4937	0.0	0.0024	0.1573
4	161	7	18258	0.0	0.0018	0.0191
4	161	7	23796	0.0	0.0014	0.0095
4	161	8	6674	0.0	0.0000	0.0101
4	161	8	19845	0.0	0.0002	0.0080
4	161	9	25888	0.0	0.0	0.0017
4	14882	4	14882	0.0180	0.0000	0.0693
4	14882	4	18083	0.2226	0.1179	0.0453
4	14882	4	20565	0.2695	0.0467	0.0319

APPENDIX V

TABLE 2
U(K)*2 FOR PM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
4	14882	5	1639	0.0025	0.1468	0.3679
4	14882	5	16208	0.1380	0.1409	0.0143
4	14882	5	20303	0.2552	0.0213	0.1351
4	14882	5	22476	0.3371	0.0000	0.0587
4	14882	6	3247	0.0056	0.2931	0.0830
4	14882	6	16957	0.0009	0.0003	0.0158
4	14882	6	22787	0.2040	0.2208	0.0915
4	14882	7	4937	0.0	0.1589	0.0239
4	14882	7	18258	0.0	0.0254	0.0257
4	14882	7	23796	0.0	0.0012	0.0137
4	14882	8	6674	0.0	0.2025	0.7232
4	14882	8	19845	0.0	0.0118	0.0050
4	14882	9	25888	0.0	0.0	0.0186
4	14882	10	30230	0.0	0.0	0.0041
4	18083	4	18083	0.0771	0.2855	0.0396
4	18083	4	20565	0.1287	0.0925	0.0303
4	18083	5	1639	0.0515	0.0449	0.0979
4	18083	5	16208	0.0245	0.0025	0.0946
4	18083	5	20303	0.0017	0.0122	0.0196
4	18083	5	22476	0.0302	0.0744	0.0689
4	18083	6	3247	0.2166	0.0001	0.0000
4	18083	6	16957	0.0285	0.0400	0.3893
4	18083	6	22787	0.0146	0.0133	0.1606
4	18083	7	4937	0.0	0.1903	0.0493
4	18083	7	18258	0.0	0.0617	0.7751
4	18083	7	23796	0.0	0.0783	0.1901
4	18083	8	6674	0.0	0.0249	0.0004
4	18083	8	19845	0.0	0.0652	0.4024
4	18083	9	25888	0.0	0.0	0.0095
4	18083	10	30230	0.0	0.0	0.0141
4	20565	4	20565	0.0129	0.0744	0.0520
4	20565	5	1639	0.1773	0.2720	0.0052
4	20565	5	16208	0.0263	0.0356	0.1679
4	20565	5	20303	0.0072	0.2639	0.0065
4	20565	5	22476	0.0011	0.0804	0.0116
4	20565	6	3247	0.7627	0.0506	0.0159
4	20565	6	16957	0.0256	0.0257	0.2629
4	20565	6	22787	0.0000	0.1290	0.1574
4	20565	7	4937	0.0	0.3106	0.0353
4	20565	7	18258	0.0	0.0247	0.3475
4	20565	7	23796	0.0	0.0106	0.0662
4	20565	8	6674	0.0	0.0252	0.0325
4	20565	8	19845	0.0	0.0001	0.1090
4	20565	9	25888	0.0	0.0	0.0498
4	20565	10	30230	0.0	0.0	0.0097
5	1639	5	1639	0.1078	0.0498	0.0514
5	1639	5	16208	0.0003	0.0229	0.1551

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TABLE 2
U(K)*2 FOR PM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
5	1639	5	20303	0.0120	0.0673	0.0867
5	1639	5	22476	0.0072	0.0792	0.0376
5	1639	6	3247	0.0352	0.1378	0.7160
5	1639	6	16957	0.0000	0.0016	0.0219
5	1639	6	22787	0.0001	0.0096	0.0181
5	1639	7	4937	0.0023	0.0372	0.7862
5	1639	7	18258	0.0003	0.0003	0.0024
5	1639	7	23796	0.0014	0.0002	0.0088
5	1639	8	6674	0.0	0.0018	0.1248
5	1639	8	19845	0.0	0.0004	0.0034
5	1639	9	25888	0.0	0.0014	0.0093
5	1639	10	30230	0.0	0.0	0.0010
5	16208	5	16208	0.1448	0.1799	0.0011
5	16208	5	20303	0.2912	0.1071	0.0634
5	16208	5	22476	0.1431	0.0674	0.0828
5	16208	6	3247	0.0027	0.1118	0.3966
5	16208	6	16957	0.0000	0.0000	0.0123
5	16208	6	22787	1.0815	0.2777	0.0181
5	16208	7	4937	0.0100	0.3247	0.6748
5	16208	7	18258	0.0003	0.0026	0.0069
5	16208	7	23796	0.0000	0.0003	0.0135
5	16208	8	6674	0.0	0.5368	0.5927
5	16208	8	19845	0.0	0.0305	0.0032
5	16208	9	25888	0.0	0.0152	0.0013
5	16208	10	30230	0.0	0.0	0.0516
5	20303	5	20303	0.0199	0.0479	0.0891
5	20303	5	22476	0.1368	0.2224	0.0646
5	20303	6	3247	0.1014	0.1560	0.1462
5	20303	6	16957	0.0009	0.0044	0.2903
5	20303	6	22787	0.0276	0.1058	0.2984
5	20303	7	4937	0.5669	0.0540	0.0186
5	20303	7	18258	0.0092	0.0097	0.0397
5	20303	7	23796	0.0000	0.0311	0.3041
5	20303	8	6674	0.0	0.3415	0.0394
5	20303	8	19845	0.0	0.0226	0.5626
5	20303	9	25888	0.0	0.1405	0.2378
5	20303	10	30230	0.0	0.0	0.0220
5	22476	5	22476	0.0557	0.0445	0.0226
5	22476	6	3247	0.1377	0.2552	0.0060
5	22476	6	16957	0.0024	0.0078	0.3494
5	22476	6	22787	0.0019	0.3339	0.0775
5	22476	7	4937	0.7352	0.1535	0.0029
5	22476	7	18258	0.0388	0.0216	0.0780
5	22476	7	23796	0.0005	0.0230	0.2824
5	22476	8	6674	0.0	0.1888	0.0431
5	22476	8	19845	0.0	0.0418	0.4974
5	22476	9	25888	0.0	0.0243	0.2139

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TABLE 2
U(K)*2 FOR PM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
5	22476	10	30230	0.0	0.0	0.0109
6	3247	6	3247	0.1216	0.0542	0.0562
6	3247	6	16957	0.0017	0.0006	0.0005
6	3247	6	22787	0.0099	0.0851	0.0846
6	3247	7	4937	0.0365	0.1528	1.0211
6	3247	7	18258	0.0001	0.0043	0.0342
6	3247	7	23796	0.0013	0.0001	0.0000
6	3247	8	6674	0.0014	0.0243	0.6224
6	3247	8	19845	0.0000	0.0001	0.0109
6	3247	10	30230	0.0	0.0033	0.0024
6	16957	6	16957	0.0139	0.0064	0.0000
6	16957	6	22787	0.0000	0.0000	0.0299
6	16957	7	4937	0.0000	0.0014	0.0072
6	16957	7	18258	0.0404	0.0227	0.0953
6	16957	7	23796	0.1936	0.1151	1.1523
6	16957	8	6674	0.0000	0.0000	0.0046
6	16957	8	19845	0.0001	0.0182	0.1470
6	16957	9	25888	0.0	0.0046	0.2582
6	16957	10	30230	0.0	0.0000	0.0159
6	22787	6	22787	0.0144	0.2478	0.1907
6	22787	7	4937	0.1320	0.3648	0.1818
6	22787	7	18258	0.0000	0.0000	0.1099
6	22787	7	23796	0.0000	0.0006	0.0551
6	22787	8	6674	1.3628	0.7629	0.1495
6	22787	8	19845	0.0003	0.0000	0.1212
6	22787	9	25888	0.0	0.0459	0.1545
6	22787	10	30230	0.0	0.0617	0.1374
7	4937	7	4937	0.1535	0.1225	0.0331
7	4937	7	18258	0.0072	0.0026	0.0000
7	4937	7	23796	0.0000	0.0005	0.0116
7	4937	8	6674	0.0266	0.1363	1.5529
7	4937	8	19845	0.0004	0.0085	0.0488
7	4937	9	25888	0.0009	0.0030	0.0325
7	4937	10	30230	0.0	0.0005	0.0044
7	18258	7	18258	0.0793	0.0054	0.3551
7	18258	7	23796	0.0840	0.0351	0.5325
7	18258	8	6674	0.0000	0.0036	0.0181
7	18258	8	19845	0.0521	0.0806	0.0000
7	18258	9	25888	0.0000	0.0388	1.2992
7	18258	10	30230	0.0	0.0168	0.3257
7	23796	7	23796	0.3401	0.7310	0.0033
7	23796	8	6674	0.0000	0.0000	0.0087
7	23796	8	19845	0.0001	0.0476	0.0645
7	23796	9	25888	0.0010	0.1302	0.0867

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TABLE 2
U(K)*2 FOR PM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
7	23796	10	30230	0.0	0.0215	0.0057
8	6674	8	6674	0.2065	0.3366	1.6741
8	6674	8	19845	0.0174	0.0094	0.0251
8	6674	9	25888	0.0082	0.0156	0.0321
8	6674	10	30230	0.0000	0.0354	0.0577
8	19845	8	19845	0.1402	0.0056	0.3464
8	19845	9	25888	0.1942	0.5884	0.6729
8	19845	10	30230	0.0000	0.5142	1.5495
9	25888	9	25888	1.3240	0.1557	0.4892
9	25888	10	30230	0.3074	1.2875	1.3587
10	30230	10	30230	3.3000	0.0004	1.5336

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APPENDIX VI

TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
0	-1	2	6H	5/2	3/2
48	52	-3	6H	5/2	1/2
115	126	-10	6H	5/2	5/2
1000	1000	0	6H	7/2	1/2
1044	1017	27	6H	7/2	5/2
1185	1203	-17	6H	7/2	-7/2
1280	1258	22	6H	7/2	3/2
2210	2191	19	6H	9/2	1/2
2245	2236	9	6H	9/2	-7/2
2343	2335	7	6H	9/2	-9/2
2409	2408	1	6H	9/2	3/2
2473	2461	12	6H	9/2	5/2
3520	3529	-8	6H	11/2	1/2
3568	3531	37	6H	11/2	-9/2
3651	3651	0	6H	11/2	-7/2
3676	3658	18	6H	11/2	3/2
3727	3731	-3	6H	11/2	-11/2
3791	3794	-2	6H	11/2	5/2
4972	4971	1	6H	13/2	-11/2
4983	4995	-11	6H	13/2	3/2
5007	5006	1	6H	13/2	1/2
5046	5014	32	6H	13/2	5/2
5056	5038	18	6H	13/2	-9/2
5123	5116	7	6H	13/2	-7/2
5160	5183	-22	6H	13/2	13/2
6309	6299	10	6H	15/2	-7/2
6342	6335	7	6H	15/2	-9/2
6406	6417	-10	6F	1/2	1/2
6450	6464	-13	6H	15/2	5/2
6461	6493	-31	6H	15/2	-11/2
6567	6565	2	6H	15/2	3/2
6567	6580	-12	6F	3/2	1/2
...	6588	...	6H	15/2	15/2
...	6660	...	6H	15/2	-11/2
6691	6710	-18	6F	3/2	3/2
6707	6736	-28	6F	3/2	1/2
7176	7168	8	6F	5/2	1/2
7184	7179	5	6F	5/2	5/2
7223	7228	-4	6F	5/2	3/2

APPENDIX VI

TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
7992	7995	-2	6F	7/2	3/2
8041	8020	21	6F	7/2	-7/2
8060	8048	12	6F	7/2	1/2
8092	8096	-3	6F	7/2	5/2
9170	9170	0	6F	9/2	1/2
9178	9171	7	6F	9/2	-7/2
9228	9209	19	6F	9/2	-9/2
9252	9240	12	6F	9/2	3/2
9268	9268	0	6F	9/2	5/2
10561	10560	1	6F	11/2	-7/2
10584	10577	7	6F	11/2	-9/2
10593	10581	11	6F	11/2	5/2
10603	10616	-12	6F	11/2	-11/2
10613	10618	-4	6F	11/2	3/2
10644	10640	4	6F	11/2	1/2
17858	17874	-15	4G	5/2	1/2
17949	17969	-19	4G	5/2	5/2
18045	18077	-31	4G	5/2	3/2
18924	18921	3	6F	3/2	3/2
18942	18934	8	6F	3/2	1/2
20037	20050	-12	4G	7/2	1/2
20093	20094	0	4G	7/2	-7/2
20112	20120	-7	4G	7/2	3/2
20164	20159	5	4G	7/2	5/2
20416	20413	3	4M	15/2	-9/2
20473	20483	-9	4I	9/2	1/2
20499	20517	-17	4I	9/2	5/2
20526	20528	-1	4I	9/2	3/2
...	20541	...	4I	9/2	-7/2
...	20653	...	4M	15/2	-11/2
...	20790	...	4M	15/2	-7/2
...	20793	...	4M	15/2	13/2
...	20870	...	4M	15/2	5/2
...	20874	...	4M	15/2	-9/2
...	20909	...	4M	15/2	1/2
...	20916	...	4M	15/2	3/2
...	20941	...	4I	11/2	5/2
...	20987	...	4M	15/2	15/2
...	21103	...	4I	11/2	-11/2
...	21124	...	4I	11/2	3/2
...	21148	...	4I	11/2	-7/2
...	21249	...	4I	11/2	1/2
...	21272	...	4I	11/2	-9/2

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TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	21539	...	4I	13/2	-7/2
...	21607	...	4I	13/2	13/2
...	21623	...	4I	13/2	-9/2
21663	21638	25	4I	13/2	5/2
21674	21659	15	4I	13/2	-11/2
21706	21666	40	4I	13/2	1/2
21736	21681	55	4I	13/2	3/2
22164	22171	-6	4F	5/2	3/2
22207	22223	-15	4G	5/2	5/2
22240	22242	-1	4F	5/2	1/2
...	22486	...	4M	17/2	13/2
...	22539	...	4M	17/2	15/2
...	22546	...	4M	17/2	-11/2
...	22559	...	4M	17/2	-9/2
...	22570	...	4M	17/2	-7/2
...	22631	...	4M	17/2	5/2
...	22678	...	4M	17/2	3/2
...	22727	...	4M	17/2	1/2
...	22734	...	4M	17/2	17/2
...	22794	...	4G	9/2	-9/2
...	22816	...	4G	9/2	5/2
...	22854	...	4G	9/2	3/2
...	22902	...	4I	15/2	-11/2
...	22943	...	4G	9/2	-7/2
...	22981	...	4I	15/2	-11/2
...	23018	...	4I	15/2	-7/2
...	23025	...	4I	15/2	-9/2
...	23035	...	4I	15/2	13/2
...	23045	...	4I	15/2	5/2
...	23077	...	4I	15/2	3/2
...	23111	...	4I	15/2	1/2
...	23146	...	4I	15/2	15/2
...	23973	...	4M	19/2	15/2
...	24032	...	4M	19/2	13/2
...	24074	...	4M	19/2	17/2
24084	24079	5	4M	19/2	-11/2
...	24100	...	4M	19/2	-9/2
24119	24115	4	4M	19/2	-7/2
...	24118	...	6P	5/2	1/2
...	24140	...	6P	5/2	3/2
...	24147	...	4M	19/2	1/2
24153	24160	-6	4M	19/2	3/2
...	24165	...	6P	5/2	5/2
...	24172	...	4M	19/2	-19/2
...	24178	...	4M	19/2	5/2

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TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
24608	24620	-11	4L	13/2	1/2
24629	24640	-10	4L	13/2	3/2
24631	24641	-9	4L	13/2	13/2
24644	24659	-14	4L	13/2	-11/2
24678	24685	-6	4L	13/2	-7/2
24682	24693	-10	4L	13/2	5/2
24710	24724	-13	4L	13/2	-9/2
24911	24913	-1	4G	7/2	5/2
24993	24974	19	4F	7/2	3/2
25007	24997	10	4G	7/2	-7/2
25064	25055	9	6P	3/2	1/2
25081	25062	19	6P	3/2	3/2
...	25093	...	4F	7/2	1/2
...	25153	...	4M	21/2	17/2
25166	25159	7	4K	11/2	1/2
25182	25198	-15	4K	11/2	3/2
...	25202	...	4K	11/2	5/2
25204	25204	0	4K	11/2	-9/2
25216	25238	-21	4K	11/2	-11/2
25248	25255	-6	4M	21/2	15/2
...	25275	...	4K	11/2	-7/2
25282	25312	-29	4M	21/2	-19/2
...	25335	...	4M	21/2	1/2
...	25404	...	4M	21/2	3/2
...	25420	...	4M	21/2	5/2
...	25444	...	4M	21/2	13/2
...	25522	...	4M	21/2	-11/2
...	25555	...	4M	21/2	-9/2
...	25582	...	4M	21/2	-7/2
...	25603	...	4L	15/2	1/2
...	25636	...	4L	15/2	3/2
...	25641	...	4L	15/2	13/2
...	25689	...	4M	21/2	-21/2
...	25691	...	4L	15/2	-11/2
...	25692	...	4L	15/2	5/2
...	25698	...	4L	15/2	15/2
...	25764	...	4L	15/2	-9/2
...	25765	...	4G	11/2	5/2
...	25778	...	4L	15/2	-7/2
...	25812	...	4G	11/2	3/2
...	25812	...	4G	11/2	-7/2
...	25849	...	4G	11/2	-11/2
...	25866	...	4G	11/2	1/2
...	25896	...	4G	11/2	-9/2
...	26492	...	4D	1/2	1/2

APPENDIX VI

TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	26691	...	4K	17/2	1/2
...	26693	...	2K	17/2	3/2
...	26707	...	4L	17/2	5/2
...	26735	...	4K	17/2	13/2
...	26747	...	6P	7/2	-7/2
...	26771	...	2K	17/2	15/2
...	26792	...	4L	17/2	17/2
...	26799	...	6P	7/2	5/2
...	26807	...	4K	17/2	-11/2
...	26809	...	6P	7/2	3/2
...	26839	...	6P	7/2	1/2
...	26845	...	4L	17/2	-7/2
...	26852	...	4K	17/2	-9/2
...	26926	...	4K	13/2	1/2
...	26953	...	4K	13/2	-9/2
...	26983	...	4K	13/2	3/2
...	26990	...	4K	13/2	-11/2
...	27011	...	4K	13/2	5/2
...	27070	...	4K	13/2	-7/2
...	27110	...	4K	13/2	13/2
27363	27361	2	4F	9/2	-7/2
27417	27432	-14	4F	9/2	5/2
27432	27468	-35	4F	9/2	3/2
27448	27484	-35	4F	9/2	1/2
27508	27533	-24	4F	9/2	-9/2
27648	27655	-6	4D	3/2	1/2
27658	27664	-5	4D	3/2	3/2
27691	27719	-27	6P	5/2	1/2
27734	27765	-30	6P	5/2	5/2
27758	27773	-14	6P	5/2	3/2
28248	28250	-1	6P	7/2	1/2
28262	28253	9	4H	7/2	5/2
28343	28349	-5	4H	7/2	-7/2
28409	28403	6	6P	7/2	3/2
28715	28738	-22	4K	15/2	5/2
28726	28742	-15	4K	15/2	1/2
28753	28753	0	4K	15/2	3/2
...	28754	...	4K	15/2	-11/2
28778	28781	-2	4K	15/2	13/2
28790	28794	-3	4K	15/2	15/2
...	28806	...	4K	15/2	-9/2
28810	28811	0	4K	15/2	-7/2

APPENDIX VI

TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
28938	28935	3	4H	9/2	-7/2
...	28956	...	4H	9/2	1/2
28981	29007	-25	4H	9/2	-9/2
29037	29063	-25	6P	7/2	5/2
29055	29076	-20	4H	9/2	3/2
29086	29103	-16	6P	7/2	3/2
29094	29103	-8	6P	7/2	1/2
...	29107	...	4K	17/2	5/2
...	29117	...	4K	17/2	-7/2
...	29136	...	4K	17/2	-9/2
...	29137	...	4K	17/2	-11/2
...	29143	...	4K	17/2	17/2
...	29138	...	6P	7/2	-7/2
...	29151	...	4K	17/2	13/2
...	29168	...	4K	17/2	3/2
...	29184	...	4H	9/2	5/2
...	29205	...	4K	17/2	1/2
...	29223	...	4K	17/2	15/2
...	29298	...	4M	19/2	1/2
...	29307	...	4M	19/2	3/2
...	29312	...	4L	19/2	5/2
...	29331	...	4H	11/2	-9/2
...	29347	...	4L	19/2	17/2
...	29356	...	4H	11/2	-11/2
...	29361	...	4H	11/2	1/2
...	29365	...	4H	11/2	-7/2
...	29412	...	4H	11/2	3/2
...	29448	...	4M	19/2	15/2
...	29456	...	4L	19/2	-19/2
...	29476	...	4M	19/2	13/2
...	29503	...	4H	11/2	5/2
...	29572	...	4M	19/2	-11/2
...	29582	...	4H	13/2	-11/2
...	29587	...	4L	19/2	-7/2
...	29590	...	4M	19/2	-9/2
...	29632	...	4H	13/2	3/2
...	29640	...	4H	13/2	1/2
...	29683	...	4H	13/2	5/2
...	29708	...	4H	13/2	-9/2
...	29712	...	4H	13/2	13/2
...	29761	...	4H	13/2	-7/2

APPENDIX VI

TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
30027	30025	2	4G	7/2	5/2
30125	30139	-13	4G	7/2	-7/2
30141	30142	0	4G	7/2	1/2
...	30191	...	4G	9/2	3/2
...	30207	...	4G	9/2	-9/2
30219	30217	2	4G	5/2	5/2
30235	30262	-26	4G	9/2	-7/2
30286	30275	11	4G	9/2	1/2
30329	30346	-16	4G	7/2	3/2
...	30444	...	4G	5/2	1/2
...	30489	...	4G	5/2	5/2
...	30539	...	4G	5/2	3/2
...	31222	...	4P	1/2	1/2
...	31341	...	2K	15/2	13/2
...	31358	...	2K	15/2	-11/2
31420	31412	8	2L	15/2	-9/2
31442	31454	-11	2L	15/2	5/2
31473	31474	0	2L	15/2	3/2
...	31488	...	2K	15/2	1/2
...	31515	...	4G	11/2	-11/2
...	31518	...	4G	11/2	5/2
...	31525	...	2L	15/2	-7/2
...	31552	...	4P	3/2	3/2
31627	31608	19	2K	15/2	1/2
...	31615	...	4G	11/2	3/2
...	31628	...	4G	11/2	-7/2
...	31676	...	2L	15/2	15/2
31716	31710	6	4G	11/2	-9/2
31761	31735	26	4G	11/2	1/2
32800	32808	-7	4P	5/2	1/2
32822	32829	-6	4P	5/2	5/2
32853	32861	-7	4P	5/2	3/2
33608	33583	25	2F	5/2	1/2
33681	33658	23	2F	5/2	5/2
33765	33742	23	2K	13/2	-11/2
...	33795	...	2K	13/2	-9/2
...	33824	...	2F	5/2	3/2
...	33891	...	2K	13/2	1/2
...	33903	...	2K	13/2	-7/2
...	33942	...	4F	9/2	-7/2
...	33961	...	2K	13/2	3/2
...	33966	...	4F	9/2	5/2
...	33996	...	4F	9/2	-9/2
...	34033	...	4F	9/2	1/2
...	34048	...	2K	13/2	5/2
...	34056	...	4F	9/2	3/2
...	34090	...	2K	13/2	13/2

APPENDIX VI

TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	34331	...	2L	17/2	13/2
...	34347	...	2L	17/2	15/2
...	34397	...	2L	17/2	-11/2
...	34402	...	2L	17/2	-7/2
...	34407	...	2L	17/2	3/2
...	34453	...	2L	17/2	5/2
...	34455	...	2L	17/2	-11/2
...	34474	...	2L	17/2	-9/2
...	34487	...	4I	9/2	5/2
...	34534	...	2L	17/2	17/2
...	34557	...	4I	9/2	5/2
...	34588	...	4I	9/2	3/2
...	34599	...	4I	9/2	-9/2
...	34630	...	4I	9/2	1/2
...	35575	...	2N	19/2	-19/2
...	35651	...	4F	7/2	5/2
...	35666	...	2N	19/2	17/2
...	35678	...	4F	7/2	1/2
...	35699	...	2N	19/2	-9/2
...	35701	...	2N	19/2	-11/2
...	35718	...	2N	19/2	-7/2
...	35728	...	2N	19/2	17/2
...	35737	...	2N	19/2	13/2
...	35759	...	2N	19/2	5/2
...	35762	...	2N	19/2	3/2
...	35762	...	2N	19/2	1/2
...	35794	...	4F	7/2	-7/2
...	35864	...	2P	1/2	1/2
...	35874	...	4F	7/2	3/2
35890	35902	-11	4I	11/2	-7/2
35905	35920	-14	4I	11/2	-9/2
35954	35955	0	4I	11/2	5/2
35996	35983	13	4I	11/2	-11/2
36007	36009	-1	4I	11/2	3/2
36055	36052	3	4I	11/2	1/2

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TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	36310	...	4I	15/2	13/2
...	36339	...	4I	15/2	-11/2
...	36404	...	2K	15/2	-9/2
...	36461	...	4I	15/2	-7/2
...	36496	...	4F	5/2	1/2
...	36520	...	2K	15/2	3/2
...	36526	...	4I	15/2	1/2
...	36526	...	4I	15/2	5/2
36567	36550	17	4F	5/2	5/2
...	36571	...	2K	15/2	15/2
...	36572	...	4I	13/2	-11/2
...	36602	...	4I	13/2	-9/2
...	36632	...	2N	21/2	-19/2
...	36643	...	2N	21/2	-21/2
...	36645	...	2N	21/2	17/2
...	36648	...	4F	3/2	3/2
...	36651	...	4I	13/2	-7/2
36651	36659	-7	4F	5/2	3/2
...	36680	...	2N	21/2	1/2
...	36700	...	2N	21/2	3/2
...	36702	...	4I	13/2	5/2
...	36709	...	4I	13/2	1/2
...	36726	...	4I	13/2	3/2
...	36735	...	4I	17/2	13/2
...	36738	...	2N	21/2	5/2
36755	36752	3	4F	3/2	1/2
...	36781	...	2N	21/2	15/2
...	36839	...	2N	21/2	-7/2
...	36839	...	2N	21/2	13/2
...	36840	...	2N	21/2	-9/2
...	36845	...	2N	21/2	-11/2
...	36903	...	2M	17/2	17/2
...	36922	...	2M	17/2	17/2
...	36960	...	2M	17/2	-9/2
...	37037	...	2M	17/2	1/2
...	37051	...	2M	17/2	5/2
...	37072	...	2M	17/2	3/2
...	37131	...	2M	17/2	-11/2
...	37216	...	2M	17/2	15/2
...	37268	...	2M	17/2	13/2
37623	37599	24	2H	9/2	-7/2
37634	37614	20	2H	9/2	1/2
37634	37619	15	2H	9/2	-9/2
37657	37638	19	2H	9/2	3/2
37679	37661	18	2H	9/2	5/2

APPENDIX VI

TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	38184	...	2F	7/2	3/2
...	38256	...	2F	7/2	-7/2
...	38280	...	2F	7/2	1/2
38467	38467	0	2P	3/2	3/2
38492	38484	9	2P	3/2	1/2
...	38499	...	2F	7/2	5/2
...	38902	...	2K	15/2	13/2
...	38971	...	2K	15/2	-11/2
...	39000	...	2G	7/2	5/2
...	39117	...	2K	15/2	3/2
...	39142	...	2G	7/2	1/2
...	39171	...	2G	7/2	-7/2
...	39214	...	2K	15/2	1/2
...	39245	...	2K	15/2	5/2
...	39316	...	2G	7/2	3/2
...	39361	...	2K	15/2	-9/2
...	39400	...	2H	11/2	-7/2
...	39446	...	2H	11/2	-9/2
...	39455	...	2H	11/2	-11/2
...	39468	...	2K	15/2	15/2
...	39475	...	2H	11/2	5/2
...	39506	...	2H	11/2	1/2
...	39541	...	2G	7/2	3/2
...	39581	...	2K	15/2	-7/2
...	40316	...	2M	19/2	-19/2
...	40486	...	2M	19/2	-7/2
...	40505	...	2M	19/2	-9/2
...	40555	...	2M	19/2	-11/2
...	40696	...	2M	19/2	1/2
...	40698	...	2M	19/2	5/2
...	40719	...	2M	19/2	3/2
...	40762	...	2D	5/2	1/2
...	40781	...	2D	5/2	1/2
...	40806	...	2D	5/2	5/2
...	40849	...	2D	5/2	3/2
...	40883	...	2I	11/2	-11/2
...	40895	...	2M	19/2	17/2
...	40909	...	2I	11/2	3/2
...	40972	...	2I	11/2	1/2
...	40981	...	2I	11/2	-9/2
...	41061	...	2M	19/2	15/2
...	41087	...	2I	11/2	-7/2
...	41139	...	2K	13/2	-11/2
...	41178	...	2I	11/2	5/2
...	41250	...	2K	13/2	-9/2
...	41252	...	2K	13/2	1/2
...	41359	...	2K	13/2	5/2
...	41382	...	2K	13/2	3/2

APPENDIX VI

TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	41397	...	2K	13/2	13/2
...	41534	...	2K	13/2	-7/2
...	41737	...	2D	3/2	1/2
...	41756	...	2D	3/2	3/2
42066	42054	12	2G	9/2	-9/2
42124	42102	22	2G	9/2	5/2
42135	42112	23	2G	9/2	3/2
42176	42158	18	2G	9/2	1/2
42227	42199	28	2G	9/2	-7/2
42378	42390	-11	4G	5/2	1/2
42462	42465	-2	4G	5/2	5/2
42486	42481	5	4G	5/2	3/2
42616	42616	0	4G	7/2	-7/2
...	42625	...	4G	7/2	1/2
42658	42642	16	4G	7/2	3/2
42711	42700	11	4G	7/2	5/2
...	42715	...	2O	21/2	-21/2
...	42875	...	2K	15/2	13/2
...	42923	...	2K	15/2	-11/2
...	42938	...	4H	9/2	3/2
...	42963	...	4H	9/2	5/2
42959	42973	-13	4H	9/2	-9/2
42990	42993	-2	4H	9/2	1/2
43040	43023	17	4H	9/2	-7/2
...	43025	...	2O	21/2	-9/2
43074	43045	29	4H	9/2	-7/2
...	43045	...	2N	21/2	-9/2
...	43079	...	2K	15/2	1/2
...	43088	...	2O	21/2	-11/2
...	43118	...	2K	15/2	5/2
...	43144	...	2K	15/2	15/2
...	43146	...	2K	15/2	-7/2
...	43167	...	4H	11/2	1/2
...	43169	...	2K	15/2	-9/2
...	43196	...	2O	21/2	13/2
...	43215	...	4I	11/2	-11/2
...	43226	...	4H	11/2	3/2
...	43228	...	2O	21/2	-19/2
...	43237	...	2O	21/2	3/2
...	43266	...	2O	21/2	1/2
43258	43266	-7	4H	11/2	-7/2
...	43272	...	4H	11/2	-9/2
...	43276	...	4H	11/2	5/2
...	43294	...	2K	15/2	-7/2
43324	43302	22	2O	21/2	17/2
...	43368	...	2O	21/2	15/2

APPENDIX VI

TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	38184	...	2F	7/2	3/2
...	38256	...	2F	7/2	-7/2
...	38280	...	2F	7/2	1/2
38467	38467	0	2P	3/2	3/2
38492	38484	9	2P	3/2	1/2
...	38499	...	2F	7/2	5/2
...	38902	...	2K	15/2	13/2
...	38971	...	2K	15/2	-11/2
...	39000	...	2G	7/2	5/2
...	39117	...	2K	15/2	3/2
...	39142	...	2G	7/2	1/2
...	39171	...	2G	7/2	-7/2
...	39214	...	2K	15/2	1/2
...	39245	...	2K	15/2	5/2
...	39316	...	2G	7/2	3/2
...	39361	...	2K	15/2	-9/2
...	39400	...	2H	11/2	-7/2
...	39446	...	2H	11/2	-9/2
...	39455	...	2H	11/2	-11/2
...	39468	...	2K	15/2	15/2
...	39475	...	2H	11/2	5/2
...	39506	...	2H	11/2	1/2
...	39541	...	2G	7/2	3/2
...	39581	...	2K	15/2	-7/2
...	40316	...	2M	19/2	-19/2
...	40486	...	2M	19/2	-7/2
...	40505	...	2M	19/2	-9/2
...	40555	...	2M	19/2	-11/2
...	40696	...	2M	19/2	1/2
...	40698	...	2M	19/2	5/2
...	40719	...	2M	19/2	3/2
...	40762	...	2D	5/2	1/2
...	40781	...	2D	5/2	1/2
...	40806	...	2D	5/2	5/2
...	40849	...	2D	5/2	3/2
...	40883	...	2I	11/2	-11/2
...	40895	...	2M	19/2	17/2
...	40909	...	2I	11/2	3/2
...	40972	...	2I	11/2	1/2
...	40981	...	2I	11/2	-9/2
...	41061	...	2M	19/2	15/2
...	41087	...	2I	11/2	-7/2
...	41139	...	2K	13/2	-11/2
...	41178	...	2I	11/2	5/2
...	41250	...	2K	13/2	-9/2
...	41252	...	2K	13/2	1/2
...	41359	...	2K	13/2	5/2
...	41382	...	2K	13/2	3/2

APPENDIX VI

TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	41397	...	2K	13/2	13/2
...	41534	...	2K	13/2	-7/2
...	41737	...	2D	3/2	1/2
...	41756	...	2D	3/2	3/2
42066	42054	12	2G	9/2	-9/2
42124	42102	22	2G	9/2	5/2
42135	42112	23	2G	9/2	3/2
42176	42158	18	2G	9/2	1/2
42227	42199	28	2G	9/2	-7/2
42378	42390	-11	4G	5/2	1/2
42462	42465	-2	4G	5/2	5/2
42486	42481	5	4G	5/2	3/2
42616	42616	0	4G	7/2	-7/2
...	42625	...	4G	7/2	1/2
42658	42642	16	4G	7/2	3/2
42711	42700	11	4G	7/2	5/2
...	42715	...	2O	21/2	-21/2
...	42875	...	2K	15/2	13/2
...	42923	...	2K	15/2	-11/2
...	42938	...	4H	9/2	3/2
...	42963	...	4H	9/2	5/2
42959	42973	-13	4H	9/2	-9/2
42990	42993	-2	4H	9/2	1/2
43040	43023	17	4H	9/2	-7/2
...	43025	...	2O	21/2	-9/2
43074	43045	29	4H	9/2	-7/2
...	43045	...	2N	21/2	-9/2
...	43079	...	2K	15/2	1/2
...	43088	...	2O	21/2	-11/2
...	43118	...	2K	15/2	5/2
...	43144	...	2K	15/2	15/2
...	43146	...	2K	15/2	-7/2
...	43167	...	4H	11/2	1/2
...	43169	...	2K	15/2	-9/2
...	43196	...	2O	21/2	13/2
...	43215	...	4I	11/2	-11/2
...	43226	...	4H	11/2	3/2
...	43228	...	2O	21/2	-19/2
...	43237	...	2O	21/2	3/2
...	43266	...	2O	21/2	1/2
43258	43266	-7	4H	11/2	-7/2
...	43272	...	4H	11/2	-9/2
...	43276	...	4H	11/2	5/2
...	43294	...	2K	15/2	-7/2
43324	43302	22	2O	21/2	17/2
...	43368	...	2O	21/2	15/2

APPENDIX VI

TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	43446	...	4H	13/2	13/2
...	43542	...	4H	13/2	3/2
...	43545	...	4H	13/2	-7/2
...	43545	...	4H	13/2	-11/2
...	43565	...	4H	13/2	1/2
...	43576	...	4H	13/2	5/2
...	43590	...	2H	13/2	-9/2
...	43703	...	2I	11/2	5/2
...	43728	...	2I	11/2	-11/2
...	43780	...	2I	11/2	3/2
...	43789	...	2I	11/2	-7/2
...	43829	...	2I	11/2	1/2
...	43888	...	2I	11/2	-9/2
...	43953	...	4H	7/2	-7/2
...	44003	...	4H	7/2	3/2
...	44005	...	4H	7/2	1/2
...	44016	...	4H	7/2	5/2
...	44481	...	2G	9/2	-7/2
...	44559	...	2G	9/2	1/2
44597	44622	-24	2G	9/2	-9/2
...	44692	...	2G	9/2	5/2
...	44710	...	2G	9/2	3/2
...	45031	...	4G	7/2	1/2
...	45065	...	4G	7/2	-7/2
...	45071	...	4G	7/2	3/2
45122	45146	-23	4G	7/2	5/2
...	45262	...	4G	9/2	1/2
...	45320	...	4G	9/2	-7/2
...	45324	...	4G	9/2	-9/2
45366	45379	-12	4G	9/2	3/2
...	45440	...	4G	9/2	5/2
...	45668	...	2I	13/2	13/2
...	45732	...	2I	13/2	1/2
...	45770	...	2I	13/2	3/2
...	45812	...	4G	11/2	5/2
...	45817	...	2I	13/2	-11/2
...	45828	...	4G	11/2	3/2
...	45837	...	4G	11/2	1/2
...	45845	...	4H	13/2	5/2
...	45861	...	4G	11/2	-11/2
...	45869	...	4G	11/2	-7/2
...	45891	...	2I	13/2	-9/2
...	45917	...	4H	13/2	-7/2
...	45930	...	4G	11/2	-9/2

APPENDIX VI

TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	46204	...	2H	11/2	1/2
...	46222	...	2H	11/2	-9/2
...	46267	...	4H	13/2	13/2
...	46269	...	2L	17/2	17/2
...	46298	...	2L	17/2	-7/2
46284	46300	-15	2H	11/2	-11/2
...	46330	...	2L	17/2	3/2
...	46334	...	2L	17/2	1/2
...	46341	...	2L	17/2	15/2
...	46349	...	2L	17/2	5/2
...	46393	...	2H	11/2	3/2
...	46412	...	4H	13/2	1/2
46402	46422	-19	4H	13/2	5/2
...	46422	...	4H	13/2	3/2
...	46435	...	2L	17/2	-11/2
...	46445	...	2L	17/2	-9/2
...	46448	...	2L	17/2	13/2
...	46473	...	4H	13/2	-7/2
...	46492	...	4H	13/2	-7/2
...	46512	...	4H	13/2	-11/2
...	46531	...	4H	13/2	-9/2
...	46550	...	4P	3/2	3/2
46603	46587	16	4P	3/2	1/2
...	46592	...	2H	11/2	-7/2
...	46962	...	2D	5/2	5/2
...	46972	...	2D	5/2	3/2
...	47057	...	2D	5/2	1/2
...	47266	...	2H	11/2	-11/2
47336	47327	9	2H	11/2	5/2
47374	47397	-22	2H	11/2	3/2
...	47471	...	2H	11/2	-7/2
...	47620	...	2H	11/2	-9/2

APPENDIX VI

TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	43446	...	4H	13/2	13/2
...	43542	...	4H	13/2	3/2
...	43545	...	4H	13/2	-7/2
...	43545	...	4H	13/2	-11/2
...	43565	...	4H	13/2	1/2
...	43576	...	4H	13/2	5/2
...	43590	...	2H	13/2	-9/2
...	43703	...	2I	11/2	5/2
...	43728	...	2I	11/2	-11/2
...	43780	...	2I	11/2	3/2
...	43789	...	2I	11/2	-7/2
...	43829	...	2I	11/2	1/2
...	43888	...	2I	11/2	-9/2
...	43953	...	4H	7/2	-7/2
...	44003	...	4H	7/2	3/2
...	44005	...	4H	7/2	1/2
...	44016	...	4H	7/2	5/2
...	44481	...	2G	9/2	-7/2
...	44559	...	2G	9/2	1/2
44597	44622	-24	2G	9/2	-9/2
...	44692	...	2G	9/2	5/2
...	44710	...	2G	9/2	3/2
...	45031	...	4G	7/2	1/2
...	45065	...	4G	7/2	-7/2
...	45071	...	4G	7/2	3/2
45122	45146	-23	4G	7/2	5/2
...	45262	...	4G	9/2	1/2
...	45320	...	4G	9/2	-7/2
...	45324	...	4G	9/2	-9/2
45366	45379	-12	4G	9/2	3/2
...	45440	...	4G	9/2	5/2
...	45668	...	2I	13/2	13/2
...	45732	...	2I	13/2	1/2
...	45770	...	2I	13/2	3/2
...	45812	...	4G	11/2	5/2
...	45817	...	2I	13/2	-11/2
...	45828	...	4G	11/2	3/2
...	45837	...	4G	11/2	1/2
...	45845	...	4H	13/2	5/2
...	45861	...	4G	11/2	-11/2
...	45869	...	4G	11/2	-7/2
...	45891	...	2I	13/2	-9/2
...	45917	...	4H	13/2	-7/2
...	45930	...	4G	11/2	-9/2

APPENDIX VI

TABLE 1
SM+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	46204	...	2H	11/2	1/2
...	46222	...	2H	11/2	-9/2
...	46267	...	4H	13/2	13/2
...	46269	...	2L	17/2	17/2
...	46298	...	2L	17/2	-7/2
46284	46300	-15	2H	11/2	-11/2
...	46330	...	2L	17/2	3/2
...	46334	...	2L	17/2	1/2
...	46341	...	2L	17/2	15/2
...	46349	...	2L	17/2	5/2
...	46393	...	2H	11/2	3/2
...	46412	...	4H	13/2	1/2
46402	46422	-19	4H	13/2	5/2
...	46422	...	4H	13/2	3/2
...	46435	...	2L	17/2	-11/2
...	46445	...	2L	17/2	-9/2
...	46448	...	2L	17/2	13/2
...	46473	...	4H	13/2	-7/2
...	46492	...	4H	13/2	-7/2
...	46512	...	4H	13/2	-11/2
...	46531	...	4H	13/2	-9/2
...	46550	...	4P	3/2	3/2
46603	46587	16	4P	3/2	1/2
...	46592	...	2H	11/2	-7/2
...	46962	...	2D	5/2	5/2
...	46972	...	2D	5/2	3/2
...	47057	...	2D	5/2	1/2
...	47266	...	2H	11/2	-11/2
47336	47327	9	2H	11/2	5/2
47374	47397	-22	2H	11/2	3/2
...	47471	...	2H	11/2	-7/2
...	47620	...	2H	11/2	-9/2

APPENDIX VI

TABLE 1A
SM+3:LAF3 CENTERS OF GRAVITY

CALC CENTER	STATE
101	6H 5/2
1135	6H 7/2
2341	6H 9/2
3667	6H11/2
5072	6H13/2
6387	6F 1/2
6520	6H15/2
6637	6F 3/2
7141	6F 5/2
8009	6F 7/2
9189	6F 9/2
10583	6F11/2
18031	4G 5/2
18982	4F 3/2
20161	4G 7/2
20660	4I 9/2
20825	4M15/2
21147	4I11/2
21644	4I13/2
22301	4F 5/2
22612	4M17/2
22873	4G 9/2
23048	4I15/2
24132	6P 5/2
24138	4M19/2
24676	4L13/2
24995	4F 7/2
25064	6P 3/2
25201	4K11/2
25434	4M21/2
25667	4L15/2
25829	4G11/2
26446	4D 1/2
26762	4L17/2
26786	6P 7/2

APPENDIX VI

TABLE 2
U(K)*2 FOR SM+3

J1	IEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
1/2	6387	3/2	6637	0.0174	0.0	0.0
1/2	6387	3/2	25064	0.1920	0.0	0.0
1/2	6387	5/2	101	0.1938	0.0	0.0
1/2	6387	5/2	7141	0.0140	0.0	0.0
1/2	6387	5/2	22301	0.0011	0.0	0.0
1/2	6387	5/2	24132	0.0106	0.0	0.0
1/2	6387	7/2	1135	0.0	0.1386	0.0
1/2	6387	7/2	8009	0.0	0.0306	0.0
1/2	6387	7/2	24995	0.0	0.0030	0.0
1/2	6387	7/2	26786	0.0	0.0966	0.0
1/2	6387	9/2	2341	0.0	0.1521	0.0
1/2	6387	9/2	9189	0.0	0.0071	0.0
1/2	6387	9/2	20660	0.0	0.0012	0.0
1/2	6387	11/2	3667	0.0	0.0	0.3365
1/2	6387	11/2	10583	0.0	0.0	0.0287
1/2	6387	11/2	25829	0.0	0.0	0.0015
1/2	6387	13/2	5072	0.0	0.0	0.1026
1/2	6387	13/2	24676	0.0	0.0	0.0026
1/2	26446	3/2	18982	0.0079	0.0	0.0
1/2	26446	3/2	25064	0.0061	0.0	0.0
1/2	26446	5/2	18031	0.0180	0.0	0.0
1/2	26446	5/2	22301	0.0532	0.0	0.0
1/2	26446	5/2	24132	0.0106	0.0	0.0
1/2	26446	7/2	20161	0.0	0.0226	0.0
1/2	26446	7/2	24995	0.0	0.0789	0.0
1/2	26446	7/2	26786	0.0	0.0028	0.0
1/2	26446	9/2	20660	0.0	0.0805	0.0
1/2	26446	9/2	22873	0.0	0.0294	0.0
1/2	26446	11/2	3667	0.0	0.0	0.0029
1/2	26446	11/2	21147	0.0	0.0	0.0992
1/2	26446	11/2	25201	0.0	0.0	0.0527
1/2	26446	11/2	25829	0.0	0.0	0.0816
1/2	26446	13/2	21644	0.0	0.0	0.0297
1/2	26446	13/2	24676	0.0	0.0	0.1446
3/2	6637	3/2	6637	0.0029	0.0	0.0
3/2	6637	3/2	18982	0.0011	0.0	0.0
3/2	6637	3/2	25064	0.2922	0.0	0.0
3/2	6637	5/2	101	0.1444	0.1365	0.0
3/2	6637	5/2	7141	0.0222	0.0282	0.0
3/2	6637	5/2	18031	0.0010	0.0000	0.0
3/2	6637	5/2	22301	0.0036	0.0003	0.0
3/2	6637	5/2	24132	0.0711	0.0237	0.0
3/2	6637	7/2	1135	0.2434	0.1174	0.0
3/2	6637	7/2	8009	0.0183	0.0080	0.0
3/2	6637	7/2	20161	0.0023	0.0009	0.0
3/2	6637	7/2	24995	0.0010	0.0063	0.0
3/2	6637	7/2	26786	0.0024	0.1592	0.0
3/2	6637	9/2	2341	0.0	0.1183	0.3793

APPENDIX VI

TABLE 2
U(K)*2 FOR SM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
3/2	6637	9/2	9189	0.0	0.0301	0.0098
3/2	6637	9/2	22873	0.0	0.0000	0.0026
3/2	6637	11/2	3667	0.0	0.2119	0.0287
3/2	6637	11/2	10583	0.0	0.0041	0.0489
3/2	6637	11/2	21147	0.0	0.0062	0.0001
3/2	6637	11/2	25201	0.0	0.0013	0.0001
3/2	6637	11/2	25829	0.0	0.0000	0.0013
3/2	6637	13/2	5072	0.0	0.0	0.4036
3/2	6637	15/2	6520	0.0	0.0	0.0615
3/2	6637	15/2	20825	0.0	0.0	0.0099
3/2	6637	15/2	23048	0.0	0.0	0.0028
3/2	6637	15/2	25667	0.0	0.0	0.0021
3/2	18982	3/2	18982	0.0023	0.0	0.0
3/2	18982	3/2	25064	0.0037	0.0	0.0
3/2	18982	5/2	18031	0.0763	0.0440	0.0
3/2	18982	5/2	22301	0.0609	0.0018	0.0
3/2	18982	5/2	24132	0.0015	0.0771	0.0
3/2	18982	7/2	1135	0.0083	0.0000	0.0
3/2	18982	7/2	8009	0.0001	0.0013	0.0
3/2	18982	7/2	20161	0.0289	0.1525	0.0
3/2	18982	7/2	24995	0.0149	0.0001	0.0
3/2	18982	7/2	26786	0.0013	0.0158	0.0
3/2	18982	9/2	2341	0.0	0.0029	0.0049
3/2	18982	9/2	20660	0.0	0.1075	0.0204
3/2	18982	9/2	22873	0.0	0.0401	0.3729
3/2	18982	11/2	21147	0.0	0.2990	0.0985
3/2	18982	11/2	25201	0.0	0.1483	0.0066
3/2	18982	11/2	25829	0.0	0.0016	0.2396
3/2	18982	13/2	5072	0.0	0.0	0.0014
3/2	18982	13/2	21644	0.0	0.0	0.0556
3/2	18982	13/2	24676	0.0	0.0	0.0754
3/2	18982	15/2	20825	0.0	0.0	0.3577
3/2	18982	15/2	23048	0.0	0.0	0.1386
3/2	18982	15/2	25667	0.0	0.0	0.0019
3/2	25064	3/2	25064	0.0096	0.0	0.0
3/2	25064	5/2	101	0.0000	0.1630	0.0
3/2	25064	5/2	7141	0.2638	0.0094	0.0
3/2	25064	5/2	18031	0.0008	0.0001	0.0
3/2	25064	5/2	22301	0.0012	0.0310	0.0
3/2	25064	5/2	24132	0.1220	0.0013	0.0
3/2	25064	7/2	1135	0.0000	0.1589	0.0
3/2	25064	7/2	8009	0.1450	0.0469	0.0
3/2	25064	7/2	20161	0.0018	0.0087	0.0
3/2	25064	7/2	24995	0.0326	0.0070	0.0
3/2	25064	7/2	26786	0.4736	0.0000	0.0
3/2	25064	9/2	2341	0.0	0.1125	0.0011
3/2	25064	9/2	9189	0.0	0.1448	0.0000
3/2	25064	9/2	20660	0.0	0.0101	0.0023

APPENDIX VI

TABLE 2
U(K)*2 FOR SM+3

J1	IEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
3/2	25064	9/2	22873	0.0	0.0388	0.0016
3/2	25064	11/2	3667	0.0	0.0465	0.0118
3/2	25064	11/2	10583	0.0	0.3702	0.0000
3/2	25064	11/2	21147	0.0	0.0040	0.0470
3/2	25064	11/2	25201	0.0	0.0039	0.0000
3/2	25064	11/2	25829	0.0	0.0049	0.0118
3/2	25064	13/2	5072	0.0	0.0	0.0570
3/2	25064	13/2	21644	0.0	0.0	0.0574
3/2	25064	15/2	6520	0.0	0.0	0.1418
3/2	25064	15/2	25667	0.0	0.0	0.0316
5/2	101	5/2	101	0.3881	0.0567	0.0
5/2	101	5/2	7141	0.0331	0.2844	0.0
5/2	101	5/2	24132	0.0000	0.0244	0.0
5/2	101	7/2	1135	0.2062	0.1963	0.0952
5/2	101	7/2	8009	0.0020	0.1429	0.4301
5/2	101	7/2	20161	0.0003	0.0017	0.0023
5/2	101	7/2	24995	0.0002	0.0011	0.0005
5/2	101	7/2	26786	0.0000	0.0015	0.0663
5/2	101	9/2	2341	0.0257	0.1397	0.3262
5/2	101	9/2	9189	0.0000	0.0205	0.3416
5/2	101	9/2	20660	0.0022	0.0005	0.0014
5/2	101	9/2	22873	0.0000	0.0009	0.0027
5/2	101	11/2	3667	0.0	0.0240	0.2649
5/2	101	11/2	10583	0.0	0.0006	0.0516
5/2	101	11/2	21147	0.0	0.0000	0.0111
5/2	101	11/2	25201	0.0	0.0004	0.0024
5/2	101	11/2	25829	0.0	0.0001	0.0010
5/2	101	13/2	5072	0.0	0.0006	0.0662
5/2	101	13/2	21644	0.0	0.0032	0.0237
5/2	101	13/2	24676	0.0	0.0080	0.0092
5/2	101	15/2	6520	0.0	0.0	0.0043
5/2	101	15/2	20825	0.0	0.0	0.0319
5/2	101	15/2	25667	0.0	0.0	0.0056
5/2	101	17/2	22612	0.0	0.0	0.0054
5/2	7141	5/2	7141	0.0007	0.0117	0.0
5/2	7141	5/2	18031	0.0062	0.0014	0.0
5/2	7141	5/2	22301	0.0072	0.0042	0.0
5/2	7141	5/2	24132	0.1884	0.0674	0.0
5/2	7141	7/2	1135	0.2118	0.0507	0.4192
5/2	7141	7/2	8009	0.0397	0.0037	0.0045
5/2	7141	7/2	20161	0.0004	0.0008	0.0019
5/2	7141	7/2	24995	0.0014	0.0074	0.0003
5/2	7141	7/2	26786	0.0243	0.1802	0.0000
5/2	7141	9/2	2341	0.3374	0.1013	0.0475
5/2	7141	9/2	9189	0.0140	0.0298	0.0356
5/2	7141	9/2	20660	0.0000	0.0011	0.0019
5/2	7141	9/2	22873	0.0023	0.0004	0.0004
5/2	7141	11/2	3667	0.0	0.2305	0.2087

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TABLE 2
U(K)*2 FOR SM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
5/2	7141	11/2	10583	0.0	0.0225	0.0511
5/2	7141	11/2	21147	0.0	0.0027	0.0000
5/2	7141	11/2	25201	0.0	0.0016	0.0004
5/2	7141	11/2	25829	0.0	0.0000	0.0075
5/2	7141	13/2	5072	0.0	0.2116	0.2867
5/2	7141	13/2	21644	0.0	0.0094	0.0001
5/2	7141	13/2	24676	0.0	0.0000	0.0018
5/2	7141	15/2	6520	0.0	0.0	0.3400
5/2	7141	15/2	20825	0.0	0.0	0.0179
5/2	7141	17/2	22612	0.0	0.0	0.0193
5/2	18031	5/2	18031	0.3424	0.2483	0.0
5/2	18031	5/2	22301	0.0098	0.0369	0.0
5/2	18031	5/2	24132	0.0106	0.0391	0.0
5/2	18031	7/2	1135	0.0000	0.0078	0.0075
5/2	18031	7/2	8009	0.0000	0.0015	0.0001
5/2	18031	7/2	20161	0.0000	0.0083	0.4094
5/2	18031	7/2	24995	0.0022	0.0057	0.0281
5/2	18031	7/2	26786	0.0018	0.0250	0.0008
5/2	18031	9/2	2341	0.0096	0.0061	0.0019
5/2	18031	9/2	9189	0.0016	0.0002	0.0002
5/2	18031	9/2	20660	0.0369	0.1101	0.0188
5/2	18031	9/2	22873	0.0032	0.0187	0.0309
5/2	18031	11/2	3667	0.0	0.0045	0.0018
5/2	18031	11/2	21147	0.0	0.0009	0.2350
5/2	18031	11/2	25201	0.0	0.0074	0.0289
5/2	18031	11/2	25829	0.0	0.0013	0.1314
5/2	18031	13/2	5072	0.0	0.0000	0.0014
5/2	18031	13/2	21644	0.0	0.3028	0.7218
5/2	18031	13/2	24676	0.0	0.1459	0.0767
5/2	18031	15/2	20825	0.0	0.0	0.8354
5/2	18031	15/2	23048	0.0	0.0	0.0435
5/2	18031	15/2	25667	0.0	0.0	0.0057
5/2	18031	17/2	22612	0.0	0.0	0.0203
5/2	18031	17/2	26762	0.0	0.0	0.0092
5/2	22301	5/2	22301	0.0003	0.0345	0.0
5/2	22301	5/2	24132	0.0444	0.0016	0.0
5/2	22301	7/2	1135	0.0004	0.0059	0.0008
5/2	22301	7/2	8009	0.0123	0.0087	0.0000
5/2	22301	7/2	20161	0.1850	0.0808	0.0373
5/2	22301	7/2	24995	0.0203	0.0319	0.1124
5/2	22301	7/2	26786	0.0125	0.0128	0.0000
5/2	22301	9/2	2341	0.0064	0.0008	0.0000
5/2	22301	9/2	9189	0.0099	0.0037	0.0000
5/2	22301	9/2	20660	0.0229	0.0091	0.1122
5/2	22301	9/2	22873	0.0222	0.1156	0.0721
5/2	22301	11/2	3667	0.0	0.0141	0.0080
5/2	22301	11/2	10583	0.0	0.0044	0.0001
5/2	22301	11/2	21147	0.0	0.0054	0.3369

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TABLE 2
U(K)*2 FOR SM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
5/2	22301	11/2	25201	0.0	0.1495	0.0116
5/2	22301	11/2	25829	0.0	0.0056	0.2032
5/2	22301	13/2	5072	0.0	0.0035	0.0070
5/2	22301	13/2	21644	0.0	0.1186	0.1111
5/2	22301	13/2	24676	0.0	0.1341	0.0639
5/2	22301	15/2	20825	0.0	0.0	0.0082
5/2	22301	15/2	23048	0.0	0.0	0.0172
5/2	22301	15/2	25667	0.0	0.0	0.1934
5/2	22301	17/2	22612	0.0	0.0	0.6557
5/2	24132	5/2	24132	0.2386	0.0005	0.0
5/2	24132	7/2	1135	0.0000	0.0706	0.0050
5/2	24132	7/2	8009	0.3046	0.1199	0.0000
5/2	24132	7/2	20161	0.0062	0.0319	0.0017
5/2	24132	7/2	24995	0.0651	0.0110	0.0005
5/2	24132	7/2	26786	0.2737	0.0077	0.0001
5/2	24132	9/2	2341	0.0004	0.1302	0.0178
5/2	24132	9/2	9189	0.3246	0.1715	0.0000
5/2	24132	9/2	20660	0.0007	0.0185	0.1326
5/2	24132	9/2	22873	0.0577	0.0195	0.0052
5/2	24132	11/2	3667	0.0	0.1527	0.0467
5/2	24132	11/2	10583	0.0	0.1616	0.0000
5/2	24132	11/2	21147	0.0	0.0205	0.0009
5/2	24132	11/2	25201	0.0	0.0265	0.0217
5/2	24132	11/2	25829	0.0	0.1119	0.0627
5/2	24132	13/2	5072	0.0	0.1224	0.0824
5/2	24132	13/2	21644	0.0	0.0002	0.0476
5/2	24132	13/2	24676	0.0	0.0047	0.0015
5/2	24132	15/2	6520	0.0	0.0	0.0740
5/2	24132	15/2	20825	0.0	0.0	0.0249
5/2	24132	15/2	23048	0.0	0.0	0.2011
5/2	24132	17/2	22612	0.0	0.0	0.0186
5/2	24132	17/2	26762	0.0	0.0	0.1009
7/2	1135	7/2	1135	0.2831	0.0143	0.2951
7/2	1135	7/2	8009	0.0420	0.2955	0.0004
7/2	1135	7/2	20161	0.0000	0.0024	0.0048
7/2	1135	7/2	24995	0.0000	0.0000	0.0026
7/2	1135	7/2	26786	0.0000	0.0088	0.0862
7/2	1135	9/2	2341	0.2938	0.1652	0.0080
7/2	1135	9/2	9189	0.0017	0.1328	0.4555
7/2	1135	9/2	20660	0.0002	0.0007	0.0066
7/2	1135	11/2	3667	0.0382	0.1792	0.2542
7/2	1135	11/2	10583	0.0000	0.0104	0.2281
7/2	1135	11/2	21147	0.0002	0.0000	0.0104
7/2	1135	11/2	25201	0.0016	0.0000	0.0061
7/2	1135	11/2	25829	0.0000	0.0005	0.0004
7/2	1135	13/2	5072	0.0	0.0245	0.2811
7/2	1135	13/2	24676	0.0	0.0000	0.0095
7/2	1135	15/2	6520	0.0	0.0003	0.0467

TABLE 2
U(K)*2 FOR SM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
7/2	1135	15/2	23048	0.0	0.0019	0.0104
7/2	1135	15/2	25667	0.0	0.0076	0.0071
7/2	1135	17/2	22612	0.0	0.0	0.0220
7/2	1135	17/2	26762	0.0	0.0	0.0033
7/2	1135	19/2	24138	0.0	0.0	0.0043
7/2	8009	7/2	8009	0.0034	0.0217	0.0290
7/2	8009	7/2	20161	0.0070	0.0000	0.0004
7/2	8009	7/2	24995	0.0035	0.0041	0.0000
7/2	8009	7/2	26786	0.1128	0.1713	0.0000
7/2	8009	9/2	2341	0.2493	0.1320	0.2625
7/2	8009	9/2	9189	0.0550	0.0051	0.0586
7/2	8009	9/2	20660	0.0000	0.0023	0.0009
7/2	8009	9/2	22873	0.0000	0.0007	0.0031
7/2	8009	11/2	3667	0.4881	0.0308	0.3276
7/2	8009	11/2	10583	0.0065	0.0497	0.0357
7/2	8009	11/2	21147	0.0000	0.0006	0.0013
7/2	8009	11/2	25201	0.0000	0.0018	0.0013
7/2	8009	11/2	25829	0.0012	0.0000	0.0017
7/2	8009	13/2	5072	0.0	0.4372	0.0002
7/2	8009	13/2	21644	0.0	0.0049	0.0017
7/2	8009	15/2	6520	0.0	0.1306	0.7121
7/2	8009	15/2	20825	0.0	0.0012	0.0043
7/2	8009	15/2	23048	0.0	0.0038	0.0015
7/2	8009	15/2	25667	0.0	0.0019	0.0031
7/2	8009	17/2	22612	0.0	0.0	0.0230
7/2	8009	19/2	24138	0.0	0.0	0.0215
7/2	20161	7/2	20161	0.3327	0.1197	0.0001
7/2	20161	7/2	24995	0.0066	0.0556	0.0266
7/2	20161	7/2	26786	0.0003	0.0436	0.0062
7/2	20161	9/2	2341	0.0000	0.0090	0.0038
7/2	20161	9/2	9189	0.0004	0.0000	0.0006
7/2	20161	9/2	20660	0.0099	0.0768	0.1086
7/2	20161	9/2	22873	0.0006	0.0005	0.1904
7/2	20161	11/2	3667	0.0099	0.0014	0.0000
7/2	20161	11/2	10583	0.0010	0.0000	0.0001
7/2	20161	11/2	21147	0.0240	0.0741	0.1662
7/2	20161	11/2	25201	0.0000	0.0081	0.1439
7/2	20161	11/2	25829	0.0079	0.0022	0.0660
7/2	20161	13/2	5072	0.0	0.0059	0.0000
7/2	20161	13/2	21644	0.0	0.0133	0.0169
7/2	20161	13/2	24676	0.0	0.0685	0.3055
7/2	20161	15/2	20825	0.0	0.1441	0.0000
7/2	20161	15/2	23048	0.0	0.1223	0.9751
7/2	20161	15/2	25667	0.0	0.2806	0.1634
7/2	20161	17/2	22612	0.0	0.0	0.5022
7/2	20161	17/2	26762	0.0	0.0	0.0769
7/2	20161	19/2	24138	0.0	0.0	0.0330

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TABLE 2
U(K)*2 FOR SM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
7/2	24995	7/2	24995	0.0048	0.0668	0.0135
7/2	24995	7/2	26786	0.0000	0.0030	0.0106
7/2	24995	9/2	2341	0.0009	0.0011	0.0103
7/2	24995	9/2	9189	0.0137	0.0010	0.0000
7/2	24995	9/2	20660	0.0092	0.0009	0.2028
7/2	24995	9/2	22873	0.2300	0.1546	0.0049
7/2	24995	11/2	3667	0.0074	0.0002	0.0121
7/2	24995	11/2	10583	0.0230	0.0010	0.0001
7/2	24995	11/2	21147	0.0122	0.0098	0.0373
7/2	24995	11/2	25201	0.0003	0.0576	0.1335
7/2	24995	11/2	25829	0.0137	0.0245	0.0991
7/2	24995	13/2	5072	0.0	0.0121	0.0016
7/2	24995	13/2	21644	0.0	0.0230	0.1164
7/2	24995	13/2	24676	0.0	0.0061	0.1391
7/2	24995	15/2	6520	0.0	0.0185	0.0007
7/2	24995	15/2	20825	0.0	0.0001	0.0074
7/2	24995	15/2	23048	0.0	0.1892	0.0009
7/2	24995	15/2	25667	0.0	0.0196	0.1390
7/2	24995	17/2	26762	0.0	0.0	0.1659
7/2	24995	19/2	24138	0.0	0.0	0.7863
7/2	26786	7/2	26786	0.1550	0.0042	0.0005
7/2	26786	9/2	2341	0.0000	0.0361	0.0968
7/2	26786	9/2	9189	0.3402	0.1343	0.0000
7/2	26786	9/2	20660	0.0002	0.0002	0.1008
7/2	26786	9/2	22873	0.0000	0.0714	0.0240
7/2	26786	11/2	3667	0.0004	0.1080	0.0933
7/2	26786	11/2	10583	0.8957	0.0658	0.0000
7/2	26786	11/2	21147	0.0002	0.0072	0.0975
7/2	26786	11/2	25201	0.0000	0.0075	0.0690
7/2	26786	11/2	25829	0.0765	0.1692	0.0281
7/2	26786	13/2	5072	0.0	0.2295	0.0706
7/2	26786	13/2	21644	0.0	0.0122	0.0721
7/2	26786	13/2	24676	0.0	0.0082	0.0481
7/2	26786	15/2	6520	0.0	0.4309	0.0305
7/2	26786	15/2	20825	0.0	0.0002	0.0059
7/2	26786	15/2	23048	0.0	0.0000	0.0594
7/2	26786	15/2	25667	0.0	0.0049	0.0295
7/2	26786	17/2	26762	0.0	0.0	0.0398
7/2	26786	19/2	24138	0.0	0.0	0.0394
9/2	2341	9/2	2341	0.3286	0.0210	0.2632
9/2	2341	9/2	9189	0.0336	0.3340	0.1809
9/2	2341	9/2	20660	0.0002	0.0001	0.0034
9/2	2341	9/2	22873	0.0000	0.0026	0.0028
9/2	2341	11/2	3667	0.3432	0.2317	0.0000
9/2	2341	11/2	10583	0.0007	0.0691	0.5206
9/2	2341	11/2	21147	0.0000	0.0006	0.0015
9/2	2341	11/2	25201	0.0010	0.0000	0.0043
9/2	2341	11/2	25829	0.0001	0.0001	0.0011

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TABLE 2
U(K)*2 FOR SM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
9/2	2341	13/2	5072	0.0337	0.1744	0.3905
9/2	2341	13/2	21644	0.0000	0.0001	0.0129
9/2	2341	13/2	24676	0.0002	0.0014	0.0002
9/2	2341	15/2	6520	0.0	0.0117	0.2043
9/2	2341	15/2	20825	0.0	0.0008	0.0056
9/2	2341	15/2	25667	0.0	0.0000	0.0069
9/2	2341	17/2	22612	0.0	0.0002	0.0018
9/2	2341	17/2	26762	0.0	0.0066	0.0095
9/2	2341	19/2	24138	0.0	0.0	0.0125
9/2	2341	21/2	25434	0.0	0.0	0.0016
9/2	9189	9/2	9189	0.0368	0.0094	0.0482
9/2	9189	9/2	20660	0.0000	0.0009	0.0003
9/2	9189	9/2	22873	0.0072	0.0001	0.0003
9/2	9189	11/2	3667	0.2417	0.3531	0.0092
9/2	9189	11/2	10583	0.0503	0.0652	0.0149
9/2	9189	11/2	21147	0.0000	0.0035	0.0000
9/2	9189	11/2	25201	0.0000	0.0010	0.0000
9/2	9189	11/2	25829	0.0002	0.0008	0.0004
9/2	9189	13/2	5072	0.7085	0.0332	0.4312
9/2	9189	13/2	21644	0.0005	0.0013	0.0020
9/2	9189	13/2	24676	0.0001	0.0018	0.0000
9/2	9189	15/2	6520	0.0	0.5743	0.7457
9/2	9189	15/2	20825	0.0	0.0010	0.0002
9/2	9189	15/2	23048	0.0	0.0037	0.0090
9/2	9189	17/2	22612	0.0	0.0002	0.0048
9/2	9189	17/2	26762	0.0	0.0023	0.0061
9/2	9189	19/2	24138	0.0	0.0	0.0231
9/2	9189	21/2	25434	0.0	0.0	0.0160
9/2	20660	9/2	20660	0.2267	0.1580	0.0048
9/2	20660	9/2	22873	0.0029	0.0356	0.1400
9/2	20660	11/2	10583	0.0000	0.0000	0.0009
9/2	20660	11/2	21147	0.1471	0.1009	0.0782
9/2	20660	11/2	25201	0.0316	0.0554	0.2256
9/2	20660	11/2	25829	0.0007	0.0138	0.0687
9/2	20660	13/2	5072	0.0000	0.0000	0.0017
9/2	20660	13/2	21644	0.0306	0.1225	0.2710
9/2	20660	13/2	24676	0.0181	0.1904	0.4506
9/2	20660	15/2	6520	0.0	0.0000	0.0010
9/2	20660	15/2	20825	0.0	0.0222	1.0055
9/2	20660	15/2	23048	0.0	0.0288	0.0265
9/2	20660	15/2	25667	0.0	0.0630	0.2417
9/2	20660	17/2	22612	0.0	0.0011	0.4636
9/2	20660	17/2	26762	0.0	0.0029	0.0027
9/2	20660	19/2	24138	0.0	0.0	0.0253
9/2	22873	9/2	22873	0.3143	0.0224	0.1291
9/2	22873	11/2	3667	0.0000	0.0095	0.0016
9/2	22873	11/2	21147	0.0176	0.0879	0.0067

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TABLE 2
U(K)*2 FOR SM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
9/2	22873	11/2	25201	0.0015	0.0041	0.2043
9/2	22873	11/2	25829	0.0100	0.0015	0.0005
9/2	22873	13/2	5072	0.0044	0.0005	0.0000
9/2	22873	13/2	21644	0.0120	0.0497	0.1406
9/2	22873	13/2	24676	0.0002	0.0319	0.0272
9/2	22873	15/2	6520	0.0	0.0016	0.0002
9/2	22873	15/2	20825	0.0	0.0161	0.0706
9/2	22873	15/2	23048	0.0	0.0007	0.1630
9/2	22873	15/2	25667	0.0	0.0793	0.2881
9/2	22873	17/2	22612	0.0	0.2156	0.0357
9/2	22873	17/2	26762	0.0	0.4347	1.1074
9/2	22873	19/2	24138	0.0	0.0	0.2849
9/2	22873	21/2	25434	0.0	0.0	0.0467
11/2	3667	11/2	3667	0.4871	0.0004	0.2837
11/2	3667	11/2	10583	0.0158	0.2559	0.7610
11/2	3667	11/2	21147	0.0017	0.0000	0.0050
11/2	3667	11/2	25829	0.0002	0.0008	0.0068
11/2	3667	13/2	5072	0.3428	0.3560	0.1086
11/2	3667	13/2	21644	0.0000	0.0016	0.0011
11/2	3667	13/2	24676	0.0005	0.0002	0.0101
11/2	3667	15/2	6520	0.0171	0.1085	0.4978
11/2	3667	15/2	20825	0.0000	0.0016	0.0000
11/2	3667	15/2	23048	0.0000	0.0001	0.0209
11/2	3667	15/2	25667	0.0002	0.0031	0.0025
11/2	3667	17/2	22612	0.0	0.0018	0.0137
11/2	3667	17/2	26762	0.0	0.0001	0.0029
11/2	3667	19/2	24138	0.0	0.0018	0.0032
11/2	3667	21/2	25434	0.0	0.0	0.0051
11/2	10583	11/2	10583	0.1382	0.0483	0.0026
11/2	10583	11/2	21147	0.0000	0.0008	0.0033
11/2	10583	11/2	25201	0.0000	0.0001	0.0012
11/2	10583	11/2	25829	0.0066	0.0001	0.0005
11/2	10583	13/2	5072	0.1668	0.5949	0.7112
11/2	10583	13/2	21644	0.0002	0.0038	0.0042
11/2	10583	13/2	24676	0.0000	0.0015	0.0035
11/2	10583	15/2	6520	1.0103	0.7789	0.3420
11/2	10583	15/2	20825	0.0003	0.0012	0.0004
11/2	10583	15/2	23048	0.0018	0.0079	0.0029
11/2	10583	15/2	25667	0.0002	0.0034	0.0047
11/2	10583	17/2	26762	0.0	0.0012	0.0041
11/2	10583	19/2	24138	0.0	0.0001	0.0027
11/2	10583	21/2	25434	0.0	0.0	0.0200
11/2	21147	11/2	21147	0.1181	0.0495	0.3297
11/2	21147	11/2	25201	0.0141	0.0374	0.3388
11/2	21147	11/2	25829	0.0093	0.0739	0.1636
11/2	21147	13/2	21644	0.2640	0.0481	0.1449
11/2	21147	13/2	24676	0.0437	0.1422	0.1556

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APPENDIX VI

TABLE 2
U(K)*2 FOR SM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
11/2	21147	15/2	6520	0.0000	0.0000	0.0028
11/2	21147	15/2	20825	0.0278	0.5935	0.0427
11/2	21147	15/2	23048	0.0129	0.0092	0.0950
11/2	21147	15/2	25667	0.0316	0.0593	0.3142
11/2	21147	17/2	22612	0.0	0.0122	0.8906
11/2	21147	17/2	26762	0.0	0.0386	0.1126
11/2	21147	19/2	24138	0.0	0.0078	0.4568
11/2	21147	21/2	25434	0.0	0.0	0.0141
11/2	25201	11/2	25201	0.1673	0.0033	0.0060
11/2	25201	11/2	25829	0.0005	0.0051	0.0909
11/2	25201	13/2	5072	0.0000	0.0000	0.0048
11/2	25201	13/2	21644	0.0251	0.0020	0.2442
11/2	25201	13/2	24676	0.4310	0.2064	0.0427
11/2	25201	15/2	6520	0.0000	0.0000	0.0029
11/2	25201	15/2	20825	0.0052	0.5504	0.1659
11/2	25201	15/2	23048	0.0048	0.1994	0.3966
11/2	25201	15/2	25667	0.0001	0.0549	0.1969
11/2	25201	17/2	22612	0.0	0.2208	0.0289
11/2	25201	17/2	26762	0.0	0.0801	0.0920
11/2	25201	19/2	24138	0.0	0.0063	0.0648
11/2	25201	21/2	25434	0.0	0.0	0.0038
11/2	25829	11/2	25829	0.1454	0.0061	0.0652
11/2	25829	13/2	5072	0.0017	0.0032	0.0063
11/2	25829	13/2	21644	0.0409	0.1123	0.0487
11/2	25829	13/2	24676	0.0120	0.0224	0.0820
11/2	25829	15/2	6520	0.0000	0.0011	0.0012
11/2	25829	15/2	20825	0.0004	0.0070	0.0126
11/2	25829	15/2	23048	0.0010	0.0569	0.0001
11/2	25829	15/2	25667	0.0298	0.0086	0.0973
11/2	25829	17/2	22612	0.0	0.0415	0.0828
11/2	25829	17/2	26762	0.0	0.0039	0.0935
11/2	25829	19/2	24138	0.0	0.3623	0.0759
11/2	25829	21/2	25434	0.0	0.0	0.0548
13/2	5072	13/2	5072	0.7978	0.0745	0.1034
13/2	5072	13/2	21644	0.0048	0.0000	0.0022
13/2	5072	13/2	24676	0.0007	0.0000	0.0014
13/2	5072	15/2	6520	0.2504	0.4148	0.6992
13/2	5072	15/2	20825	0.0001	0.0021	0.0039
13/2	5072	15/2	23048	0.0000	0.0010	0.0074
13/2	5072	15/2	25667	0.0015	0.0009	0.0179
13/2	5072	17/2	22612	0.0000	0.0057	0.0038
13/2	5072	17/2	26762	0.0000	0.0036	0.0310
13/2	5072	19/2	24138	0.0	0.0024	0.0314
13/2	5072	21/2	25434	0.0	0.0039	0.0028

TABLE 2
U(K)*2 FOR SM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
13/2	21644	13/2	21644	0.0493	0.0529	0.0871
13/2	21644	13/2	24676	0.0727	0.1363	0.0550
13/2	21644	15/2	6520	0.0001	0.0001	0.0041
13/2	21644	15/2	20825	0.3284	0.1409	0.0720
13/2	21644	15/2	23048	0.0388	0.1682	0.2002
13/2	21644	15/2	25667	0.0649	0.0926	0.1637
13/2	21644	17/2	22612	0.0529	0.5293	0.0138
13/2	21644	17/2	26762	0.0346	0.0208	0.2962
13/2	21644	19/2	24138	0.0	0.0228	1.0742
13/2	21644	21/2	25434	0.0	0.0055	0.3034
13/2	24676	13/2	24676	0.0081	0.0818	0.0001
13/2	24676	15/2	6520	0.0000	0.0000	0.0034
13/2	24676	15/2	20825	0.5111	0.1021	0.4209
13/2	24676	15/2	23048	0.2441	0.0014	0.1029
13/2	24676	15/2	25667	0.0007	0.0717	0.0032
13/2	24676	17/2	22612	0.0113	0.0124	0.8855
13/2	24676	17/2	26762	0.0258	0.0452	0.6603
13/2	24676	19/2	24138	0.0	0.0245	0.0316
13/2	24676	21/2	25434	0.0	0.0000	0.0681
15/2	6520	15/2	6520	1.3358	0.6497	0.4629
15/2	6520	15/2	20825	0.0022	0.0000	0.0001
15/2	6520	15/2	23048	0.0103	0.0001	0.0038
15/2	6520	15/2	25667	0.0009	0.0000	0.0037
15/2	6520	17/2	22612	0.0004	0.0019	0.0015
15/2	6520	17/2	26762	0.0034	0.0026	0.0003
15/2	6520	19/2	24138	0.0003	0.0095	0.0056
15/2	6520	21/2	25434	0.0	0.0030	0.0049
15/2	20825	15/2	20825	0.3461	0.9739	0.0240
15/2	20825	15/2	23048	0.1093	0.0122	0.2040
15/2	20825	15/2	25667	0.0334	0.0723	0.2713
15/2	20825	17/2	22612	0.0501	0.0137	0.3581
15/2	20825	17/2	26762	0.0071	0.0156	0.2598
15/2	20825	19/2	24138	0.0154	0.1631	0.1581
15/2	20825	21/2	25434	0.0	0.0009	0.3139
15/2	23048	15/2	23048	0.0608	0.4222	0.0139
15/2	23048	15/2	25667	0.0336	0.1600	0.0933
15/2	23048	17/2	22612	0.1358	0.3701	0.0002
15/2	23048	17/2	26762	0.0855	0.0082	0.0013
15/2	23048	19/2	24138	0.0469	0.4440	0.0138
15/2	23048	21/2	25434	0.0	0.0003	1.1875
15/2	25667	15/2	25667	0.0038	0.0858	0.0767
15/2	25667	17/2	22612	0.7604	0.2200	0.0417
15/2	25667	17/2	26762	0.0001	0.1437	0.0484
15/2	25667	19/2	24138	0.0276	0.2182	0.9932
15/2	25667	21/2	25434	0.0	0.1058	0.0364

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TABLE 2
U(K)*2 FOR SM+3

J1	IEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
17/2	22612	17/2	22612	0.6020	0.8442	0.0008
17/2	22612	17/2	26762	0.0007	0.0629	0.4190
17/2	22612	19/2	24138	0.0499	0.0676	0.4943
17/2	22612	21/2	25434	0.0056	0.0853	0.3317
17/2	26762	17/2	26762	0.0007	0.1350	0.0459
17/2	26762	19/2	24138	0.9357	0.5552	0.0670
17/2	26762	21/2	25434	0.0674	0.5015	0.7585
19/2	24138	19/2	24138	0.6771	0.9087	0.0275
19/2	24138	21/2	25434	0.0437	0.0943	0.8814
21/2	25434	21/2	25434	0.6674	1.2562	0.9348

APPENDIX VII

APPENDIX VII

TABLE 1
EU+3:LAF3 CENTERS OF GRAVITY

OBSERVED	CALC	O-C	STATE
...	0	...	7F0
...	372	...	7F1
...	1026	...	7F2
...	1866	...	7F3
...	2823	...	7F4
...	3849	...	7F5
...	4907	...	7F6
...	17293	...	5D0
...	19027	...	5D1
...	21483	...	5D2
...	24355	...	5D3
...	25325	...	5L6
...	26357	...	5L7
...	26392	...	5G2
...	26622	...	5G3
...	26735	...	5G4
...	26752	...	5G6
...	26763	...	5G5
...	27244	...	5L8
...	27586	...	5D4
...	27960	...	5L9
...	28427	...	5L10

3/2 6637 9/2 2341 0.0 0.1183 0.3795

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TABLE 2
U(K)*2 FOR EU+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
0	0	2	1026	0.1374	0.0	0.0
0	0	4	2823	0.0	0.1402	0.0
0	0	4	27586	0.0	0.0011	0.0
0	0	6	4907	0.0	0.0	0.1450
0	0	6	25325	0.0	0.0	0.0153
0	0	6	26752	0.0	0.0	0.0037
0	17293	2	1026	0.0032	0.0	0.0
0	17293	2	21483	0.0142	0.0	0.0
0	17293	2	26392	0.0146	0.0	0.0
0	17293	4	2823	0.0	0.0023	0.0
0	17293	4	26735	0.0	0.0359	0.0
0	17293	4	27586	0.0	0.0134	0.0
0	17293	6	25325	0.0	0.0	0.2384
0	17293	6	26752	0.0	0.0	0.2212
1	372	1	372	0.1541	0.0	0.0
1	372	1	19027	0.0025	0.0	0.0
1	372	2	1026	0.0518	0.0	0.0
1	372	3	1866	0.2092	0.1281	0.0
1	372	3	24355	0.0004	0.0012	0.0
1	372	3	26622	0.0002	0.0012	0.0
1	372	4	2823	0.0	0.1741	0.0
1	372	5	3849	0.0	0.1192	0.0544
1	372	5	26763	0.0	0.0004	0.0097
1	372	6	4907	0.0	0.0	0.3774
1	372	6	25325	0.0	0.0	0.0091
1	372	6	26752	0.0	0.0	0.0049
1	372	7	26357	0.0	0.0	0.0181
1	19027	1	19027	0.0133	0.0	0.0
1	19027	2	21483	0.0122	0.0	0.0
1	19027	2	26392	0.0209	0.0	0.0
1	19027	3	1866	0.0038	0.0019	0.0
1	19027	3	24355	0.0183	0.0059	0.0
1	19027	3	26622	0.0164	0.0594	0.0
1	19027	4	2823	0.0	0.0028	0.0
1	19027	4	27586	0.0	0.0078	0.0
1	19027	5	26763	0.0	0.0484	0.2332
1	19027	6	25325	0.0	0.0	0.1479
1	19027	6	26752	0.0	0.0	0.5717
1	19027	7	26357	0.0	0.0	0.2020
2	1026	2	1026	0.1000	0.1219	0.0
2	1026	2	21483	0.0018	0.0015	0.0
2	1026	3	1866	0.1863	0.2124	0.0
2	1026	3	24355	0.0002	0.0020	0.0
2	1026	4	2823	0.2226	0.0062	0.0329
2	1026	4	26735	0.0000	0.0007	0.0078
2	1026	5	3849	0.0	0.3153	0.2089

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APPENDIX VII

TABLE 2
U(K)*2 FOR EU+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
2	1026	5	26763	0.0	0.0003	0.0046
2	1026	6	4907	0.0	0.0477	0.4696
2	1026	6	26752	0.0	0.0000	0.0019
2	1026	7	26357	0.0	0.0	0.0110
2	1026	8	27244	0.0	0.0	0.0193
2	21483	2	21483	0.0011	0.0069	0.0
2	21483	2	26392	0.0086	0.0482	0.0
2	21483	3	1866	0.0023	0.0026	0.0
2	21483	3	24355	0.0351	0.0126	0.0
2	21483	3	26622	0.0305	0.0031	0.0
2	21483	4	2823	0.0020	0.0003	0.0000
2	21483	4	26735	0.0267	0.0320	0.2210
2	21483	4	27586	0.0042	0.0003	0.0040
2	21483	5	3849	0.0	0.0016	0.0000
2	21483	5	26763	0.0	0.0008	0.3829
2	21483	6	25325	0.0	0.0041	0.1586
2	21483	6	26752	0.0	0.0343	0.1586
2	21483	7	26357	0.0	0.0	0.2479
2	21483	8	27244	0.0	0.0	0.2481
2	26392	2	26392	0.0784	0.0032	0.0
2	26392	3	24355	0.0017	0.0373	0.0
2	26392	3	26622	0.1097	0.0215	0.0
2	26392	4	2823	0.0000	0.0000	0.0019
2	26392	4	26735	0.0225	0.0279	0.0057
2	26392	4	27586	0.0005	0.0040	0.4282
2	26392	5	26763	0.0	0.0067	0.1056
2	26392	6	25325	0.0	0.0480	0.4599
2	26392	6	26752	0.0	0.0004	0.0192
2	26392	7	26357	0.0	0.0	0.5130
2	26392	8	27244	0.0	0.0	0.0853
3	1866	3	1866	0.0275	0.0260	0.0281
3	1866	3	24355	0.0010	0.0005	0.0000
3	1866	3	26622	0.0000	0.0004	0.0048
3	1866	4	2823	0.3880	0.1352	0.1588
3	1866	4	26735	0.0002	0.0001	0.0030
3	1866	5	3849	0.1754	0.2527	0.3836
3	1866	5	26763	0.0000	0.0011	0.0005
3	1866	6	4907	0.0	0.2310	0.4135
3	1866	6	25325	0.0	0.0000	0.0013
3	1866	6	26752	0.0	0.0004	0.0102
3	1866	8	27244	0.0	0.0	0.0092
3	1866	9	27960	0.0	0.0	0.0168
3	24355	3	24355	0.0149	0.0023	0.0031
3	24355	3	26622	0.0115	0.0229	0.2656
3	24355	4	2823	0.0039	0.0002	0.0000
3	24355	4	26735	0.0215	0.0005	0.3633

5/2 7141 11/2 3667 0.0 0.2305 0.2087

TABLE 2
U(K)*2 FOR EU+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
3	24355	4	27586	0.0592	0.0063	0.0030
3	24355	5	3849	0.0001	0.0014	0.0000
3	24355	5	26763	0.0328	0.0174	0.2023
3	24355	6	25325	0.0	0.0000	0.0164
3	24355	6	26752	0.0	0.0097	0.0500
3	24355	7	26357	0.0	0.0067	0.1349
3	24355	8	27244	0.0	0.0	0.3256
3	24355	9	27960	0.0	0.0	0.3477
3	26622	3	26622	0.0227	0.0017	0.0644
3	26622	4	26735	0.1414	0.0745	0.1508
3	26622	4	27586	0.0021	0.0129	0.2131
3	26622	5	3849	0.0000	0.0000	0.0010
3	26622	5	26763	0.0292	0.0508	0.0086
3	26622	6	4907	0.0	0.0000	0.0020
3	26622	6	25325	0.0	0.0155	0.3677
3	26622	6	26752	0.0	0.0019	0.1249
3	26622	7	26357	0.0	0.1106	0.1248
3	26622	8	27244	0.0	0.0	0.5665
3	26622	9	27960	0.0	0.0	0.1166
4	2823	4	2823	0.0117	0.2841	0.3528
4	2823	4	26735	0.0002	0.0009	0.0005
4	2823	4	27586	0.0005	0.0006	0.0002
4	2823	5	3849	0.5684	0.0128	0.4412
4	2823	5	26763	0.0001	0.0000	0.0059
4	2823	6	4907	0.0856	0.5145	0.2691
4	2823	6	25325	0.0000	0.0002	0.0046
4	2823	6	26752	0.0001	0.0020	0.0048
4	2823	7	26357	0.0	0.0000	0.0080
4	2823	8	27244	0.0	0.0000	0.0040
4	2823	9	27960	0.0	0.0	0.0052
4	2823	10	28427	0.0	0.0	0.0093
4	26735	4	26735	0.0407	0.0000	0.0116
4	26735	4	27586	0.0156	0.0381	0.1108
4	26735	5	3849	0.0009	0.0000	0.0036
4	26735	5	26763	0.0982	0.1241	0.0505
4	26735	6	4907	0.0000	0.0003	0.0020
4	26735	6	25325	0.0094	0.0297	0.1569
4	26735	6	26752	0.0279	0.0538	0.0001
4	26735	7	26357	0.0	0.0070	0.2662
4	26735	8	27244	0.0	0.1897	0.1232
4	26735	9	27960	0.0	0.0	0.8211
4	26735	10	28427	0.0	0.0	0.0161
4	27586	4	27586	0.0817	0.0022	0.0068
4	27586	5	3849	0.0034	0.0004	0.0003
4	27586	5	26763	0.0825	0.0322	0.0384
4	27586	6	4907	0.0012	0.0000	0.0000

TABLE 2
U(K)*2 FOR EU+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
4	27586	6	25325	0.0005	0.0020	0.0166
4	27586	6	26752	0.0363	0.0028	0.0000
4	27586	7	26357	0.0	0.0023	0.0608
4	27586	8	27244	0.0	0.0001	0.1575
4	27586	9	27960	0.0	0.0	0.1547
4	27586	10	28427	0.0	0.0	0.6379
5	3849	5	3849	0.2762	0.2063	0.3225
5	3849	5	26763	0.0020	0.0002	0.0047
5	3849	6	4907	0.5410	0.6451	0.1213
5	3849	6	26752	0.0001	0.0016	0.0026
5	3849	7	26357	0.0000	0.0002	0.0073
5	3849	8	27244	0.0	0.0000	0.0176
5	3849	9	27960	0.0	0.0002	0.0176
5	3849	10	28427	0.0	0.0	0.0015
5	26763	5	26763	0.0511	0.0008	0.0186
5	26763	6	4907	0.0010	0.0011	0.0012
5	26763	6	25325	0.0070	0.0403	0.0405
5	26763	6	26752	0.0743	0.1716	0.0025
5	26763	7	26357	0.0163	0.0692	0.1518
5	26763	8	27244	0.0	0.0134	0.3016
5	26763	9	27960	0.0	0.2596	0.4888
5	26763	10	28427	0.0	0.0	0.6377
6	4907	6	4907	1.2029	0.3940	0.0294
6	4907	6	26752	0.0085	0.0022	0.0003
6	4907	7	26357	0.0000	0.0001	0.0013
6	4907	8	27244	0.0000	0.0003	0.0074
6	4907	9	27960	0.0	0.0000	0.0242
6	4907	10	28427	0.0	0.0020	0.0524
6	25325	6	25325	0.0050	0.9355	0.1758
6	25325	6	26752	0.0019	0.0328	0.0009
6	25325	7	26357	0.0147	0.3310	0.1468
6	25325	8	27244	0.0076	0.0725	0.1020
6	25325	9	27960	0.0	0.0000	0.0046
6	25325	10	28427	0.0	0.0067	0.0563
6	26752	6	26752	0.1047	0.0578	0.0094
6	26752	7	26357	0.0004	0.0612	0.0509
6	26752	8	27244	0.0177	0.0480	0.0601
6	26752	9	27960	0.0	0.0384	0.3009
6	26752	10	28427	0.0	0.2938	1.4460
7	26357	7	26357	0.0152	0.6740	0.0269
7	26357	8	27244	0.0249	0.4856	0.1671
7	26357	9	27960	0.0083	0.0804	0.1032
7	26357	10	28427	0.0	0.0000	0.0313

7/2	1135	15/2	6520	0.0	0.0003	0.0467

TABLE 2
U(K)*2 FOR EU+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
8	27244	8	27244	0.0176	0.7179	0.0175
8	27244	9	27960	0.0345	0.5312	0.1917
8	27244	10	28427	0.0055	0.0466	0.1105
9	27960	9	27960	0.0110	1.0574	0.0513
9	27960	10	28427	0.0379	0.4237	0.2855
10	28427	10	28427	0.0002	1.8415	0.4018

APPENDIX VIII

9/2 2341 11/2 25829 0.0001 0.0001 0.0011

APPENDIX VIII

TABLE 1
GD+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
0.0	1	0	8S	7/2	-7/2
0.0	1	0	8S	7/2	5/2
0.0	1	0	8S	7/2	3/2
0.0	1	0	8S	7/2	1/2
32177.11	32183	-5	6P	7/2	-7/2
32185.62	32189	-3	6P	7/2	5/2
32199.61	32209	-8	6P	7/2	3/2
32228.57	32232	-3	6P	7/2	1/2
32771.75	32787	-14	6P	5/2	3/2
32791.96	32788	4	6P	5/2	5/2
32809.29	32799	10	6P	5/2	1/2
33352.00	33351	1	6P	3/2	1/2
33370.00	33366	4	6P	3/2	3/2
35923.00	35929	-5	6I	7/2	5/2
35945.24	35939	6	6I	7/2	3/2
35969.03	35962	7	6I	7/2	-7/2
35996.14	35979	17	6I	7/2	1/2
36275.25	36268	8	6I	9/2	5/2
36286.08	36276	10	6I	9/2	-7/2
36306.24	36297	9	6I	9/2	3/2
36314.26	36305	10	6I	9/2	-9/2
36333.45	36316	17	6I	9/2	1/2
36340.81	36342	-1	6I	17/2	-9/2
36343.03	36344	0	6I	17/2	-11/2
36347.18	36344	3	6I	17/2	-7/2
36351.69	36346	5	6I	17/2	13/2
36354.80	36348	7	6I	17/2	15/2
36364.51	36350	15	6I	17/2	5/2
36371.71	36355	17	6I	17/2	3/2
36377.86	36358	20	6I	17/2	17/2
36384.90	36359	26	6I	17/2	1/2
36551.43	36556	-4	6I	11/2	-7/2
36563.33	36567	-3	6I	11/2	-9/2
36573.18	36575	-1	6I	11/2	5/2
36586.14	36593	-6	6I	11/2	3/2
36594.86	36593	2	6I	11/2	-11/2
36613.04	36611	2	6I	11/2	1/2
36661.81	36674	-11	6I	15/2	-9/2
36670.99	36686	-14	6I	15/2	-11/2
36679.98	36690	-9	6I	15/2	-7/2
36690.17	36706	-14	6I	15/2	5/2
36700.50	36707	-5	6I	15/2	13/2

APPENDIX VIII

TABLE 1
GD+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
36703.65	36714	-10	6I	15/2	15/2
36713.00	36722	-8	6I	13/2	-7/2
36715.52	36722	-6	6I	15/2	3/2
36720.08	36725	-3	6I	15/2	15/2
36724.82	36732	-6	6I	15/2	1/2
36734.46	36737	-2	6I	13/2	-11/2
36738.99	36737	2	6I	13/2	5/2
36752.82	36759	-5	6I	13/2	13/2
36763.02	36769	-5	6I	13/2	3/2
36772.50	36770	2	6I	13/2	1/2
39667.00	39660	7	6D	9/2	-9/2
39686.00	39694	-7	6D	9/2	1/2
39719.00	39729	-9	6D	9/2	3/2
39742.00	39741	1	6D	9/2	-7/2
39758.00	39763	-4	6D	9/2	5/2
...	40644	...	6D	1/2	1/2
40734.00	40732	2	6D	7/2	5/2
40740.00	40737	3	6D	7/2	3/2
40744.00	40743	1	6D	7/2	1/2
40751.00	40754	-2	6D	7/2	-7/2
...	40895	...	6D	3/2	3/2
...	40909	...	6D	3/2	1/2
...	41004	...	6D	5/2	3/2
...	41049	...	6D	5/2	5/2
...	41061	...	6D	5/2	1/2
49170.00	49159	11	6G	7/2	-7/2
...	49232	...	6G	7/2	3/2
49221.00	49233	-11	6G	7/2	5/2
49240.00	49248	-7	6G	7/2	1/2
...	49533	...	6G	11/2	-11/2
...	49539	...	6G	9/2	-9/2
...	49608	...	6G	9/2	-7/2
...	49633	...	6G	9/2	1/2
...	49643	...	6G	5/2	5/2
...	49670	...	6G	9/2	3/2
...	49674	...	6G	9/2	-7/2
...	49695	...	6G	9/2	3/2
...	49732	...	6G	11/2	1/2
...	49735	...	6G	11/2	3/2
...	49741	...	6G	11/2	5/2
...	49815	...	6G	11/2	-7/2
...	49849	...	6G	11/2	-9/2

11/2 21147 13/2 24676 0.0437 0.1422 0.1556

APPENDIX VIII

TABLE 1A
GD+3:LAF3 CENTERS OF GRAVITY

CALC CENTER	STATE
2	8S 7/2
32232	6P 7/2
32827	6P 5/2
33398	6P 3/2
35949	6I 7/2
36291	6I 9/2
36345	6I17/2
36582	6I11/2
36704	6I15/2
36742	6I13/2
39723	6D 7/2
40654	6D 1/2
40901	6F 3/2
41037	6D 5/2

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TABLE 2
U(K)*2 FOR GD+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
1/2	40654	3/2	33398	0.0028	0.0	0.0
1/2	40654	3/2	40901	0.0090	0.0	0.0
1/2	40654	5/2	32827	0.0572	0.0	0.0
1/2	40654	5/2	41037	0.0301	0.0	0.0
1/2	40654	9/2	36291	0.0	0.0031	0.0
1/2	40654	9/2	39723	0.0	0.0088	0.0
1/2	40654	11/2	36582	0.0	0.0	0.0033
3/2	33398	3/2	33398	0.0109	0.0	0.0
3/2	33398	3/2	40901	0.0222	0.0	0.0
3/2	33398	5/2	32827	0.0430	0.0002	0.0
3/2	33398	5/2	41037	0.0725	0.0013	0.0
3/2	33398	7/2	32232	0.0090	0.0004	0.0
3/2	33398	9/2	36291	0.0	0.0002	0.2310
3/2	33398	9/2	39723	0.0	0.0022	0.0000
3/2	33398	11/2	36582	0.0	0.0016	0.4382
3/2	33398	13/2	36742	0.0	0.0	0.5719
3/2	33398	15/2	36704	0.0	0.0	0.5483
3/2	40901	3/2	40901	0.0323	0.0	0.0
3/2	40901	5/2	32827	0.0742	0.0018	0.0
3/2	40901	5/2	41037	0.0130	0.0061	0.0
3/2	40901	7/2	32232	0.0276	0.0022	0.0
3/2	40901	7/2	35949	0.0000	0.0045	0.0
3/2	40901	9/2	36291	0.0	0.0005	0.0011
3/2	40901	11/2	36582	0.0	0.0116	0.0362
3/2	40901	13/2	36742	0.0	0.0	0.0837
3/2	40901	15/2	36704	0.0	0.0	0.0355
5/2	32827	5/2	32827	0.0292	0.0013	0.0
5/2	32827	5/2	41037	0.0424	0.0073	0.0
5/2	32827	7/2	32232	0.0180	0.0001	0.0001
5/2	32827	7/2	35949	0.0000	0.0023	0.7074
5/2	32827	9/2	36291	0.0001	0.0015	0.4109
5/2	32827	9/2	39723	0.2003	0.0014	0.0002
5/2	32827	11/2	36582	0.0	0.0000	0.1428
5/2	32827	13/2	36742	0.0	0.0052	0.0026
5/2	32827	15/2	36704	0.0	0.0	0.1435
5/2	32827	17/2	36345	0.0	0.0	1.1037
5/2	41037	5/2	41037	0.0005	0.0247	0.0
5/2	41037	7/2	2	0.0026	0.0000	0.0000
5/2	41037	7/2	32232	0.0868	0.0005	0.0000
5/2	41037	7/2	35949	0.0002	0.0123	0.0445
5/2	41037	9/2	36291	0.0001	0.0088	0.0945
5/2	41037	9/2	39723	0.0035	0.0120	0.0002
5/2	41037	11/2	36582	0.0	0.0000	0.0660
5/2	41037	13/2	36742	0.0	0.0245	0.0015
5/2	41037	15/2	36704	0.0	0.0	0.0715
5/2	41037	17/2	36345	0.0	0.0	0.1368

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APPENDIX VIII

TABLE 2
U(K)*2 FOR GD+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
7/2	2	7/2	32232	0.0011	0.0000	0.0000
7/2	2	7/2	35949	0.0000	0.0000	0.0044
7/2	2	9/2	36291	0.0000	0.0000	0.0110
7/2	2	9/2	39723	0.0060	0.0001	0.0000
7/2	2	11/2	36582	0.0000	0.0000	0.0188
7/2	2	13/2	36742	0.0	0.0000	0.0257
7/2	2	15/2	36704	0.0	0.0000	0.0287
7/2	2	17/2	36345	0.0	0.0	0.0228
1/2	0	1/2	0			
7/2	32232	7/2	32232	0.1202	0.0017	0.0001
7/2	32232	7/2	35949	0.0000	0.0018	0.1763
7/2	32232	9/2	36291	0.0003	0.0048	0.3759
7/2	32232	9/2	39723	0.1879	0.0210	0.0000
7/2	32232	11/2	36582	0.0000	0.0051	0.5639
7/2	32232	13/2	36742	0.0	0.0019	0.7186
7/2	32232	15/2	36704	0.0	0.0037	0.8186
7/2	32232	17/2	36345	0.0	0.0	0.7818
7/2	35949	7/2	35949	0.0047	0.0087	0.0007
7/2	35949	9/2	36291	0.0008	0.0013	0.0025
7/2	35949	9/2	39723	0.0002	0.0011	0.0046
7/2	35949	11/2	36582	0.0008	0.0005	0.0000
7/2	35949	15/2	36704	0.0	0.0001	0.0009
9/2	36291	9/2	36291	0.0099	0.0141	0.0005
9/2	36291	9/2	39723	0.0008	0.0060	0.0099
9/2	36291	11/2	36582	0.0021	0.0019	0.0018
9/2	36291	13/2	36742	0.0016	0.0013	0.0001
9/2	36291	15/2	36704	0.0	0.0019	0.0002
9/2	39723	9/2	39723	0.0854	0.0722	0.0017
9/2	39723	11/2	36582	0.0011	0.0191	0.0075
9/2	39723	13/2	36742	0.0002	0.0326	0.0002
9/2	39723	15/2	36704	0.0	0.0318	0.0095
9/2	39723	17/2	36345	0.0	0.0140	0.0409
11/2	36582	11/2	36582	0.0129	0.0191	0.0007
11/2	36582	13/2	36742	0.0045	0.0009	0.0016
11/2	36582	15/2	36704	0.0019	0.0033	0.0000
11/2	36582	17/2	36345	0.0	0.0018	0.0011
13/2	36742	13/2	36742	0.0122	0.0235	0.0015
13/2	36742	15/2	36704	0.0082	0.0001	0.0010
13/2	36742	17/2	36345	0.0013	0.0055	0.0012
15/2	36704	15/2	36704	0.0067	0.0189	0.0040
15/2	36704	17/2	36345	0.0115	0.0088	0.0008

APPENDIX IX

APPENDIX IX

TABLE 1
TB+3:LAF3 CENTERS OF GRAVITY

OBSERVED	CALC	O-C	STATE
...	124	...	7F6
...	2172	...	7F5
...	3439	...	7F4
4423	4418	5	7F3
5074	5106	-31	7F2
5560	5561	0	7F1
5814	5784	30	7F0
20566	20568	-1	5D4
26317	26360	-42	5D3
26529	26547	-17	5G6
27111	27095	16	5L10
27919	27891	28	5G5
28247	28231	16	5D2
...	28411	...	5G4
28489	28532	-42	5L9
29069	29101	-31	5G3
29343	29314	29	5L8
29595	29581	14	5L7
...	29655	...	5G2
...	29734	...	5L6
30750	30734	16	5D1
...	31348	...	5D0
31492	31503	-10	5H7
32998	33015	-16	5H6
33942	33891	51	5H5
34466	34463	3	5H4
35063	35058	5	5F5
...	35060	...	5H3
35344	35255	89	5I8
...	35498	...	5F4
...	36674	...	5F3
36657	36713	-55	5I7
37275	37260	15	5F2
...	37606	...	5F1
...	37722	...	5I6
...	37732	...	5I4
...	38110	...	5I5
39287	39297	-9	5K9
...	39515	...	5D2
...	40309	...	5G6
40913	40939	-25	5K8
41447	41458	-10	5K5
...	41473	...	5G6
...	41817	...	5K7

2	1026	4	26735	0.0000	0.0007	0.0078
2	1026	5	3849	0.0	0.3153	0.2089

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TABLE 2
U(K)*2 FOR TB+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
0	5784	2	5106	0.1391	0.0	0.0
0	5784	2	28231	0.0010	0.0	0.0
0	5784	4	3439	0.0	0.1389	0.0
0	5784	4	20569	0.0	0.0017	0.0
0	5784	6	125	0.0	0.0	0.1441
1	5561	1	5561	0.1562	0.0	0.0
1	5561	2	5106	0.0513	0.0	0.0
1	5561	3	4419	0.2102	0.1273	0.0
1	5561	3	26360	0.0011	0.0013	0.0
1	5561	4	3439	0.0	0.1719	0.0
1	5561	4	20569	0.0	0.0025	0.0
1	5561	5	2173	0.0	0.1188	0.0537
1	5561	6	125	0.0	0.0	0.3761
1	5561	7	29582	0.0	0.0	0.0093
2	5106	2	5106	0.1002	0.1211	0.0
2	5106	2	28231	0.0010	0.0010	0.0
2	5106	3	4419	0.1829	0.2101	0.0
2	5106	3	26360	0.0014	0.0026	0.0
2	5106	4	3439	0.2224	0.0060	0.0324
2	5106	4	20569	0.0011	0.0004	0.0001
2	5106	4	28412	0.0016	0.0000	0.0005
2	5106	5	2173	0.0	0.3135	0.2071
2	5106	5	27892	0.0	0.0001	0.0014
2	5106	6	125	0.0	0.0481	0.4695
2	5106	7	29582	0.0	0.0	0.0157
2	5106	8	29315	0.0	0.0	0.0199
2	28231	2	28231	0.0168	0.0080	0.0
2	28231	3	4419	0.0028	0.0024	0.0
2	28231	3	26360	0.0269	0.0056	0.0
2	28231	4	3439	0.0009	0.0005	0.0000
2	28231	4	20569	0.0362	0.0048	0.0059
2	28231	4	28412	0.0602	0.0008	0.0217
2	28231	5	2173	0.0	0.0027	0.0006
2	28231	5	27892	0.0	0.0166	0.1466
2	28231	6	26548	0.0	0.0255	0.3510
2	28231	7	29582	0.0	0.0	0.3579
2	28231	8	29315	0.0	0.0	0.2572
3	4419	3	4419	0.0272	0.0253	0.0278
3	4419	3	26360	0.0007	0.0009	0.0000
3	4419	4	3439	0.3782	0.1343	0.1575
3	4419	4	20569	0.0022	0.0005	0.0006
3	4419	4	28412	0.0025	0.0000	0.0026
3	4419	5	2173	0.1767	0.2504	0.3816
3	4419	5	27892	0.0019	0.0001	0.0020
3	4419	6	125	0.0	0.2323	0.4129
3	4419	8	29315	0.0	0.0	0.0152

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3	24355	4	26735	0.0215	0.0005	0.3633

TABLE 2
U(K)*2 FOR TB+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
3	4419	9	28532	0.0	0.0	0.0255
3	26360	3	26360	0.0000	0.0021	0.0027
3	26360	4	3439	0.0065	0.0001	0.0002
3	26360	4	20569	0.0535	0.0291	0.0085
3	26360	4	28412	0.0058	0.0228	0.1398
3	26360	5	2173	0.0005	0.0028	0.0016
3	26360	5	27892	0.0837	0.0303	0.2981
3	26360	6	125	0.0	0.0002	0.0014
3	26360	6	26548	0.0	0.0341	0.2412
3	26360	7	29582	0.0	0.0035	0.0221
3	26360	8	29315	0.0	0.0	0.2546
3	26360	9	28532	0.0	0.0	0.4161
4	3439	4	3439	0.0120	0.2792	0.3500
4	3439	4	20569	0.0002	0.0022	0.0014
4	3439	4	28412	0.0000	0.0006	0.0068
4	3439	5	2173	0.5541	0.0120	0.4374
4	3439	5	27892	0.0042	0.0009	0.0012
4	3439	6	125	0.0888	0.5159	0.2658
4	3439	6	26548	0.0023	0.0000	0.0025
4	3439	7	29582	0.0	0.0029	0.0069
4	3439	8	29315	0.0	0.0014	0.0004
4	3439	9	28532	0.0	0.0	0.0150
4	3439	10	27096	0.0	0.0	0.0322
4	20569	4	20569	0.0463	0.0310	0.0038
4	20569	4	28412	0.0004	0.0051	0.5115
4	20569	5	2173	0.0142	0.0013	0.0022
4	20569	5	27892	0.0046	0.0631	0.3964
4	20569	6	125	0.0009	0.0008	0.0013
4	20569	6	26548	0.1131	0.2067	0.1457
4	20569	7	29582	0.0	0.0333	0.0336
4	20569	8	29315	0.0	0.0104	0.0723
4	20569	9	28532	0.0	0.0	0.2758
4	20569	10	27096	0.0	0.0	0.8669
4	28412	4	28412	0.0682	0.0148	0.0062
4	28412	5	2173	0.0005	0.0000	0.0021
4	28412	5	27892	0.0285	0.1564	0.0665
4	28412	6	125	0.0001	0.0003	0.0087
4	28412	6	26548	0.0113	0.0903	0.0677
4	28412	7	29582	0.0	0.2416	0.3920
4	28412	8	29315	0.0	0.0016	0.0036
4	28412	9	28532	0.0	0.0	0.2736
4	28412	10	27096	0.0	0.0	0.0540
5	2173	5	2173	0.2764	0.2071	0.3179
5	2173	5	27892	0.0001	0.0002	0.0065
5	2173	6	125	0.5377	0.6420	0.1178

4	27586	5	3849	0.0034	0.0004	0.0003
4	27586	5	26763	0.0825	0.0322	0.0384
4	27586	6	4907	0.0012	0.0000	0.0000

TABLE 2
U(K)*2 FOR TB+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
5	2173	6	26548	0.0040	0.0028	0.0093
5	2173	7	29582	0.0002	0.0003	0.0066
5	2173	8	29315	0.0	0.0019	0.0210
5	2173	9	28532	0.0	0.0007	0.0136
5	2173	10	27096	0.0	0.0	0.0015
5	27892	5	27892	0.2578	0.0001	0.0540
5	27892	6	125	0.0012	0.0018	0.0131
5	27892	6	26548	0.0203	0.1466	0.0648
5	27892	7	29582	0.0115	0.1091	0.3075
5	27892	8	29315	0.0	0.2877	0.3396
5	27892	9	28532	0.0	0.0001	0.0532
5	27892	10	27096	0.0	0.0	0.4457
6	125	6	125	1.2125	0.3881	0.0275
6	125	6	26548	0.0016	0.0044	0.0116
6	125	7	29582	0.0006	0.0001	0.0121
6	125	8	29315	0.0000	0.0001	0.0228
6	125	9	28532	0.0	0.0019	0.0455
6	125	10	27096	0.0	0.0003	0.0580
6	26548	6	26548	0.5802	0.0288	0.3499
6	26548	7	29582	0.0464	0.0002	0.3264
6	26548	8	29315	0.0059	0.0256	0.5607
6	26548	9	28532	0.0	0.2520	0.7123
6	26548	10	27096	0.0	0.0068	0.9143
7	29582	7	29582	0.0832	0.4493	0.2158
7	29582	8	29315	0.0829	0.4047	0.0877
7	29582	9	28532	0.0003	0.0342	0.1139
7	29582	10	27096	0.0	0.1037	0.0029
8	29315	8	29315	0.0509	0.6174	0.1799
8	29315	9	28532	0.0771	0.4809	0.1204
8	29315	10	27096	0.0000	0.0698	0.0803
9	28532	9	28532	0.0236	0.9206	0.1766
9	28532	10	27096	0.0727	0.4668	0.1548
10	27096	10	27096	0.0002	1.8580	0.3777

7	26357	10	28427	0.0		0.0000	0.0313

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APPENDIX X

APPENDIX X

TABLE 1
DY+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
0	22	-21	6H	15/2	1/2
17	26	-8	6H	15/2	15/2
69	79	-9	6H	15/2	13/2
124	106	18	6H	15/2	3/2
184	195	-10	6H	15/2	5/2
208	216	-7	6H	15/2	-11/2
307	323	-15	6H	15/2	-9/2
...	335	...	6H	15/2	-7/2
3502	3493	9	6H	13/2	13/2
...	3579	...	6H	13/2	-7/2
3576	3616	-39	6H	13/2	3/2
3618	3636	-17	6H	13/2	5/2
3630	3637	-6	6H	13/2	1/2
3645	3671	-25	6H	13/2	-9/2
3695	3679	16	6H	13/2	-11/2
5882	5873	9	6H	11/2	-7/2
5908	5910	-1	6H	11/2	-11/2
5924	5913	11	6H	11/2	-9/2
5944	5931	13	6H	11/2	5/2
5975	5968	7	6H	11/2	3/2
6020	6021	0	6H	11/2	1/2
7633	7613	20	6H	9/2	5/2
7665	7654	11	6H	9/2	-9/2
7728	7719	9	6H	9/2	3/2
7758	7777	-18	6F	11/2	1/2
7801	7809	-7	6H	9/2	-7/2
7814	7839	-24	6F	11/2	1/2
7838	7840	-1	6F	11/2	5/2
7842	7852	-9	6F	11/2	3/2
7933	7938	-4	6H	9/2	1/2
7998	8009	-10	6F	11/2	-7/2
8077	8094	-16	6F	11/2	-9/2
8992	8974	18	6F	9/2	5/2
9087	9069	18	6H	7/2	3/2
9074	9072	2	6F	9/2	-7/2
9144	9139	5	6F	9/2	3/2
9181	9176	5	6F	9/2	1/2
9235	9240	-4	6F	9/2	-9/2
9282	9277	5	6H	7/2	-7/2
9343	9330	13	6H	7/2	1/2
9435	9447	-11	6H	7/2	5/2
10222	10211	11	6H	5/2	5/2
10285	10265	20	6H	5/2	1/2
10345	10336	9	6H	5/2	3/2

36679.98	36690	-9	6I	15/2	-7/2
36690.17	36706	-14	6I	15/2	5/2
36700.50	36707	-5	6I	15/2	13/2

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...	49813	...	6G	11/2	-7/2
...	49849	...	6G	11/2	-9/2

APPENDIX X

TABLE 1
DY+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
11037	11028	9	6F	7/2	5/2
11109	11101	8	6F	7/2	1/2
11140	11141	0	6F	7/2	-7/2
11153	11143	10	6F	7/2	3/2
12456	12455	1	6F	5/2	3/2
12504	12493	11	6F	5/2	5/2
12520	12512	8	6F	5/2	1/2
13271	13277	-5	6F	3/2	3/2
13285	13286	0	6F	3/2	1/2
...	13827	...	6F	1/2	1/2
21057	21071	-13	4F	9/2	-9/2
21142	21137	5	4F	9/2	5/2
21159	21163	-3	4F	9/2	3/2
21205	21205	0	4I	9/2	1/2
21395	21393	2	4F	9/2	-7/2
22022	21956	66	4I	15/2	15/2
22132	22111	21	4I	15/2	5/2
22175	22155	20	4I	15/2	13/2
22189	22184	5	4I	15/2	1/2
22213	22209	4	4F	15/2	-7/2
22292	22272	20	4I	15/2	-9/2
22342	22332	10	4I	15/2	-11/2
22379	22357	22	4I	15/2	13/2
23468	23457	11	4G	11/2	-9/2
23497	23512	-14	4G	11/2	-7/2
23513	23531	-17	4G	11/2	-11/2
23537	23554	-16	4F	11/2	5/2
23551	23570	-18	4G	11/2	3/2
...	23616	...	4G	11/2	1/2
...	24865	...	4M	21/2	-21/2
...	24955	...	4M	21/2	-7/2
24990	24969	21	4M	21/2	3/2
25008	24986	22	4M	21/2	1/2
25073	25097	-23	4M	21/2	-9/2
...	25097	...	4M	21/2	-11/2
25098	25102	-3	4M	21/2	5/2
...	25145	...	4M	21/2	13/2
25195	25227	-31	4M	21/2	15/2
...	25229	...	4M	21/2	-19/2
25303	25272	31	4M	21/2	17/2

APPENDIX X

TABLE 1
DY+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	25588	...	4I	13/2	13/2
25661	25647	14	4I	13/2	5/2
25691	25713	-21	4I	13/2	3/2
25740	25716	24	4I	13/2	-7/2
25748	25748	0	4F	7/2	1/2
25778	25811	-32	4K	17/2	17/2
...	25814	...	4I	13/2	-9/2
25824	25819	5	4I	13/2	-11/2
...	25831	...	4K	17/2	-7/2
25849	25859	-9	4I	13/2	1/2
25867	25899	-31	4K	17/2	5/2
...	25900	...	4I	13/2	-9/2
...	25907	...	4F	7/2	-7/2
...	25910	...	4F	7/2	3/2
25903	25920	-16	4K	17/2	1/2
25918	25929	-10	4K	17/2	3/2
...	25958	...	4F	7/2	5/2
25940	25968	-27	4K	17/2	15/2
25953	25974	-20	4I	17/2	-11/2
25990	25986	4	4I	17/2	13/2
...	26178	...	4M	19/2	-19/2
...	26188	...	4M	19/2	-9/2
...	26194	...	4M	19/2	-7/2
26260	26228	32	4M	19/2	-11/2
26358	26348	10	4M	19/2	13/2
26429	26396	33	4M	19/2	5/2
26448	26421	27	4M	19/2	3/2
26509	26481	28	4M	19/2	1/2
26571	26517	54	4M	19/2	17/2
26583	26527	56	4M	19/2	15/2
27482	27508	-25	4P	3/2	1/2
27536	27556	-19	6P	3/2	3/2
27581	27586	-4	6P	5/2	5/2
27624	27626	-1	6P	5/2	3/2
27665	27659	6	6P	5/2	1/2
...	27841	...	4I	11/2	-11/2
27919	27944	-24	4I	11/2	5/2
...	27959	...	4I	11/2	3/2
27988	28001	-12	4I	11/2	1/2
28036	28006	30	4I	11/2	-7/2
28074	28035	39	4I	11/2	-9/2

APPENDIX X

TABLE 1
DY+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
28347	28409	-61	4M	15/2	15/2
28381	28448	-66	4M	15/2	5/2
...	28515	...	4M	15/2	3/2
28536	28574	-37	4M	15/2	1/2
28577	28600	-22	4M	15/2	-7/2
28613	28632	-18	6P	7/2	3/2
28636	28653	-16	6P	7/2	1/2
28658	28662	-3	6P	7/2	3/2
28674	28667	7	6P	7/2	5/2
28715	28707	8	6P	7/2	-7/2
28734	28769	-34	4M	15/2	-11/2
...	28797	...	4M	15/2	13/2
...	29467	...	4F	5/2	3/2
29535	29574	-38	4I	9/2	1/2
29638	29620	18	4I	9/2	-9/2
29667	29622	45	4F	5/2	5/2
29684	29688	-3	4F	5/2	1/2
29752	29732	20	4I	9/2	-7/2
29787	29825	-37	4I	9/2	3/2
29855	29855	0	4I	9/2	5/2
29890	29917	-26	4G	9/2	-7/2
...	29945	...	4M	17/2	5/2
...	29949	...	4M	17/2	3/2
...	29984	...	4M	17/2	17/2
...	29986	...	4M	17/2	-9/2
29982	29988	-5	4K	17/2	1/2
...	30037	...	4M	17/2	15/2
...	30047	...	4K	17/2	-11/2
30075	30066	9	4K	17/2	13/2
30141	30131	10	4M	17/2	-7/2
...	30193	...	4G	9/2	1/2
30243	30220	23	4G	9/2	3/2
...	30269	...	4G	9/2	5/2
30302	30293	9	4G	9/2	3/2
30887	30868	19	6P	3/2	1/2
30924	30897	27	6P	3/2	3/2

5/2	41037	15/2	36704	0.0	0.0	0.0715
5/2	41037	17/2	36345	0.0	0.0	0.1368

APPENDIX X

TABLE 1
DY+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
31055	31061	-5	4K	15/2	1/2
...	31101	...	4K	15/2	13/2
31134	31137	-2	4K	15/2	3/2
31169	31152	17	4L	19/2	15/2
31194	31171	23	4K	15/2	-11/2
31211	31219	-7	4K	15/2	5/2
31225	31232	-6	4L	19/2	-9/2
...	31234	...	4M	19/2	17/2
31259	31250	9	4M	19/2	17/2
31282	31282	0	2L	19/2	1/2
31294	31315	-20	4L	19/2	-9/2
...	31319	...	4M	19/2	5/2
31328	31329	0	4M	19/2	-19/2
...	31344	...	4K	15/2	-7/2
...	31348	...	4L	19/2	15/2
31379	31382	-2	2L	19/2	13/2
31452	31431	21	2L	19/2	-11/2
...	31434	...	4K	15/2	-9/2
31580	31570	10	4G	7/2	5/2
31660	31655	5	4G	7/2	3/2
...	31712	...	4G	7/2	1/2
31716	31717	0	4G	7/2	-7/2
...	32060	...	4D	5/2	1/2
...	32089	...	4D	5/2	5/2
...	32169	...	4D	1/2	1/2
...	32182	...	4D	5/2	3/2
33146	33149	-2	4K	13/2	-11/2
...	33179	...	4K	13/2	-7/2
33202	33186	16	4K	13/2	13/2
...	33196	...	4K	13/2	3/2
33218	33207	11	4K	13/2	1/2
33236	33212	24	4K	13/2	-9/2
33256	33225	31	4K	13/2	5/2
...	33492	...	4H	13/2	-9/2
33527	33515	12	4H	13/2	13/2
33527	33519	8	4H	13/2	5/2
33527	33520	7	4H	13/2	3/2
33527	33523	4	4H	13/2	13/2
33623	33578	45	4K	13/2	-7/2
33558	33579	-20	4H	13/2	1/2
33666	33645	21	4F	3/2	1/2
33652	33646	6	4F	3/2	3/2

APPENDIX X

TABLE 1
DY+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
34029	34021	8	4D	7/2	1/2
34040	34022	18	4D	7/2	3/2
34052	34036	16	4D	7/2	-7/2
34080	34058	22	4D	7/2	5/2
...	34236	...	4H	11/2	-9/2
...	34237	...	4H	11/2	-7/2
...	34267	...	4H	11/2	-11/2
34247	34272	-24	4L	17/2	3/2
34250	34284	-33	4L	17/2	1/2
...	34284	...	4H	11/2	-7/2
...	34293	...	4F	5/2	3/2
...	34317	...	4H	11/2	1/2
34298	34322	-23	4L	17/2	5/2
34313	34327	-13	4L	17/2	15/2
...	34328	...	4L	17/2	13/2
...	34345	...	4L	17/2	3/2
...	34354	...	4L	17/2	-11/2
...	34361	...	4H	11/2	-7/2
...	34367	...	4L	17/2	-9/2
34366	34384	-17	4L	17/2	17/2
34393	34418	-24	4H	9/2	-9/2
34418	34437	-18	4H	9/2	1/2
34426	34439	-12	4H	9/2	-7/2
34477	34470	7	4H	11/2	5/2
34466	34470	-3	4H	9/2	3/2
...	34482	...	4F	5/2	1/2
34525	34502	23	4H	9/2	5/2
34854	34851	3	4G	11/2	-9/2
34873	34874	0	4H	11/2	-7/2
34904	34902	2	4H	11/2	5/2
34914	34906	8	4G	11/2	1/2
34935	34929	6	4G	11/2	3/2
34973	34998	-24	4G	11/2	-11/2
...	35780	...	4K	11/2	-9/2
...	35781	...	4K	11/2	1/2
...	35910	...	4K	11/2	-11/2
35940	35952	-11	4K	11/2	-7/2
35966	35963	3	4K	11/2	3/2
35994	35988	6	4G	7/2	3/2
36006	36008	-1	4G	7/2	-7/2
36055	36054	1	4G	7/2	1/2
36055	36095	-39	4K	11/2	-7/2
36080	36162	-81	4G	7/2	5/2

APPENDIX X

TABLE 1
DY+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	36467	...	4L	13/2	5/2
...	36469	...	4G	5/2	1/2
...	36469	...	4L	15/2	3/2
36494	36502	-7	4L	15/2	1/2
36512	36526	-13	4L	13/2	-7/2
36536	36543	-6	4L	15/2	13/2
...	36544	...	4L	13/2	-9/2
...	36564	...	4L	15/2	15/2
...	36564	...	4L	15/2	5/2
...	36565	...	4L	13/2	1/2
...	36582	...	4L	13/2	13/2
...	36586	...	4L	13/2	3/2
...	36604	...	4G	5/2	5/2
36634	36610	24	4G	5/2	3/2
...	36622	...	4L	13/2	-11/2
36668	36639	29	4L	15/2	-7/2
36653	36640	13	4L	15/2	-9/2
36686	36677	9	4L	13/2	1/2
36752	36750	2	4G	9/2	-7/2
36780	36785	-4	4G	9/2	3/2
...	36812	...	4G	9/2	-9/2
...	36840	...	4G	9/2	-7/2
...	36854	...	4G	9/2	1/2
...	37638	...	4G	7/2	3/2
...	37672	...	4P	1/2	1/2
...	37681	...	4L	7/2	5/2
...	37777	...	4L	7/2	-7/2
...	37794	...	4G	7/2	1/2
37944	37948	-3	2L	15/2	15/2
...	37977	...	4F	3/2	1/2
37978	38011	-32	2L	15/2	-7/2
...	38021	...	4F	3/2	3/2
...	38112	...	2L	15/2	-9/2
...	38214	...	2L	15/2	5/2
...	38223	...	2L	15/2	1/2
...	38296	...	2L	15/2	-9/2
...	38416	...	2L	15/2	-11/2
...	38476	...	2L	15/2	13/2
38937	38908	29	4P	5/2	3/2
38996	38994	2	4P	5/2	5/2
39090	39080	10	4P	5/2	1/2
39152	39169	-16	4P	3/2	3/2
39176	39192	-15	4P	3/2	1/2

APPENDIX X

TABLE 1A
DY+3:LAF3 CENTERS OF GRAVITY

CALC CENTER	STATE
175	6H15/2
3626	6H13/2
5952	6H11/2
7806	6H 9/2
7853	6F11/2
9166	6F 9/2
9223	6H 7/2
10273	6H 5/2
11070	6F 7/2
12471	6F 5/2
13267	6F 3/2
13814	6F 1/2
21228	4F 9/2
22222	4H15/2
23563	4G11/2
25109	4M21/2
25794	4I13/2
25856	4F 7/2
25890	4K17/2
26334	4M19/2
27543	6P 3/2
27624	6P 5/2

3	4419	5	27892	0.0019	0.0001	0.0020
3	4419	6	125	0.0	0.2323	0.4129
3	4419	8	29315	0.0	0.0	0.0152

TABLE 2
U(K)*2 FOR DY+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
1/2	13814	3/2	13267	0.0175	0.0	0.0
1/2	13814	3/2	27543	0.0665	0.0	0.0
1/2	13814	5/2	10273	0.1918	0.0	0.0
1/2	13814	5/2	12471	0.0100	0.0	0.0
1/2	13814	5/2	27624	0.0147	0.0	0.0
1/2	13814	7/2	9223	0.0	0.1394	0.0
1/2	13814	7/2	11070	0.0	0.0294	0.0
1/2	13814	7/2	25856	0.0	0.0156	0.0
1/2	13814	9/2	7806	0.0	0.1512	0.0
1/2	13814	9/2	9166	0.0	0.0060	0.0
1/2	13814	11/2	5952	0.0	0.0	0.3478
1/2	13814	11/2	7853	0.0	0.0	0.0050
1/2	13814	11/2	23563	0.0	0.0	0.0020
1/2	13814	13/2	3626	0.0	0.0	0.1001
1/2	13814	13/2	25794	0.0	0.0	0.0013
3/2	13267	3/2	27543	0.1391	0.0	0.0
3/2	13267	5/2	10273	0.1396	0.1346	0.0
3/2	13267	5/2	12471	0.0222	0.0260	0.0
3/2	13267	5/2	27624	0.0964	0.0227	0.0
3/2	13267	7/2	9223	0.2421	0.1179	0.0
3/2	13267	7/2	11070	0.0134	0.0104	0.0
3/2	13267	7/2	25856	0.0000	0.0212	0.0
3/2	13267	9/2	7806	0.0	0.1224	0.3636
3/2	13267	9/2	9166	0.0	0.0311	0.0112
3/2	13267	11/2	5952	0.0	0.1935	0.0390
3/2	13267	11/2	7853	0.0	0.0166	0.0353
3/2	13267	13/2	3626	0.0	0.0	0.3950
3/2	13267	13/2	25794	0.0	0.0	0.0076
3/2	13267	15/2	175	0.0	0.0	0.0611
3/2	13267	15/2	22222	0.0	0.0	0.0014
3/2	27543	3/2	27543	0.0572	0.0	0.0
3/2	27543	5/2	10273	0.0007	0.0743	0.0
3/2	27543	5/2	12471	0.1151	0.0023	0.0
3/2	27543	5/2	27624	0.0185	0.0000	0.0
3/2	27543	7/2	9223	0.0004	0.0494	0.0
3/2	27543	7/2	11070	0.0420	0.0179	0.0
3/2	27543	7/2	25856	0.1907	0.0479	0.0
3/2	27543	9/2	7806	0.0	0.0393	0.0089
3/2	27543	9/2	9166	0.0	0.0757	0.0009
3/2	27543	9/2	21228	0.0	0.1031	0.0114
3/2	27543	11/2	5952	0.0	0.0072	0.0070
3/2	27543	11/2	7853	0.0	0.1731	0.0000
3/2	27543	11/2	23563	0.0	0.0417	0.0296
3/2	27543	13/2	3626	0.0	0.0	0.0016
3/2	27543	13/2	25794	0.0	0.0	0.1531
3/2	27543	15/2	175	0.0	0.0	0.0508
3/2	27543	15/2	22222	0.0	0.0	0.0051

5	2173	5	27892	0.0001	0.0002	0.0065
5	2173	6	125	0.5377	0.6420	0.1178

TABLE 2
U(K)*2 FOR DY+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
5/2	10273	5/2	10273	0.3736	0.0659	0.0
5/2	10273	5/2	12471	0.0379	0.2727	0.0
5/2	10273	5/2	27624	0.0000	0.0302	0.0
5/2	10273	7/2	9223	0.2143	0.1919	0.0758
5/2	10273	7/2	11070	0.0044	0.1315	0.4393
5/2	10273	7/2	25856	0.0007	0.0059	0.0113
5/2	10273	9/2	7806	0.0237	0.1300	0.3127
5/2	10273	9/2	9166	0.0000	0.0182	0.3551
5/2	10273	9/2	21228	0.0000	0.0035	0.0011
5/2	10273	11/2	5952	0.0	0.0236	0.2993
5/2	10273	11/2	7853	0.0	0.0031	0.0177
5/2	10273	11/2	23563	0.0	0.0007	0.0014
5/2	10273	13/2	3626	0.0	0.0012	0.0590
5/2	10273	15/2	175	0.0	0.0	0.0026
5/2	10273	17/2	25890	0.0	0.0	0.0024
5/2	12471	5/2	12471	0.0007	0.0171	0.0
5/2	12471	5/2	27624	0.2868	0.0890	0.0
5/2	12471	7/2	9223	0.1943	0.0583	0.4192
5/2	12471	7/2	11070	0.0439	0.0033	0.0087
5/2	12471	7/2	25856	0.0059	0.0188	0.0005
5/2	12471	9/2	7806	0.3358	0.1045	0.0390
5/2	12471	9/2	9166	0.0095	0.0333	0.0301
5/2	12471	9/2	21228	0.0062	0.0008	0.0004
5/2	12471	11/2	5952	0.0	0.1971	0.1557
5/2	12471	11/2	7853	0.0	0.0503	0.0898
5/2	12471	13/2	3626	0.0	0.2103	0.2852
5/2	12471	13/2	25794	0.0	0.0008	0.0007
5/2	12471	15/2	175	0.0	0.0	0.3446
5/2	27624	5/2	27624	0.2570	0.0004	0.0
5/2	27624	7/2	9223	0.0000	0.0997	0.0144
5/2	27624	7/2	11070	0.4684	0.1866	0.0000
5/2	27624	7/2	25856	0.0910	0.0146	0.0005
5/2	27624	9/2	7806	0.0011	0.1621	0.0279
5/2	27624	9/2	9166	0.4981	0.2551	0.0000
5/2	27624	9/2	21228	0.0087	0.0046	0.0110
5/2	27624	11/2	5952	0.0	0.3230	0.0664
5/2	27624	11/2	7853	0.0	0.1638	0.0029
5/2	27624	11/2	23563	0.0	0.0199	0.0283
5/2	27624	13/2	3626	0.0	0.1722	0.0820
5/2	27624	13/2	25794	0.0	0.0098	0.0010
5/2	27624	15/2	175	0.0	0.0	0.0721
5/2	27624	17/2	25890	0.0	0.0	0.0633
7/2	9223	7/2	9223	0.2618	0.0087	0.2859
7/2	9223	7/2	11070	0.0511	0.2930	0.0000
7/2	9223	7/2	25856	0.0031	0.0045	0.0231
7/2	9223	9/2	7806	0.3035	0.1534	0.0132
7/2	9223	9/2	9166	0.0039	0.1255	0.4498

TABLE 2
U(K)*2 FOR DY+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
7/2	9223	9/2	21228	0.0008	0.0079	0.0067
7/2	9223	11/2	5952	0.0348	0.1465	0.3426
7/2	9223	11/2	7853	0.0004	0.0306	0.1438
7/2	9223	11/2	23563	0.0001	0.0044	0.0013
7/2	9223	13/2	3626	0.0	0.0309	0.2763
7/2	9223	13/2	25794	0.0	0.0034	0.0001
7/2	9223	15/2	175	0.0	0.0006	0.0393
7/2	9223	15/2	22222	0.0	0.0016	0.0003
7/2	9223	17/2	25890	0.0	0.0	0.0021
7/2	9223	19/2	26334	0.0	0.0	0.0082
7/2	11070	7/2	11070	0.0016	0.0274	0.0267
7/2	11070	7/2	25856	0.0102	0.0243	0.0004
7/2	11070	9/2	7806	0.2267	0.1387	0.2508
7/2	11070	9/2	9166	0.0630	0.0052	0.0435
7/2	11070	9/2	21228	0.0002	0.0043	0.0029
7/2	11070	11/2	5952	0.4449	0.0503	0.2521
7/2	11070	11/2	7853	0.0344	0.0344	0.0843
7/2	11070	11/2	23563	0.0107	0.0000	0.0000
7/2	11070	13/2	3626	0.0	0.4217	0.0000
7/2	11070	13/2	25794	0.0	0.0015	0.0076
7/2	11070	15/2	175	0.0	0.1352	0.7138
7/2	11070	17/2	25890	0.0	0.0	0.0073
7/2	11070	19/2	26334	0.0	0.0	0.0156
7/2	25856	7/2	25856	0.0512	0.0275	0.0123
7/2	25856	9/2	7806	0.0027	0.0074	0.0112
7/2	25856	9/2	9166	0.0544	0.0266	0.0008
7/2	25856	9/2	21228	0.0465	0.0838	0.3307
7/2	25856	11/2	5952	0.0405	0.0318	0.0020
7/2	25856	11/2	7853	0.1014	0.0198	0.0001
7/2	25856	11/2	23563	0.0872	0.1410	0.2588
7/2	25856	13/2	3626	0.0	0.0111	0.0321
7/2	25856	13/2	25794	0.0	0.3756	0.0007
7/2	25856	15/2	175	0.0	0.0695	0.0260
7/2	25856	15/2	22222	0.0	0.0389	0.0045
7/2	25856	17/2	25890	0.0	0.0	0.0393
7/2	25856	19/2	26334	0.0	0.0	0.2900
9/2	7806	9/2	7806	0.3081	0.0160	0.2684
9/2	7806	9/2	9166	0.0424	0.3327	0.1716
9/2	7806	9/2	21228	0.0021	0.0024	0.0032
9/2	7806	11/2	5952	0.3446	0.1662	0.0137
9/2	7806	11/2	7853	0.0037	0.1159	0.4969
9/2	7806	11/2	23563	0.0002	0.0074	0.0000
9/2	7806	13/2	3626	0.0338	0.1712	0.3921
9/2	7806	13/2	25794	0.0057	0.0000	0.0040
9/2	7806	15/2	175	0.0	0.0166	0.2017
9/2	7806	15/2	22222	0.0	0.0077	0.0000
9/2	7806	17/2	25890	0.0	0.0202	0.0000

TABLE 2
U(K)*2 FOR DY+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
9/2	7806	21/2	25109	0.0	0.0	0.0226
9/2	9166	9/2	9166	0.0313	0.0106	0.0428
9/2	9166	9/2	21228	0.0007	0.0055	0.0004
9/2	9166	11/2	5952	0.2561	0.3942	0.0114
9/2	9166	11/2	7853	0.0239	0.0190	0.0154
9/2	9166	11/2	23563	0.0061	0.0001	0.0085
9/2	9166	13/2	3626	0.6670	0.0236	0.3778
9/2	9166	13/2	25794	0.0012	0.0167	0.0082
9/2	9166	15/2	175	0.0	0.5746	0.7186
9/2	9166	15/2	22222	0.0	0.0126	0.0063
9/2	9166	17/2	25890	0.0	0.0321	0.0132
9/2	9166	19/2	26334	0.0	0.0	0.0425
9/2	9166	21/2	25109	0.0	0.0	0.0919
9/2	21228	9/2	21228	0.0226	0.2572	0.3827
9/2	21228	11/2	5952	0.0093	0.0018	0.0033
9/2	21228	11/2	7853	0.0032	0.0032	0.0024
9/2	21228	11/2	23563	0.4708	0.1686	0.1511
9/2	21228	13/2	3626	0.0490	0.0164	0.0545
9/2	21228	13/2	25794	0.0068	0.0418	0.3971
9/2	21228	15/2	175	0.0	0.0046	0.0292
9/2	21228	15/2	22222	0.0	0.5584	0.0182
9/2	21228	17/2	25890	0.0	0.4557	0.0315
9/2	21228	19/2	26334	0.0	0.0	0.1410
9/2	21228	21/2	25109	0.0	0.0	0.9115
11/2	5952	11/2	5952	0.4989	0.0328	0.0498
11/2	5952	11/2	7853	0.0021	0.1919	0.8336
11/2	5952	11/2	23563	0.0001	0.0001	0.0019
11/2	5952	13/2	3626	0.2547	0.4933	0.0300
11/2	5952	13/2	25794	0.0032	0.0031	0.0221
11/2	5952	15/2	175	0.0912	0.0369	0.6392
11/2	5952	15/2	22222	0.0049	0.0026	0.0006
11/2	5952	17/2	25890	0.0	0.0042	0.0113
11/2	5952	19/2	26334	0.0	0.0213	0.0330
11/2	5952	21/2	25109	0.0	0.0	0.0376
11/2	7853	11/2	7853	0.1428	0.1385	0.0624
11/2	7853	11/2	23563	0.0156	0.0001	0.0083
11/2	7853	13/2	3626	0.2518	0.4248	0.7751
11/2	7853	13/2	25794	0.0004	0.0068	0.0038
11/2	7853	15/2	175	0.9394	0.8299	0.2061
11/2	7853	15/2	22222	0.0020	0.0270	0.0022
11/2	7853	17/2	25890	0.0	0.0037	0.0036
11/2	7853	19/2	26334	0.0	0.0001	0.0208
11/2	7853	21/2	25109	0.0	0.0	0.0318
11/2	23563	11/2	23563	0.3577	0.0555	0.0127
11/2	23563	13/2	3626	0.0012	0.0299	0.0065

TABLE 2
U(K)*2 FOR DY+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
11/2	23563	13/2	25794	0.0000	0.0053	0.5958
11/2	23563	15/2	175	0.0004	0.0141	0.0003
11/2	23563	15/2	22222	0.1356	0.0812	0.9026
11/2	23563	17/2	25890	0.0	0.0981	0.7694
11/2	23563	19/2	26334	0.0	0.4117	0.5393
11/2	23563	21/2	25109	0.0	0.0	0.6624
13/2	3626	13/2	3626	0.7945	0.0738	0.1064
13/2	3626	13/2	25794	0.0014	0.0003	0.0004
13/2	3626	15/2	175	0.2454	0.4136	0.6834
13/2	3626	15/2	22222	0.0049	0.0041	0.0107
13/2	3626	17/2	25890	0.0022	0.0044	0.0001
13/2	3626	19/2	26334	0.0	0.0049	0.0026
13/2	3626	21/2	25109	0.0	0.0034	0.0037
13/2	25794	13/2	25794	0.5060	0.2108	0.1877
13/2	25794	15/2	175	0.0039	0.0012	0.0249
13/2	25794	15/2	22222	0.0220	0.0103	0.0886
13/2	25794	17/2	25890	0.0009	0.1791	0.0081
13/2	25794	19/2	26334	0.0	0.2761	0.0029
13/2	25794	21/2	25109	0.0	0.0878	0.4522
15/2	175	15/2	175	1.3310	0.6452	0.4266
15/2	175	15/2	22222	0.0071	0.0003	0.0659
15/2	175	17/2	25890	0.0101	0.0042	0.0905
15/2	175	19/2	26334	0.0002	0.0139	0.0968
15/2	175	21/2	25109	0.0	0.0101	0.0808
15/2	22222	15/2	22222	0.4738	0.4363	0.5634
15/2	22222	17/2	25890	0.2741	0.0548	1.2889
15/2	22222	19/2	26334	0.0014	0.4909	1.0251
15/2	22222	21/2	25109	0.0	0.2399	0.8452
17/2	25890	17/2	25890	0.1263	0.0733	0.1346
17/2	25890	19/2	26334	0.8045	0.0361	0.0265
17/2	25890	21/2	25109	0.0018	1.2616	0.0075
19/2	26334	19/2	26334	0.0428	0.0612	1.6829
19/2	26334	21/2	25109	0.7683	0.3865	0.1317
21/2	25109	21/2	25109	0.6719	1.2335	0.8622

APPENDIX XI

APPENDIX XI

TABLE 1
HO+3:LAF3 CENTERS OF GRAVITY

OBSERVED	CALC	O-C	STATE
0	9	-8	5I8
5146	5064	82	5I7
8568	8578	-9	5I6
11123	11145	-21	5I5
...	13212	...	5I4
15420	15456	-35	5F5
18397	18381	16	5S2
18524	18538	-13	5F4
20596	20594	2	5F3
21056	21039	17	5F2
21279	21267	12	3K8
22187	22179	8	5G6
...	22255	...	5F1
23942	23987	-44	5G5
25872	25859	13	5G4
26087	26058	29	3K7
27672	27652	20	5G5
27672	27678	-5	3H6
...	28234	...	5F2
28878	28875	3	5G3
28878	28895	-16	3L9
29943	29941	2	3K6.
29943	29947	-3	3F4
30795	30799	-3	5G2
...	33063	...	3D3
...	33247	...	3P1
34100	34072	28	3M10
34100	34156	-55	3L8
34811	34812	0	5G4
35206	35203	3	3G3
...	36008	...	3P0
...	36009	...	5D4
...	36294	...	3F2
...	36314	...	1L8
36724	36720	4	3H5
...	37794	...	3P2
...	37900	...	3L7
38378	38339	39	3I7
...	38515	...	3F4'

...	25229	...	4M	21/2	19/2	
25303	25272	31	4M	21/2	17/2	

TABLE 2
U(K)*2 FOR HO+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
0	36008	2	21040	0.0027	0.0	0.0
0	36008	4	13212	0.0	0.0089	0.0
0	36008	4	18538	0.0	0.0013	0.0
0	36008	6	8579	0.0	0.0	0.0175
0	36008	6	22180	0.0	0.0	0.0351
0	36008	6	27679	0.0	0.0	0.0805
1	22255	1	22255	0.0302	0.0	0.0
1	22255	2	18381	0.0109	0.0	0.0
1	22255	2	21040	0.0539	0.0	0.0
1	22255	3	20595	0.0084	0.0586	0.0
1	22255	4	13212	0.0	0.1442	0.0
1	22255	4	18538	0.0	0.0468	0.0
1	22255	4	25859	0.0	0.0564	0.0
1	22255	5	11146	0.0	0.1396	0.1704
1	22255	5	15457	0.0	0.0000	0.1147
1	22255	5	23988	0.0	0.0070	0.0537
1	22255	5	27653	0.0	0.0074	0.0548
1	22255	6	8579	0.0	0.0	0.2383
1	22255	6	22180	0.0	0.0	0.0528
1	22255	7	5065	0.0	0.0	0.0568
1	22255	7	26059	0.0	0.0	0.0020
2	18381	2	18381	0.0000	0.0016	0.0
2	18381	2	21040	0.0016	0.0035	0.0
2	18381	3	20595	0.0065	0.0000	0.0
2	18381	4	13212	0.0014	0.0302	0.2839
2	18381	4	18538	0.0000	0.0159	0.0033
2	18381	4	25859	0.0328	0.2811	0.0216
2	18381	5	11146	0.0	0.0052	0.0968
2	18381	5	15457	0.0	0.0123	0.0050
2	18381	5	23988	0.0	0.1062	0.0004
2	18381	5	27653	0.0	0.0570	0.0006
2	18381	6	8579	0.0	0.0240	0.1458
2	18381	6	22180	0.0	0.3128	0.0047
2	18381	6	27679	0.0	0.0437	0.0065
2	18381	7	5065	0.0	0.0	0.4195
2	18381	7	26059	0.0	0.0	0.0553
2	18381	8	9	0.0	0.0	0.2145
2	21040	2	21040	0.0077	0.0271	0.0
2	21040	3	20595	0.0521	0.0000	0.0
2	21040	4	13212	0.0005	0.2011	0.0293
2	21040	4	18538	0.0085	0.0805	0.0317
2	21040	4	25859	0.2608	0.0012	0.1204
2	21040	5	11146	0.0	0.0473	0.3024
2	21040	5	15457	0.0	0.0052	0.1466
2	21040	5	23988	0.0	0.1423	0.0115
2	21040	5	27653	0.0	0.1233	0.0012
2	21040	6	8579	0.0	0.1365	0.1604

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APPENDIX XI

TABLE 2
U(K)*2 FOR HO+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
2	21040	6	22180	0.0	0.0225	0.1010
2	21040	6	27679	0.0	0.0068	0.0099
2	21040	7	5065	0.0	0.0	0.0789
2	21040	7	26059	0.0	0.0	0.0550
2	21040	8	9	0.0	0.0	0.2041
2	21040	8	21268	0.0	0.0	0.0036
3	20595	3	20595	0.0358	0.0637	0.0275
3	20595	4	13212	0.0002	0.0982	0.3949
3	20595	4	18538	0.0973	0.0298	0.0966
3	20595	4	25859	0.2147	0.0176	0.0509
3	20595	5	11146	0.0000	0.2173	0.0175
3	20595	5	15457	0.0396	0.0816	0.0851
3	20595	5	23988	0.1800	0.1005	0.0325
3	20595	5	27653	0.1544	0.0474	0.0059
3	20595	6	8579	0.0	0.0897	0.2172
3	20595	6	22180	0.0	0.0655	0.1526
3	20595	6	27679	0.0	0.0112	0.0509
3	20595	7	5065	0.0	0.2463	0.2279
3	20595	7	26059	0.0	0.0068	0.0049
3	20595	8	9	0.0	0.0	0.3464
3	20595	8	21268	0.0	0.0	0.0067
3	20595	9	28896	0.0	0.0	0.0012
4	13212	4	13212	0.1222	0.1308	0.3456
4	13212	4	18538	0.0002	0.0241	0.2576
4	13212	4	25859	0.0152	0.1072	0.0555
4	13212	5	11146	0.0310	0.1237	0.9103
4	13212	5	15457	0.0001	0.0061	0.0036
4	13212	5	23988	0.0000	0.0091	0.0418
4	13212	5	27653	0.0036	0.0097	0.0008
4	13212	6	8579	0.0023	0.0282	0.6639
4	13212	6	22180	0.0005	0.0013	0.0000
4	13212	6	27679	0.0000	0.0000	0.0200
4	13212	7	5065	0.0	0.0034	0.1568
4	13212	7	26059	0.0	0.0006	0.0068
4	13212	8	9	0.0	0.0000	0.0076
4	13212	8	21268	0.0	0.0046	0.0012
4	13212	10	34072	0.0	0.0	0.0019
4	18538	4	18538	0.0770	0.0085	0.0886
4	18538	4	25859	0.3962	0.1052	0.0217
4	18538	5	11146	0.0016	0.1334	0.4666
4	18538	5	15457	0.1980	0.0920	0.0071
4	18538	5	23988	0.2751	0.0238	0.1395
4	18538	5	27653	0.2974	0.0025	0.0517
4	18538	6	8579	0.0011	0.2574	0.1704
4	18538	6	22180	0.2526	0.2380	0.1289
4	18538	6	27679	0.0103	0.0210	0.0259
4	18538	7	5065	0.0	0.1965	0.0320

	33666	33645	21	4F	3/2	1/2
177	33652	33646	6	4F	3/2	3/2

APPENDIX XI

TABLE 2
U(K)*2 FOR HO+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
4	18538	7	26059	0.0	0.0156	0.0091
4	18538	8	9	0.0	0.2385	0.7090
4	18538	8	21268	0.0	0.0085	0.0007
4	18538	9	28896	0.0	0.0	0.0093
4	18538	10	34072	0.0	0.0	0.0417
4	25859	4	25859	0.0098	0.0138	0.1812
4	25859	5	11146	0.2254	0.2700	0.0329
4	25859	5	15457	0.0345	0.0138	0.2147
4	25859	5	23988	0.0128	0.1484	0.0268
4	25859	5	27653	0.0415	0.1417	0.0182
4	25859	6	8579	0.6896	0.0226	0.0003
4	25859	6	22180	0.0036	0.2047	0.2909
4	25859	6	27679	0.0030	0.0067	0.0093
4	25859	7	5065	0.0	0.2857	0.0642
4	25859	7	26059	0.0	0.0152	0.0044
4	25859	8	9	0.0	0.0351	0.0332
4	25859	8	21268	0.0	0.0919	0.0013
4	25859	9	28896	0.0	0.0	0.0492
4	25859	10	34072	0.0	0.0	0.2687
5	11146	5	11146	0.1023	0.0364	0.0176
5	11146	5	15457	0.0071	0.0281	0.1630
5	11146	5	23988	0.0031	0.0642	0.0568
5	11146	5	27653	0.0040	0.0487	0.0418
5	11146	6	8579	0.0435	0.1703	0.5720
5	11146	6	22180	0.0171	0.0312	0.0124
5	11146	6	27679	0.0004	0.0011	0.0153
5	11146	7	5065	0.0028	0.0226	0.8896
5	11146	7	26059	0.0072	0.0042	0.0312
5	11146	8	9	0.0	0.0102	0.0930
5	11146	8	21268	0.0	0.0004	0.0041
5	11146	9	28896	0.0	0.0253	0.0242
5	11146	10	34072	0.0	0.0	0.0368
5	15457	5	15457	0.0729	0.1815	0.0050
5	15457	5	23988	0.3425	0.0353	0.1145
5	15457	5	27653	0.0907	0.1752	0.0483
5	15457	6	8579	0.0113	0.1242	0.4972
5	15457	6	22180	1.1305	0.3616	0.0321
5	15457	6	27679	0.1113	0.0000	0.0002
5	15457	7	5065	0.0194	0.3309	0.4298
5	15457	7	26059	0.0015	0.0112	0.0142
5	15457	8	9	0.0	0.4201	0.5701
5	15457	8	21268	0.0	0.0258	0.0190
5	15457	9	28896	0.0	0.0608	0.0741
5	15457	10	34072	0.0	0.0	0.1693
5	23988	5	23988	0.0706	0.0473	0.0139
5	23988	5	27653	0.0263	0.0132	0.2050

TABLE 2
U(K)*2 FOR HO+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
5	23988	6	8579	0.1286	0.1695	0.0789
5	23988	6	22180	0.0565	0.2568	0.2456
5	23988	6	27679	0.1987	0.0657	0.0168
5	23988	7	5065	0.5696	0.0240	0.1171
5	23988	7	26059	0.0164	0.0059	0.2487
5	23988	8	9	0.0	0.5239	0.0000
5	23988	8	21268	0.0	0.0083	0.0007
5	23988	9	28896	0.0	0.3321	0.1702
5	23988	10	34072	0.0	0.0	0.3522
5	27653	5	27653	0.0360	0.0058	0.0012
5	27653	6	8579	0.0949	0.2452	0.0460
5	27653	6	22180	0.0005	0.0711	0.1580
5	27653	6	27679	0.1501	0.5825	0.0000
5	27653	7	5065	0.7003	0.1913	0.0584
5	27653	7	26059	0.0036	0.0104	0.4806
5	27653	8	9	0.0	0.0938	0.1596
5	27653	8	21268	0.0	0.0051	0.0214
5	27653	9	28896	0.0	0.1803	0.1726
5	27653	10	34072	0.0	0.0	0.2616
6	8579	6	8579	0.1273	0.0681	0.0402
6	8579	6	22180	0.0091	0.0819	0.1094
6	8579	6	27679	0.0001	0.0051	0.0024
6	8579	7	5065	0.0314	0.1324	0.9295
6	8579	7	26059	0.0011	0.0057	0.0722
6	8579	8	9	0.0087	0.0389	0.6920
6	8579	8	21268	0.0059	0.0041	0.0142
6	8579	9	28896	0.0	0.0071	0.0357
6	8579	10	34072	0.0	0.0177	0.0211
6	22180	6	22180	0.0025	0.3968	0.1209
6	22180	6	27679	0.0509	0.2992	0.0069
6	22180	7	5065	0.1484	0.4284	0.2633
6	22180	7	26059	0.0000	0.0003	0.1239
6	22180	8	9	1.4830	0.8201	0.1400
6	22180	8	21268	0.0000	0.0048	0.3076
6	22180	9	28896	0.0	0.0402	0.2810
6	22180	10	34072	0.0	0.0455	0.1696
6	27679	6	27679	0.1499	0.1032	0.0418
6	27679	7	5065	0.0314	0.0586	0.0087
6	27679	7	26059	0.0040	0.0502	0.6854
6	27679	8	9	0.2540	0.1399	0.0013
6	27679	8	21268	0.1077	0.1109	1.5985
6	27679	9	28896	0.0	0.1181	0.8288
6	27679	10	34072	0.0	0.3381	0.2755
7	5065	7	5065	0.1502	0.1193	0.0297
7	5065	7	26059	0.0055	0.0059	0.0047

39152	39169	-16	4P	3/2	3/2
39176	39192	-15	4P	3/2	1/2

TABLE 2
U(K)*2 FOR HO+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
7	5065	8	9	0.0249	0.1344	1.5231
7	5065	8	21268	0.0018	0.0044	0.0402
7	5065	9	28896	0.0009	0.0041	0.0103
7	5065	10	34072	0.0	0.0003	0.0059
7	26059	7	26059	0.0016	0.0223	0.0175
7	26059	8	9	0.0056	0.0044	0.0335
7	26059	8	21268	0.0865	0.0002	0.1223
7	26059	9	28896	0.0788	0.1963	0.1391
7	26059	10	34072	0.0	0.3112	0.3289
8	9	8	9	0.1951	0.3117	1.5460
8	9	8	21268	0.0205	0.0317	0.1535
8	9	9	28896	0.0179	0.0051	0.1499
8	9	10	34072	0.0003	0.0681	0.0789
8	21268	8	21268	0.0260	0.0465	0.2019
8	21268	9	28896	0.3163	0.0568	2.0495
8	21268	10	34072	0.0134	1.0322	0.8500
9	28896	9	28896	0.6858	1.3547	0.0291
9	28896	10	34072	0.7340	1.4855	0.5524
10	34072	10	34072	3.3219	0.0011	1.4872

APPENDIX XII

3/2	27543	15/2	175	0.0	0.0	0.0508
3/2	27543	15/2	22222	0.0	0.0	0.0051

APPENDIX XII

TABLE 1
ER+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
0	-9	10	4I	15/2	13/2
51	50	1	4I	15/2	-11/2
121	121	0	4I	15/2	3/2
200	188	12	4I	15/2	5/2
219	198	22	4I	15/2	1/2
314	310	4	4I	15/2	-9/2
400	397	3	4I	15/2	-7/2
443	442	1	4I	15/2	15/2
6604	6607	-2	4I	13/2	-11/2
6630	6639	-8	4I	13/2	-9/2
6670	6677	-6	4I	13/2	-7/2
6700	6696	4	4I	13/2	1/2
6723	6730	-6	4I	13/2	3/2
6754	6765	-10	4I	13/2	5/2
6823	6835	-11	4I	13/2	13/2
10301	10299	2	4I	11/2	-9/2
10311	10309	2	4I	11/2	-7/2
10330	10336	-5	4I	11/2	1/2
10344	10348	-3	4I	11/2	3/2
10358	10359	0	4I	11/2	5/2
10395	10408	-12	4I	11/2	-11/2
12419	12401	18	4I	9/2	7/2
12518	12535	-16	4I	9/2	1/2
12615	12605	10	4I	9/2	3/2
12701	12705	-3	4I	9/2	5/2
12730	12725	5	4I	9/2	-9/2
15391	15393	-1	4F	9/2	5/2
15432	15439	-6	4F	9/2	3/2
15443	15447	-3	4F	9/2	-7/2
15474	15476	-1	4F	9/2	3/2
15527	15529	-1	4F	9/2	1/2
18557	18559	-1	4S	3/2	3/2
18588	18588	0	4S	3/2	1/2
19266	19271	-4	2H2	11/2	1/2
19307	19296	11	2H2	11/2	-9/2
19314	19318	-3	2H2	11/2	-11/2
19359	19344	15	2H2	11/2	-7/2
19359	19350	9	2H2	11/2	3/2
19418	19403	15	2H2	11/2	5/2
20656	20655	1	4F	7/2	-7/2
20703	20698	5	4F	7/2	1/2
20734	20736	-1	4F	7/2	5/2
20786	20788	-1	4F	7/2	3/2

7/2	9223	9/2	7806	0.3035	0.1534	0.0132
7/2	9223	9/2	9166	0.0039	0.1255	0.4498

APPENDIX XII

TABLE 1
ER+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
22370	22364	6	4F	5/2	5/2
22374	22369	5	4F	5/2	1/2
22407	22399	9	4F	5/2	3/2
22684	22689	-4	4F	3/2	3/2
22751	22741	10	4F	3/2	1/2
24602	24580	22	4F	9/2	-7/2
24680	24710	-29	4F	9/2	1/2
24754	24748	6	4F	9/2	3/2
24840	24840	0	4F	9/2	5/2
24862	24858	4	4F	9/2	3/2
26530	26536	-5	4G	11/2	1/2
26558	26567	-8	4G	11/2	-11/2
26583	26587	-3	4G	11/2	3/2
26647	26650	-2	4G	11/2	5/2
26647	26650	-2	4G	11/2	-9/2
26709	26713	-3	4G	11/2	-7/2
27606	27610	-3	4G	9/2	-9/2
27620	27617	3	4G	9/2	1/2
27631	27624	7	4G	9/2	3/2
27646	27639	7	4G	9/2	5/2
27671	27665	6	4G	9/2	-7/2
27813	27816	-2	2K	15/2	-9/2
27820	27823	-2	2K	15/2	-7/2
27830	27851	-20	2K	15/2	-11/2
27904	27891	13	2K	15/2	5/2
27935	27939	-3	2K	15/2	3/2
...	27959	...	2K	15/2	13/2
...	27988	...	2K	15/2	1/2
28127	28135	-7	2K	15/2	15/2
...	28221	...	4G	7/2	5/2
28243	28240	3	4G	7/2	-7/2
28257	28249	8	4G	7/2	3/2
28265	28252	13	4G	7/2	1/2
31688	31711	-22	2P	3/2	3/2
31746	31765	-18	2P	3/2	1/2
...	33094	...	2K	13/2	-9/2
33108	33105	3	2K	13/2	-7/2
33119	33142	-22	2K	13/2	-11/2
33167	33153	14	2K	13/2	5/2
33201	33203	-1	2K	13/2	1/2
33201	33206	-4	2K	13/2	3/2
...	33317	...	2P	1/2	1/2
...	33405	...	2K	13/2	13/2

				.0	0.0166	0.2017
9/2	7806	15/2	22222	0.0	0.0077	0.0000
9/2	7806	17/2	25890	0.0	0.0202	0.0000

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APPENDIX XII

TABLE 1
ER+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
...	33482	...	4G	5/2	1/2
...	33494	...	4G	5/2	5/2
...	33613	...	4G	5/2	3/2
34157	34167	-9	4G	7/2	-7/2
34196	34197	0	4G	7/2	3/2
34221	34228	-6	4G	7/2	1/2
34280	34284	-3	4G	7/2	5/2
35026	35042	-15	2D1	5/2	3/2
35052	35053	0	2D1	5/2	5/2
35085	35092	-6	2D1	5/2	1/2
36522	36529	-6	2H2	9/2	-9/2
36555	36537	18	2H2	9/2	5/2
36624	36636	-11	2H2	9/2	3/2
36721	36721	0	2H2	9/2	1/2
36805	36792	13	2H2	9/2	-7/2
38804	38794	10	4D	5/2	3/2
38841	38843	-1	4D	5/2	5/2
38834	38844	-9	4D	5/2	1/2
39454	39487	-32	4D	7/2	1/2
39539	39528	11	4D	7/2	3/2
39606	39606	0	4D	7/2	-7/2
39634	39638	-3	4D	7/2	5/2
41238	41235	3	2I	11/2	5/2
41297	41302	-4	2I	11/2	3/2
41315	41330	-14	2I	11/2	-11/2
...	41371	...	2I	11/2	-7/2
41382	41391	-9	2I	11/2	1/2
41497	41492	5	2I	11/2	-9/2
...	41809	...	2L	17/2	-7/2
...	41833	...	2L	17/2	-9/2
...	41874	...	2L	17/2	1/2
...	41875	...	2L	17/2	5/2
...	41900	...	2L	17/2	3/2
...	41926	...	2L	17/2	-11/2
...	41980	...	2L	17/2	13/2
...	42071	...	2L	17/2	17/2
...	42087	...	2L	17/2	15/2
42495	42471	24	4D	3/2	3/2
42526	42500	26	4D	3/2	1/2
43088	43096	-7	4D	3/2	1/2
43126	43121	5	4D	3/2	3/2

11/2	23563	11/2	23563	0.3577	0.0555	0.0127
11/2	23563	13/2	3626	0.0012	0.0299	0.0065

APPENDIX XII

TABLE 1
ER+3:LAF3

OBSERVED	CALC	O-C	STATE	J	MJ
43687	43709	-21	2I	13/2	5/2
43746	43722	24	2I	13/2	1/2
43746	43728	18	2I	13/2	3/2
43760	43749	11	2I	13/2	13/2
43834	43821	13	2I	13/2	-7/2
43915	43909	6	2I	13/2	-9/2
...	43968	...	2I	13/2	-11/2
...	47313	...	4D	1/2	1/2
...	47941	...	2L	15/2	-9/2
...	47989	...	2L	15/2	-7/2
...	47999	...	2L	15/2	3/2
...	48015	...	2L	15/2	1/2
...	48035	...	2L	15/2	5/2
...	48097	...	2L	15/2	-11/2
...	48193	...	2L	15/2	15/2
...	48194	...	2L	15/2	13/2
...	48371	...	2H1	9/2	5/2
...	48374	...	2H1	9/2	3/2
...	48427	...	2H1	9/2	1/2
...	48483	...	2H1	9/2	-9/2
...	48513	...	2H1	9/2	-7/2
49223	49210	13	2D2	5/2	3/2
49272	49287	-14	2D2	5/2	1/2
49357	49349	8	2D2	5/2	5/2
...	51295	...	2H1	11/2	1/2
...	51355	...	2H1	11/2	3/2
...	51370	...	2H1	11/2	-11/2
...	51441	...	2H1	11/2	5/2
...	51510	...	2H1	11/2	-9/2
...	51512	...	2H1	11/2	-7/2

APPENDIX XII

TABLE 1A
ER+3:LAF3 CENTERS OF GRAVITY

CALC CENTER	STATE
217	4I15/2
6712	4I13/2
8583	4S 3/2
10346	4I11/2
12597	4I 9/2
15455	4F 9/2
19337	2H11/2
20715	4F 7/2
22376	4F 5/2
22712	4F 3/2
24756	4F 9/2
26631	4G11/2
27637	4G 9/2
27922	2K15/2
28224	4G 7/2
33319	2P 1/2

APPENDIX XII

TABLE 2
U(K)*2 FOR ER+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
1/2	33319	3/2	18583	0.0057	0.0	0.0
1/2	33319	3/2	22712	0.0353	0.0	0.0
1/2	33319	5/2	22376	0.0073	0.0	0.0
1/2	33319	7/2	20715	0.0	0.0204	0.0
1/2	33319	7/2	28224	0.0	0.0263	0.0
1/2	33319	9/2	12597	0.0	0.0272	0.0
1/2	33319	9/2	15455	0.0	0.0460	0.0
1/2	33319	9/2	27637	0.0	0.0083	0.0
1/2	33319	11/2	10346	0.0	0.0	0.0316
1/2	33319	11/2	19337	0.0	0.0	0.1686
1/2	33319	11/2	26631	0.0	0.0	0.0264
3/2	18583	3/2	18583	0.0371	0.0	0.0
3/2	18583	3/2	22712	0.0266	0.0	0.0
3/2	18583	5/2	22376	0.0077	0.0036	0.0
3/2	18583	7/2	20715	0.0000	0.0055	0.0
3/2	18583	7/2	28224	0.0475	0.1631	0.0
3/2	18583	9/2	12597	0.0	0.0765	0.2569
3/2	18583	9/2	15455	0.0	0.0001	0.0228
3/2	18583	9/2	24756	0.0	0.0036	0.0014
3/2	18583	9/2	27637	0.0	0.1659	0.0103
3/2	18583	11/2	10346	0.0	0.0046	0.0773
3/2	18583	11/2	19337	0.0	0.2002	0.0097
3/2	18583	11/2	26631	0.0	0.1282	0.0040
3/2	18583	13/2	6712	0.0	0.0	0.3419
3/2	18583	15/2	217	0.0	0.0	0.2225
3/2	18583	15/2	27922	0.0	0.0	0.0035
3/2	22712	3/2	22712	0.0709	0.0	0.0
3/2	22712	5/2	22376	0.0605	0.0351	0.0
3/2	22712	7/2	20715	0.0027	0.0577	0.0
3/2	22712	7/2	28224	0.0961	0.0342	0.0
3/2	22712	9/2	12597	0.0	0.2338	0.0545
3/2	22712	9/2	15455	0.0	0.0022	0.0616
3/2	22712	9/2	24756	0.0	0.0188	0.0057
3/2	22712	9/2	27637	0.0	0.1711	0.1124
3/2	22712	11/2	10346	0.0	0.0913	0.4831
3/2	22712	11/2	19337	0.0	0.0004	0.0025
3/2	22712	11/2	26631	0.0	0.0232	0.0907
3/2	22712	13/2	6712	0.0	0.0	0.0347
3/2	22712	15/2	217	0.0	0.0	0.1255
5/2	22376	5/2	22376	0.0152	0.0050	0.0
5/2	22376	7/2	20715	0.0765	0.0498	0.0998
5/2	22376	7/2	28224	0.3831	0.0017	0.0380
5/2	22376	9/2	12597	0.0101	0.0629	0.1129
5/2	22376	9/2	15455	0.0005	0.2345	0.3491
5/2	22376	9/2	24756	0.0092	0.0219	0.0056
5/2	22376	9/2	27637	0.1650	0.0846	0.0024
5/2	22376	11/2	10346	0.0	0.0984	0.0028

2	21040	5	27653	0.0	0.1233	0.0012
2	21040	6	8579	0.0	0.1365	0.1604

TABLE 2
U(K)*2 FOR ER+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
5/2	22376	11/2	19337	0.0	0.0581	0.1847
5/2	22376	11/2	26631	0.0	0.0373	0.0806
5/2	22376	13/2	6712	0.0	0.1794	0.3419
5/2	22376	15/2	217	0.0	0.0	0.2221
5/2	22376	15/2	27922	0.0	0.0	0.0472
7/2	20715	7/2	20715	0.1542	0.0103	0.1001
7/2	20715	7/2	28224	0.1221	0.0409	0.0070
7/2	20715	9/2	12597	0.0155	0.0935	0.4337
7/2	20715	9/2	15455	0.0119	0.0372	0.0109
7/2	20715	9/2	24756	0.0894	0.0483	0.0273
7/2	20715	9/2	27637	0.6234	0.0067	0.1194
7/2	20715	11/2	10346	0.0032	0.2653	0.1545
7/2	20715	11/2	19337	0.1258	0.0164	0.3984
7/2	20715	11/2	26631	0.0867	0.1264	0.0168
7/2	20715	13/2	6712	0.0	0.3393	0.0001
7/2	20715	15/2	217	0.0	0.1465	0.6272
7/2	28224	7/2	28224	0.0033	0.0048	0.0005
7/2	28224	9/2	12597	0.1649	0.3703	0.2168
7/2	28224	9/2	15455	0.0000	0.0123	0.0163
7/2	28224	9/2	24756	0.0152	0.0052	0.0244
7/2	28224	9/2	27637	0.0034	0.1887	0.1494
7/2	28224	11/2	10346	0.5073	0.2776	0.1616
7/2	28224	11/2	19337	0.0006	0.0393	0.2710
7/2	28224	11/2	26631	0.0140	0.0544	0.0177
7/2	28224	13/2	6712	0.0	0.0997	0.0310
7/2	28224	15/2	217	0.0	0.0200	0.1171
7/2	28224	15/2	27922	0.0	0.1206	0.0048
9/2	12597	9/2	12597	0.0040	0.0782	0.7932
9/2	12597	9/2	15455	0.1220	0.0061	0.0203
9/2	12597	9/2	24756	0.0138	0.0066	0.0032
9/2	12597	9/2	27637	0.0041	0.0060	0.0049
9/2	12597	11/2	10346	0.0021	0.0690	0.1520
9/2	12597	11/2	19337	0.1953	0.0648	0.2837
9/2	12597	11/2	26631	0.0631	0.0122	0.0228
9/2	12597	13/2	6712	0.0003	0.0087	0.7100
9/2	12597	15/2	217	0.0	0.1587	0.0072
9/2	12597	15/2	27922	0.0	0.2101	0.0969
9/2	15455	9/2	15455	0.1369	0.0751	0.0507
9/2	15455	9/2	24756	0.0075	0.0261	0.0469
9/2	15455	9/2	27637	0.2170	0.3167	0.3650
9/2	15455	11/2	10346	0.0715	0.0101	1.2671
9/2	15455	11/2	19337	0.3790	0.0236	0.0008
9/2	15455	11/2	26631	0.4283	0.0372	0.0112
9/2	15455	13/2	6712	0.0109	0.1533	0.0828
9/2	15455	15/2	217	0.0	0.55[illegible]	0.4621
9/2	15455	15/2	27922	0.0	0.0867	0.0142

APPENDIX XII

TABLE 2
U(K)*2 FOR ER+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
9/2	24756	9/2	24756	0.0165	0.0546	0.5396
9/2	24756	9/2	27637	0.0251	0.0004	0.0328
9/2	24756	11/2	10346	0.0381	0.0753	0.1047
9/2	24756	11/2	19337	0.0285	0.1635	0.0610
9/2	24756	11/2	26631	0.2951	0.1068	0.1414
9/2	24756	13/2	6712	0.0590	0.1059	0.3531
9/2	24756	15/2	217	0.0	0.0243	0.2147
9/2	24756	15/2	27922	0.0	0.7139	0.0822
9/2	27637	9/2	27637	0.0018	0.0153	0.0078
9/2	27637	11/2	10346	0.0937	0.1601	0.0168
9/2	27637	11/2	19337	0.0237	0.3463	0.1570
9/2	27637	11/2	26631	0.0000	0.2117	0.1516
9/2	27637	13/2	6712	1.1078	0.3672	0.0106
9/2	27637	15/2	217	0.0	0.2337	0.1368
9/2	27637	15/2	27922	0.0	0.0056	0.0558
11/2	10346	11/2	10346	0.0784	0.0364	0.0277
11/2	10346	11/2	19337	0.0352	0.1385	0.0372
11/2	10346	11/2	26631	0.0002	0.0486	0.0133
11/2	10346	13/2	6712	0.0332	0.1706	1.0915
11/2	10346	15/2	217	0.0276	0.0002	0.3942
11/2	10346	15/2	27922	0.0463	0.0017	0.2426
11/2	19337	11/2	19337	0.0021	0.0726	0.1068
11/2	19337	11/2	26631	0.0004	0.1513	0.0498
11/2	19337	13/2	6712	0.0235	0.0621	0.0502
11/2	19337	15/2	217	0.7158	0.4138	0.0927
11/2	19337	15/2	27922	0.1010	0.0000	1.1445
11/2	26631	11/2	26631	0.0049	0.2513	0.0669
11/2	26631	13/2	6712	0.1005	0.2648	0.2570
11/2	26631	15/2	217	0.9156	0.5263	0.1167
11/2	26631	15/2	27922	0.0998	0.0579	0.6787
13/2	6712	13/2	6712	0.1723	0.1731	0.2298
13/2	6712	15/2	217	0.0195	0.1172	1.4325
13/2	6712	15/2	27922	0.0001	0.0015	0.0257
15/2	217	15/2	217	0.2463	0.3803	1.8611
15/2	217	15/2	27922	0.0213	0.0039	0.0735
15/2	27922	15/2	27922	1.8431	1.0174	0.0676

APPENDIX XIII

APPENDIX XIII

TABLE 1
TM+3:LAF3 CENTERS OF GRAVITY

OBSERVED	CALC	O-C	STATE
200	175	25	3H6
5858	5818	40	3F4
8336	8391	-54	3H5
12711	12721	-9	3H4
14559	14597	-37	3F3
15173	15181	-7	3F2
21352	21314	38	1G4
28061	28001	60	1D2
34886	34975	-88	1I6
35604	35579	25	3P0
36559	36615	-55	3P1
38344	38268	76	3P2
...	75300	...	1S0

APPENDIX XIII

TABLE 2
U(K)*2 FOR TM+3

J1	LEVEL 1	J2	LEVEL 2	(U2)*2	(U4)*2	(U6)*2
0	35621	2	15180	0.3618	0.0	0.0
0	35621	2	28028	0.0297	0.0	0.0
0	35621	4	5828	0.0	0.2796	0.0
0	35621	4	12735	0.0	0.0235	0.0
0	35621	6	153	0.0	0.0	0.0756
1	36603	1	36603	0.1607	0.0	0.0
1	36603	2	15180	0.1374	0.0	0.0
1	36603	2	28028	0.4521	0.0	0.0
1	36603	3	14598	0.5714	0.1964	0.0
1	36603	4	5828	0.0	0.1099	0.0
1	36603	4	12735	0.0	0.4029	0.0
1	36603	5	8396	0.0	0.2857	0.0892
1	36603	6	153	0.0	0.0	0.1239
2	15180	2	15180	0.1425	0.0443	0.0
2	15180	2	28028	0.0642	0.3073	0.0
2	15180	3	14598	0.0036	0.0745	0.0
2	15180	4	5828	0.3026	0.0562	0.0440
2	15180	4	12735	0.2969	0.1711	0.0763
2	15180	5	8396	0.0	0.2907	0.5844
2	15180	6	153	0.0	0.0000	0.2550
2	28028	2	28028	0.1931	0.0051	0.0
2	28028	3	14598	0.1638	0.0698	0.0
2	28028	4	5828	0.5689	0.0961	0.0215
2	28028	4	12735	0.1257	0.0124	0.2300
2	28028	5	8396	0.0	0.0012	0.0182
2	28028	6	153	0.0	0.3131	0.0958
3	14598	3	14598	0.0625	0.0030	0.0625
3	14598	4	5828	0.0025	0.0005	0.1688
3	14598	4	12735	0.0817	0.3522	0.2844
3	14598	5	8396	0.6285	0.3467	0.0
3	14598	6	153	0.0	0.3164	0.8413
4	5828	4	5828	0.0104	0.4059	0.2651
4	5828	4	12735	0.1275	0.1311	0.2113
4	5828	5	8396	0.0909	0.1299	0.9264
4	5828	6	153	0.5395	0.7261	0.2421
4	12735	4	12735	0.2672	0.1650	0.5704
4	12735	5	8396	0.0131	0.4762	0.0095
4	12735	6	153	0.2357	0.1081	0.5916
5	8396	5	8396	0.9192	0.3668	0.1214
5	8396	6	153	0.1074	0.2314	0.6385
6	153	6	153	1.2517	0.6916	0.7759

APPENDIX XIV

APPENDIX XIV - TABLE 1

Calculated Values of Ω_λ for $Ln^{3+}:LaF_3$

	$\Omega_2 x10^{-20} cm^2$	$\Omega_4 x10^{-20} cm^2$	$\Omega_6 x10^{-20} cm^2$	Reference
Pr^{3+}	0.12	1.77	4.78	a
Nd	0.35	2.57	2.50	a
Pm	0.5	1.9	2.2	b
Sm	1.0	0.5	1.5	b
Eu	1.19	1.16	0.39	c
Gd	1.1	1.2	0.5	b
Tb	1.1	1.4	0.9	b
Dy	1.1	1.4	0.9	b,d
Ho	1.16	1.38	0.88	e
Er	1.07	0.28	0.63	f
Tm	0.52	0.59	0.22	b,g,h

[a]Krupke (1966)

[b]Approximate values from present work

[c]Weber (1967a)

[d]Krupke (1974)

[e]Weber et al. (1972)

[f]Weber (1967b)

[g]Weber (1967c)

[h]Pappalardo (1976)

APPENDIX XIV - TABLE 2

Observed and calculated radiative life-times for $Ln^{3+}:LaF_3$

	Excited State	τ_R μsec	τ Observed (μsec)	Reference
Pr	$^1D_2$	902	520	a
	$^3P_0$	73	47	
Nd	$^4F_{3/2}$	635	670	b
Pm	$^5F_1$	566	-	c
Sm	$^4G_{5/2}$	2160	-	c
Eu	$^5D_2$	9200	5400	d
	$^5D_1$	7700	4700	
	$^5D_0$	6900	6700	
Tb	$^5D_3$	809	-	c
	$^5D_4$	1450	-	
Dy	$^4F_{9/2}$	896	-	c
Ho	$^5S_2$	826	-	e
	$^5F_5$	779	-	
Er	$^2P_{3/2}$	430	290	f
	$^4S_{3/2}$	1020	1000	
Tm	$^1D_2$	137	54	a,g
	$^1G_4$	1560	960	a,g

[a]Weber (1967c), (1968)

[b]Riseberg and Weber (1976), Weber (1967c)

[c]Present Work

[d]Weber (1967a), measured at 77°K

[e]Weber et al. (1972)

[f]Weber (1967b)

[g]Compare recent calculations by Pappalardo (1976)

APPENDIX XIV - TABLE 3

Partial lifetimes a Branching Ratios in the Relaxation of Excited States in $Tb^{3+}:LaF_3$.

Transition	Partial Electric-Dipole Lifetime (msec)	Partial Magnetic-Dipole Lifetime (msec)	β_R
$^5D_3 \rightarrow {}^5D_4$	125.4	3.413	0.24
$^7F_0$	∞		0
$^7F_1$	91.01		0.009
$^7F_2$	51.93	5.606	0.16
$^7F_3$	108.4	109.3	0.015
$^7F_4$	28.61	1.590	0.54
$^7F_5$	30.32		0.027
$^7F_6$	87.15		
	$(^5D_3)\ \tau_R$ = 0.809 msec.		
$^5D_4 \rightarrow {}^7F_0$	425.6		0.003
$^7F_1$	275.9		0.005
$^7F_2$	466.4		0.003
$^7F_3$	208.3	15.28	0.10
$^7F_4$	144.1	505.1	0.013
$^7F_5$	27.52	1.800	0.86
$^7F_6$	114.0		0.013
	$(^5D_4)\ \tau_R$ = 1.45 msec.		

[a]The intensity parameters used in the calculations are given in Appendix XIV - Table 1. The matrix elements of $\underset{\sim}{U}^{(\lambda)}$ appear in Appendix IX.