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United Kingdom Atomic Energy Authority

RESEARCH GROUP

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L. A. VAINSHTAIN
I. I. SOBELMAN

Culham Laboratory
Abingdon Berkshire

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BORN APPROXIMATION EXCITATION CROSS SECTIONS FOR ATOMS BY ELECTRONS

by

L.A. Vainshtain and I.I. Sobelman

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C O N T E N T S

CHAPTER I

INTRODUCTION

For solving numerous problems arising in atomic spectroscopy, astrophysics etc., it is necessary to know the effective excitation cross sections for atoms by electrons. The possibilities for their experimental determination are exceedingly limited. This applies especially to transitions from excited states for which virtually no experimental data are available. At the same time, in solving specific problems it is as a rule essential to have data relating to a fairly large number of atomic transitions. In all such cases one is therefore obliged to resort to theoretical cross section calculations. To perform these calculations a sufficiently universal method must be available which is valid for transitions of different types such as optically permitted and forbidden transitions, with and without change of spin, to transitions between close and widely spaced levels. Amongst the approximate methods used in atomic collision theory, the only one which may be described as sufficiently general is the simplest, namely, Born's method (including its modification taking into account exchange).

Although in specific cases other methods give results much more accurate than Born's method, they are necessarily no more accurate for the general case. As a result Born's is the only method suitable for performing systematic calculations (on the quality of Born's approximation, see section 9).

It should be noted that Born's approximation is certainly not sufficient to describe many fine effects, such as the appearance of narrow resonance peaks in elastic and inelastic scattering cross sections. Such effects are considered by special methods of atomic collision theory which are much more complex than Born's. However, for numerous applications these effects, although of considerable fundamental interest, are not important. In applications, almost invariably, one is not interested in the actual cross sections σ, but in the integrated coefficient $\langle v\sigma \rangle$ where the averaging (denoted by the angular brackets) is carried out over a sufficiently wide range of energies. Usually Born's approximation gives a value of $\langle v\sigma \rangle$ which is sufficiently accurate for most purposes.

This book gives a review of expressions and parameter tables from which the effective excitation cross sections and coefficients $\langle v\sigma \rangle$ in Born's approximation can be very simply obtained. The book is intended as a compact reference, accessible to a wide circle of physicists and engineers who are not specialists in the physics of atomic collisions. The derivation and justification of the expressions are not, therefore, reproduced and the number of literature references is kept to a minimum.

In the text symbols are used e.g. 3nj, genealogical coefficients $G^{SL}_{S_pL_p}$ and induced matrix elements $(\ell^n S_0 L_0 \| U^{\varkappa} \| \ell^n S_1 L_1)$. Some expressions for these are given in Appendices I-III. More detailed information can be obtained e.g. in[1,2].

CHAPTER II

BORN'S APPROXIMATION (GENERAL EXPRESSIONS)

In calculating the effective cross sections for the excitation of atoms by electrons it is convenient to isolate the following cases:

(1) the atom is described in the scheme of LS coupling; transitions without change of spin. In calculating the cross sections, exchange (paras. 1 and 2) can be neglected.

(2) the atom is described in the LS coupling scheme; transitions with change of spin. Transitions of this type (intercombinational) are realised only by exchange.

(3) other types of coupling (paragraph 4).

Let each of these cases now be discussed separately.

1. One Electron Beyond the Filled Shells

We consider here transitions of an optical electron situated in the centrally-symmetrical field of the nucleus and the filled shells. This case includes: the hydrogen atom, the atoms of the alkali elements, and atoms with basic configuration of the type $1s^2 2s^2 2p$. Born's expression for the effective cross section for the transition $n_0\ell_0 \to n_1\ell_1$ has the form

$$\sigma(\ell_0,\ell_1) = \frac{8\pi}{(k_0 a_0)^2}\frac{1}{(2\ell_0+1)}\sum_{m_0 m_1}\int_{k_0-k_1}^{k_0+k_1}\frac{dq}{q^3}\,|\langle n_0\ell_0 m_0|e^{i\vec{q}\vec{r}}-1|n_1\ell_1 m_1\rangle|^2 \quad \text{(I.I)} \qquad \ldots (1.1)$$

Here, and throughout below, the suffix 0,1 denotes the initial and final states (quantum numbers n_0, n_1 in the notation σ are omitted for simplicity).

$a_0 = \frac{\hbar^2}{me^2}$ is the atomic unit of length; $\vec{k}_0$, $\vec{k}_1$ the wave vector of an electron before and after the collision; $\vec{q} = \vec{k}_0 - \vec{k}_1$.

To carry out specific calculations it is convenient to represent eq.(1.1) as a sum over the multipolar interactions:

$$\sigma = \sum_{\varkappa}\sigma_{\varkappa} \quad \text{(I.2)} \qquad \ldots (1.2)$$

$$\sigma_{\varkappa} = \frac{8\pi}{(k_0 a_0)^2}(2\varkappa+1)(2\ell_1+1)\begin{pmatrix}\ell_0 & \ell_1 & \varkappa\\ 0 & 0 & 0\end{pmatrix}^2\int_{k_0-k_1}^{k_0+k_1}\frac{dq}{q^3}\left[R^{\varkappa}_{01}(q)\right]^2 \quad \text{(I.3)} \qquad \ldots (1.3)$$

$$R^{\varkappa}_{01}(q) = \int_0^{\infty} P_0(r)P_1(r)\left[j_{\varkappa}(qr)-\delta_{\varkappa 0}\right]dr \quad \text{(I.4)} \qquad \ldots (1.4)$$

where P_0, P_1 are the radial functions of the optical electron; $j_{\varkappa} = \sqrt{\frac{\pi}{2qr}}\,J_{\varkappa+1/2}(qr)$ is a spherical Bessel function. The possible values of the multipolarity coefficient are:

$$\varkappa = \varkappa_m, \varkappa_m+2, \ldots |\ell_0+\ell_1|; \quad \varkappa_m = |\ell_0-\ell_1| \quad \text{(I.5)} \qquad \ldots (1.5)$$

The term I in the matrix element in (1.1) is related to the interaction between the outer electron and the nucleus. This term must be taken into account unless strict orthogonality of the approximate wave functions of the initial and final states used in the calculation, is assured.

Yet when the wave functions are orthogonal this term makes no contribution to the cross section.

2. <u>LS Type Coupling Transitions Without Change of Spin ($\Delta S = 0$)</u>

In the general case the effective cross section for the transition between arbitrary levels γ_0, γ_1 is put in the form

$$\sigma = \sum_{\varkappa} \sigma_{\varkappa} \quad ; \quad \sigma_{\varkappa} = Q_{\varkappa}(\gamma_0, \gamma_1)\, \sigma'_{\varkappa}(l_0, l_1) \qquad (2.I) \qquad \ldots (2.1)$$

where ℓ_0, ℓ_1 are the orbital quantum numbers of the optical electron entering together with the other quantum numbers into the sets γ_0, γ_1. Suppose the atomic wave functions Ψ_γ are made up of one-electron functions ψ_α according to the general momentum composition rules and $\langle \psi_{\alpha_0} | \psi_{\alpha} \rangle = \delta_{\alpha\alpha_0}$. Suppose, moreover, that the radial functions P for all states relating to the given level, are similar. The factor $Q_{\varkappa}(\gamma_0, \gamma_1)$ then is only determined by the quantum numbers of the angular momenta. In different approximations the need arises for effective cross sections for transitions between separate levels, between two groups of closely adjacent levels and, finally, for transitions from a given level to a group of levels. Thus, one may be interested in the transitions between the separate fine structure components $SL_0J_0 \rightarrow SL_1J_1$ of two terms, or in the transition between the terms $SL_0 \rightarrow SL_1$ as a whole. In the general case the effective cross section for the group of transitions $A \rightarrow B$ can be obtained by summing the cross sections of the separate transitions $\sigma(Aa\,;\,Bb)$ according to the following expressions

$$\begin{aligned} \sigma(Aa;B) &= \sum_{b} \sigma(Aa;Bb) \\ g(A)\,\sigma(A;Bb) &= \sum_{a} g(a)\,\sigma(Aa;Bb) \\ g(A)\,\sigma(A;B) &= \sum_{ab} g(a)\,\sigma(Aa;Bb) \end{aligned} \qquad (2.2) \qquad \ldots (2.2)$$

where $g(a)$ is the statistical weighting of the level a, $g(A)$ that of the group of levels a: $g(A) = \sum_a g(a)$ when extending the above assumptions made with respect to the radial functions, to all states belonging to the group of levels A (or correspondingly B) then for all terms of the sum over a,b the radial integrals are similar. The expressions (2.2) have corresponding analogous expressions for the factors $Q_{\varkappa}$ and all summation properties of the cross sections and factors $Q_{\varkappa}$ are the same. Below we shall assume throughout that such a situation exists. We are, of course, concerned with the level group A (and correspondingly B) belonging to one electron configuration. The error relating to this

assumption is, as a rule, smaller the smaller the energy difference between the levels over which the summation is effected.

When summing over the fine structure components of the terms the following important circumstance should be noted:

$$Q_{\varkappa}(SL_0J_0, SL_1) \equiv \sum_{J_1} Q_{\varkappa}(SL_0J_0; SL_1J_1)$$

is independent of J_0. Therefore

$$(2S+1)(2L_0+1)Q_{\varkappa}(SL_0; SL_1) = \sum_{J_0J_1}(2J_0+1)Q_{\varkappa}(SL_0J_0; SL_1J_1) = \sum_{J_0}(2J_0+1)Q_{\varkappa}(SL_0J_0; SL_1)$$

Since $\sum_{J_0}(2J_0+1) = (2S+1)(2L_0+1)$ we have

$$Q_{\varkappa}(SL_0; SL_1) = Q_{\varkappa}(SL_0J_0; SL_1) \qquad (2.3) \qquad \ldots (2.3)$$

The excitation cross sections of the term SL_1, from the single level SL_0J_0 and from all levels belonging to the term SL_0 are, therefore, the same. Relations of a similar type for the factors $Q_{\varkappa}$ and the cross sections also occur when summing over the terms.

We go on to consider different specific cases. We write down the expressions for the factors $Q_{\varkappa}$ from (2.1). It is convenient to differentiate between the following four cases:

I transitions not involving groups of equivalent electrons

II transitions between ℓ_0^N, $\ell_0^{N-1}\ell_1$ configurations

III transitions between $\ell_0^N\ell_1^K$; $\ell_0^{N-1}\ell_1^{K+1}$ configurations

IV transitions between terms of one configuration

In case III the discussion will be limited to the occupied shells ℓ_0^N; $N = 2(2\ell_0+1)$ (which is sufficient for the vast majority of applications) as the general expressions are exceedingly cumbersome.

I

$$\text{I.} \quad \gamma_0 \equiv [S_pL_p]\ell_0 SL_0 \; ; \; \gamma_1 \equiv [S_pL_p]\ell_1 SL_1^{*}$$

$$Q_{\varkappa}(\gamma_0\gamma_1) = (2\ell_0+1)(2L_1+1)\begin{Bmatrix} \ell_0 & L_0 & L_p \\ L_1 & \ell_1 & \varkappa \end{Bmatrix}^2 \qquad (2.5) \qquad \ldots (2.5)$$

The sum of the factors $Q_{\varkappa}$ from (2.5) over L_1 is independent of SL_0. The summation over S and L_0 does not, therefore, change $Q_{\varkappa}$ (compare with (2.3))

$$Q_{\varkappa}([S_pL_p]\ell_0; [S_pL_p]\ell_1) =$$

$$= Q_{\varkappa}([S_pL_p]\ell_0 S; [S_pL_p]\ell_1 S) = Q_{\varkappa}([S_pL_p]\ell_0 SL_0; [S_pL_p]\ell_1 S) = 1 \qquad (2.6) \qquad \ldots (2.6)$$

---

* To simplify the notation we do not indicate the electron configuration of the atomic core but give only the spin S_p and the orbital momentum L_p of the atomic core.

The cross section for the transition $\ell_0 \to \ell_1$ for an electron in a given field of an atomic core is consequently the same as for an electron in the central field, i.e. it is independent of the angular momenta of the atomic core S_pL_p. In other words, the effective cross section of the entire multitude of transitions between two electron configurations not containing electrons equivalent to an optical electron, equals $\sigma_\varkappa(\ell_0\ell_1)$ from (1.3).

II

$$\text{II.}\quad \gamma_0 \equiv \ell_0^N SL_0 \;;\; \gamma_1 \equiv \ell_0^{N-1}[S_pL_p]\ell_1 SL_1$$

$$Q_\varkappa(\gamma_0\gamma_1) = N\left|G^{SL_0}_{S_pL_p}\right|^2 (2\ell_0+1)(2L_1+1)\begin{Bmatrix} \ell_0 & L_0 & L_p \\ L_1 & \ell_1 & \varkappa \end{Bmatrix}^2 \qquad (2.7) \qquad \ldots (2.7)$$

where $G^{SL_0}_{S_pL_p}$ is the genealogical coefficient. Summation over the momenta gives

$$Q_\varkappa(\ell_0^N SL_0 ; \ell_0^{N-1}[S_pL_p]\ell_1 S) = N\left|G^{SL_0}_{S_pL_p}\right|^2 \qquad (2.8) \qquad \ldots (2.8)$$

$$Q_\varkappa(\ell_0^N : \ell_0^{N-1}\ell_1) = Q_\varkappa(\ell_0^N S ; \ell_0^{N-1}\ell_1 S) = Q_\varkappa(\ell_0^N SL_0 ; \ell_0^{N-1}\ell_1 S) = N \qquad \ldots (2.9)$$

III

$$\text{III.}\quad \gamma_0 \equiv \ell_0^N \ell_1^K SL_0 \;;\; \gamma_1 \equiv \ell_0^{N-1}[2\ell_0]\ell_1^{K+1}[S_pL_p]SL_1 \;;\; N = 2(2\ell_0+1)^*$$

$$Q_\varkappa(\gamma_0\gamma_1) = (K+1)\left|G^{S_pL_p}_{SL_0}\right|^2 \frac{(2S_p+1)(2L_p+1)(2L_1+1)(2\ell_0+1)}{(2S+1)(2L_0+1)}\begin{Bmatrix} \ell_0 & L_1 & L_p \\ L_0 & \ell_1 & \varkappa \end{Bmatrix}^2 \qquad (2.10) \qquad \ldots (2.10)$$

Summing over the momenta gives

$$Q_\varkappa(\ell_0^N\ell_1^K SL_0 ; \ell_0^{N-1}\ell_1^{K+1}[S_pL_p]S) = (K+1)\left|G^{S_pL_p}_{SL_0}\right|^2 \frac{(2S_p+1)(2L_p+1)(2\ell_0+1)}{(2S+1)(2L_0+1)(2\ell_1+1)} \qquad \ldots (2.11)$$

$$Q_\varkappa(\ell_0^N\ell_1^K ; \ell_0^{N-1}\ell_1^{K+1}[S_pL_p]) = \frac{K+1}{g(\ell_1^K)} \cdot \frac{(2S_p+1)(2L_p+1)(2\ell_0+1)}{(2\ell_1+1)} \qquad (2.12) \qquad \ldots (2.12)$$

where $g(\ell_1^K)$ is the statistical weighting of the configurations ℓ_1^k equal to the number of summations over k from $2(2\ell_1 + 1)$

$$Q_\varkappa(\ell_0^N\ell_1^K ; \ell_0^{N-1}\ell_1^{K+1}) = Q_\varkappa(\ell_0^N\ell_1^K SL_0 ; \ell_0^{N-1}\ell_1^{K+1}S) = (2\ell_1+2-K)\frac{2\ell_0+1}{2\ell_1+1} \qquad \ldots (2.13)$$

IV

$$\text{IV.}\quad \gamma_0 \equiv \ell^N SL_0 \;;\; \gamma_1 \equiv \ell^N SL_1$$

$$Q_\varkappa(\gamma_0\gamma_1) = \frac{2\ell+1}{2L_0+1}\left|(\ell^N SL_0 \| U^\varkappa \| \ell^N SL_1)\right|^2 \qquad (2.14) \qquad \ldots (2.14)$$

---

* As mentioned earlier, in this case we only consider transitions from a filled shell.

The factors $(\ell^N SL_0 \| U^\varkappa \| \ell^N SL_1)$ for the configurations p^N and d^N are tabulated. The corresponding expressions are given in Appendix III.

The factors $Q_\varkappa$ for transitions between the fine structure components J_0, J_1 and the transitions between the terms SL_0, SL_1 are related by

$$Q_\varkappa(SL_0J_0;SL_1J_1) = (2L_0+1)(2J_1+1)\begin{Bmatrix} L_0 & J_0 & S \\ J_1 & L_1 & \varkappa \end{Bmatrix}^2 Q_\varkappa(SL_0;SL_1) \qquad (2.15) \qquad \ldots (2.15)$$

Summing over J_1, and also over J_0, gives

$$Q_\varkappa(SL_0J_0;SL_1) = Q_\varkappa(SL_0;SL_1) \qquad (2.16) \qquad \ldots (2.16)$$

This relation has been quoted earlier, see eq.(2.3). The above expressions embrace practically all possible cases which one is likely to encounter in specific calculations.

3. <u>LS Type Coupling; Intercombinational Transitions ($\Delta S \neq 0$)</u>

Transitions with change of the atomic spin during collisions with electrons are possible either because of exchange interaction, or because of a violation of LS coupling. We consider here the case of pure LS coupling when the intercombinational transitions are wholly due to exchange. Consideration of exchange within the frame work of the familiar Born-Oppenheimer method leads as a rule to unsatisfactory results. The errors incurred are considerably larger than with Born's method for transitions without change of spin. The Born-Oppenheimer method can be, however, so modified that this fault is removed. We intend here to use a modification proposed by Ochkur. Calculations have shown that discrepancies between the experimental results and Ochkur's method are of the same order as for Born's method.

The intercombinational effective transition cross sections are conveniently expressed through the values $\sigma'_\varkappa(\ell_0,\ell_1)$ analogous to $\sigma_\varkappa(\ell_0,\ell_1)$ from (1.3)*

$$\sigma = \sum_\varkappa \sigma_\varkappa \; ; \quad \sigma_\varkappa = Q_\varkappa(\gamma_0\gamma_1)\,\sigma'_\varkappa(\ell_0,\ell_1) \qquad (3.1) \qquad \ldots (3.1)$$

$$\sigma'_\varkappa(\ell_0,\ell_1) = \frac{8\pi}{a_0^2 k_0^6}(2\varkappa+1)(2\ell_1+1)\begin{pmatrix} \ell_0 & \ell_1 & \varkappa \\ 0 & 0 & 0 \end{pmatrix}^2 \int_{k_0-k_1}^{k_0+k_1} z^{-2}\,dz\,[R^\varkappa_{0l}(z)]^2 \qquad (3.2) \qquad \ldots (3.2)$$

We quote expressions for this factor $Q_\varkappa$ in the most interesting cases from a practical point of view, which correspond to transitions of the type I, II and IV of the previous section.

I. $\qquad$ I. $\gamma_0 \equiv [S_p L_p]\ell_0 S_0 L_0 \; ; \; \gamma_1 \equiv [S_p L_p]\ell_1 S_1 L_1$

---

* Note that the values $\sigma_\varkappa(\ell_0, \ell_1)$ do not have the physical meaning of transition cross sections between electron configurations as in the case $\Delta S = 0$, as the concept of the intercombinational transitions requires specification of the spins.

$$Q_x(\gamma_0\gamma_1) = \frac{2S_1+1}{2(2S_p+1)}(2\ell+1)(2L_1+1)\begin{Bmatrix} \ell & L_0 & L_p \\ L_1 & \ell & x \end{Bmatrix}^2 \qquad (3.3) \qquad \ldots (3.3)$$

Summing over L_1, or over L_0, L_1 we obtain

$$Q_x(S_0L_0;S_1) = Q_x(S_0;S_1) = \frac{2S_1+1}{2(2S_p+1)} \qquad (3.4) \qquad \ldots (3.4)$$

II.

$$\text{II.} \quad \gamma_0 \equiv \ell^N S_0L_0 \;;\; \gamma_1 \equiv \ell^{N-1}[S_pL_p]\ell\, S_1L_1$$

$$Q_x(\gamma_0,\gamma_1) = N\left|G^{S_0L_0}_{S_pL_p}\right|^2 \frac{2S_1+1}{2(2S_p+1)}(2\ell+1)(2L_1+1)\begin{Bmatrix} \ell & L_0 & L_p \\ L_1 & \ell & x \end{Bmatrix}^2 \qquad (3.5) \qquad \ldots (3.5)$$

Summing over L_1 gives

$$Q_x(S_0L_0;S_1) = N\left|G^{S_0L_0}_{S_pL_p}\right|^2 \frac{2S_1+1}{2(2S_p+1)} \qquad (3.6) \qquad \ldots (3.6)$$

IV

$$\text{IV.} \quad \gamma_0 \equiv \ell^N S_0L_0 \qquad \gamma_1 \equiv \ell^N S_1L_1$$

$$Q_x(\gamma_0,\gamma_1) = \frac{2S_1+1}{2(2S_p+1)}(2\ell+1)(2L_1+1)\sum_{S_p}\left|N\sum_{L_p} G^{S_0L_0}_{S_pL_p}G^{S_1L_1}_{S_pL_p}\begin{Bmatrix} \ell & L_0 & L_p \\ L_1 & \ell & x \end{Bmatrix}\right|^2 \qquad (3.7) \qquad \ldots (3.7)$$

where $S_p\ L_p$ are terms of the configurations ℓ^{N-1}.

The factors $Q_x(S_0L_0J_0;S_1L_1J_1)$ in cases I, II are related to the factors $Q_x(S_0L_0;S_1L_1)$ from (3.3), (3.5), by the relation

$$Q_x(S_0L_0J_0;S_1L_1J_1) = (2J_0+1)(2S_p+1)(2L_1+1)(2S_0+1)\begin{bmatrix} S_p & S_1 & L_1 & L_0 & S_0 \\ & 1/2 & J_1 & x & J_0 & 1/2 \\ S_p & S_1 & L_1 & L_0 & S_0 \end{bmatrix} Q_x(S_0L_0;S_1L_1) \qquad (3.8) \qquad \ldots (3.8)$$

Summing over J_1, or over J_0, J_1 leads as expected to $Q_x(S_0L_0;S_1L_1)$.

In the special case of singlet - triplet transitions $(S_0=0;\ J_0=L_0;\ S_1=1)$ and the triplet - singlet transitions $(S_0=1;\ S_1=0;\ J_1=L_1)$ we have

$$Q_x(0L_0J_0;1L_1J_1) = \frac{2J_1+1}{3(2L_1+1)}Q_x(0L_0;1L_1) \qquad (3.9) \qquad \ldots (3.9)$$

$$Q_x(1L_0J_0;0L_1J_1) = Q_x(1L_0;0L_1) \qquad (3.10) \qquad \ldots (3.10)$$

4. $j\ell$ Type Coupling

For a large number of levels of different atoms the approximation of LS coupling is inadequate. In the general case of coupling of an intermediate type, each specific transision requires special consideration. Amongst the limiting cases the most important in

practice is that of the $j\ell$ coupling to be discussed. In addition, expressions will also be given for transitions in which one level is described in the $j\ell$ coupling scheme and the other in the LS coupling scheme.

When LS coupling is violated intercombinational transitions become possible not only by exchange but also by the 'mixing' of states of different multiplet character. In the limiting case of coupling of a different type including $j\ell$ coupling, even without considering exchange no prohibitions with regard to spin quantum numbers arise. The situation then is analogous to transitions without change of spin for LS coupling when consideration of exchange only yields a correction of the same order of magnitude as the error in Born's method. Therefore, just as in section 2, we propose to give here the corresponding expressions for the cross sections without considering exchange.

Thus,

$$\sigma = \sum_{\varkappa} \sigma_{\varkappa} \; ; \; \sigma_{\varkappa} = Q_{\varkappa}(\gamma_0, \gamma_1)\, \sigma_{\varkappa}(\ell_0, \ell_1) \qquad (4.1) \qquad \ldots (4.1)$$

where $\sigma_{\varkappa}(\ell_0, \ell_1)$ is given by (1.3).

For transitions between configurations as a whole the cross-section is obviously independent of the type of coupling and, $Q_{\varkappa} = 1$. For transitions between terms

$$\gamma_0 \equiv [S_p L_p j]\ell_0 K_0 \; ; \; \gamma_1 \equiv [S_p L_p j]\ell_1 K_1$$

$$Q_{\varkappa}(\gamma_0 \gamma_1) = (2\ell_0+1)(2K_1+1) \begin{Bmatrix} \ell_0 & K_0 & j \\ K_1 & \ell_1 & \varkappa \end{Bmatrix}^2 \qquad (4.2) \qquad \ldots (4.2)$$

$$Q_{\varkappa}([S_p L_p j]\ell_0 ; [S_p L_p j]\ell_1) = Q_{\varkappa}([S_p L_p j]\ell_0 K_0 ; [S_p L_p j]\ell_1) = 1 \qquad (4.3) \qquad \ldots (4.3)$$

For transitions between fine structure components $J_0 = K_0 \pm 1/2$ $J_1 = K_1 \pm 1/2$ we have

$$Q_{\varkappa}(K_0 J_0 ; K_1 J_1) = (2K_0+1)(2J_1+1) \begin{Bmatrix} K_0 & J_0 & 1/2 \\ J_1 & K_1 & \varkappa \end{Bmatrix}^2 Q_{\varkappa}(K_0, K_1) \qquad (4.4) \qquad \ldots (4.4)$$

Summation over J_1 gives

$$Q_{\varkappa}(K_0 J_0 ; K_1) = Q_{\varkappa}(K_0, K_1) \qquad (4.5) \qquad \ldots (4.5)$$

For transitions from the term γ_0 described in the LS coupling scheme, to the term γ_1 described in the scheme of $j\ell$ coupling we have

$$\gamma_0 \equiv [S_p L_p]\ell_0 S_0 L_0 \; ; \; \gamma_1 \equiv [S_p L_p j]\ell_1 K_1$$

$$Q_{\varkappa}(\gamma_0, \gamma_1) = (2\ell_0+1)\frac{(2j+1)(2K_1+1)}{(2S_p+1)} \left[\sum_r (2r+1) \begin{Bmatrix} L_p & \ell_1 & r \\ \varkappa & L_0 & \ell_0 \end{Bmatrix}^2 \begin{Bmatrix} L_p & \ell_1 & r \\ K_1 & S_p & j \end{Bmatrix}^2 \right] \qquad (4.6) \qquad \ldots (4.6)$$

Summation over k_1 gives

$$Q_{\varkappa}([S_p L_p]\ell_0 S_0 L_0 ; [S_p L_p j]\ell_1) = \frac{2j+1}{(2S_p+1)(2L_p+1)} \qquad (4.7) \qquad \ldots (4.7)$$

Summing further over j we obtain

$$Q_\alpha([S_p L_p] l_0 S_0 L_0 ; [S_p L_p] l_1) = 1 \qquad (4.8) \qquad \ldots (4.8)$$

For transitions between the fine structure components we have

$$Q_\alpha(S_0 L_0 J_0 ; L_1 J_1) = (2l_0+1)(2J_1+1)(2S_0+1)(2L_0+1) \times (2j+1)(2K_1+1) \begin{bmatrix} L_0 & S_p & \alpha & K_1 \\ l_0 & J_0 & j & 1/2 \\ L_p & l_1 & S_0 & J_1 \end{bmatrix} \qquad \ldots (4.9)$$

CHAPTER III

APPROXIMATION BY ANALYTICAL EXPRESSIONS

5. Approximate Analytical Expressions for the Cross Sections

Born's effective excitation cross section for neutral atoms have a number of characteristic properties. Some of these can be obtained by investigating general expressions; others follow from the results of specific numerical calculations.

At large K_0 values for optically permitted transitions $l_1 = l_0 \pm 1$, $\Delta S = 0$

$$\sigma \sim \frac{1}{K_0^2} \ln K_0 \qquad \ldots (5.1)$$

For optically forbidden transitions $l_1 \neq l_0 \pm 1$

$$\sigma \sim \frac{1}{K_0^2} \qquad \ldots (5.2)$$

For intercombinational transitions

$$\sigma \sim \frac{1}{K_0^6} \qquad \ldots (5.3)$$

At small energies

$$\sigma \sim K_1 \qquad \ldots (5.4)$$

For the purpose of approximations it is useful to approximate the cross sections by some analytical formulae, and the cross sections are conveniently expressed in threshold units;

$$u = \frac{\mathcal{E}_1}{\Delta E} = \frac{\mathcal{E}_0}{\Delta E} - 1 , \quad \Delta E = E_1 - E_0 \qquad (5.5) \qquad \ldots (5.5)$$

where $\mathcal{E}_0$, $\mathcal{E}_1$ are the energy of the incident and of the scattered electron respectively, E_0, E_1 the initial and final energy level of the atom; ΔE the excitation threshold.

As a rule, for transitions between adjacent levels, when ΔE decreases, the maximum value of the cross section increases roughly as ΔE^{-2}. Moreover, for transitions between levels with strongly varying effective principal quantum numbers ν_0, ν_1 the cross section is approximately proportional to $\nu_1^{-3} \sim E_1^{\frac{3}{2}}$.

Lastly, numerical calculations show that the main contribution to the sum over the $\varkappa$ is made by the term with $\varkappa = \varkappa_{min}$. The reason is that in the region of small q, the most important for integrating over q in (1.3), the function $J_\varkappa(qr)\sim(qr)^\varkappa$ decreases rapidly as $\varkappa$ increases.

Taking this into account, we write the excitation cross section for the transition 0-1 in the following form

$$\sigma = \pi a_0^2 \left(\frac{R_y}{\Delta E}\right)^2 \left(\frac{E_1}{E_0}\right)^{3/2} \frac{Q_{\varkappa min}}{2l_0+1}\, \Phi(u) \qquad (5.6) \quad \ldots (5.6)$$

where $R_y = \frac{e^2}{2a_0} = \frac{me^4}{2\hbar^2}$ is the Rydberg unit of energy.

There are various ways of choosing the specific form of the function $\varphi(u)$. Here we use an expression satisfying conditions (5.1) - (5.4) and containing two parameters.

For the optically permitted transitions $l_1 = l_0 \pm 1$, $\Delta S = 0$

$$\Phi(u) = \Phi(u, C, \varphi) = C\left(\frac{u}{u+1}\right)^{1/2} \frac{\ln(16+u)}{u+\varphi} \qquad (5.8) \quad \ldots (5.8)$$

For the optically forbidden transitions $l_1 \neq l_0 \pm 1$, $\Delta S = 0$

$$\Phi(u) = \Phi(u, C, \varphi) = C\left(\frac{u}{u+1}\right)^{1/2} \frac{1}{u+\varphi} \qquad (5.9) \quad \ldots (5.9)$$

When the cross section is known the parameters C and φ can be determined by using e.g. the method of least squares.

In section 7 a table is referred to of the parameters C - φ obtained by this method from the results of approximate numerical cross section calculations*.

In the case of intercombinational transitions the form of the cross section varies from one transition to the next much more strongly than in the case $\Delta S = 0$. It was not possible therefore to construct a two-parameter expression for the intercombinational transitions.

6. Averaging Over the Maxwellian Distribution

The probability of the excitation 0-1 in a plasma with electron concentration N_e and electron temperature T equals $N_e\langle v\sigma\rangle$, where the brackets denote averaging over the Maxwellian energy distribution of the electrons. Using (5.6) for σ we have

$$\langle v\sigma_{01}\rangle = 10^{-8}\left(\frac{R_y}{\Delta E}\frac{E_1}{E_0}\right)^{3/2} e^{-\beta} \frac{Q_{\varkappa min}}{2l_0+1}\, G(\beta) \quad \left[\frac{cm^3}{cm}\right] \qquad (6.1) \quad \ldots (6.1)$$

$$G(\beta) = 2{,}13\,\beta^{3/2}\int_0^\infty (u+1)\Phi(u)\, e^{-\beta u}\, du \;; \quad \beta = \frac{\Delta E}{kT} \qquad (6.2) \quad \ldots (6.2)$$

* In compiling the table, the accuracy of the specific forms of eqs. (5.7), (5.8) was improved.

For de-excitation, i.e. the transition 1→0 the following simple relation applies

$$\langle v\sigma_{10}\rangle = \frac{g_0}{g_1}\langle v\sigma_{01}\rangle e^{\beta} \qquad \ldots (6.3)$$

The function $G(\beta)$ can be approximated by the following two-parameter expressions:

For optically permitted transitions $\ell_1 = \ell_0 \pm 1,\ \Delta S = 0$

$$G(\beta) \simeq G(\beta, A, \chi) = A\,\frac{\sqrt{\beta(\beta+1)}}{\beta+\chi}\,\ln\left(16+\frac{1}{\beta}\right) \qquad (6.4) \quad \ldots (6.4)$$

For optically forbidden transitions $\ell_1 \neq \ell_0 \pm 1,\ \Delta S = 0$

$$G(\beta) \simeq G(\beta, A, \chi) = A\,\frac{\sqrt{\beta(\beta+1)}}{\beta+\chi} \qquad \ldots (6.5)$$

For intercombinational transitions

$$G(\beta) \simeq G(\beta, A, \chi) = A\,\frac{\beta^{1/2}}{\sqrt{1+\beta}\,(\beta+\chi)} \qquad (6.6) \quad \ldots (6.6)$$

Parameters A and χ: analogous to the parameters C and φ in the previous section, they can be determined from the results from numerical calculations of $\langle v\sigma\rangle$ by the method of least squares. The corresponding tables are referred to in section 7.

7. Cross Section Tables, Description

Eqs.(5.5) - (5.9) and (6.1) - (6.6) give approximate expressions for the excitation cross section σ and the rate of excitation $\langle v\sigma_{01}\rangle$ and of de-excitation $\langle v\sigma_{10}\rangle$ through the parameters C, φ and A, χ respectively. These parameters were tabulated for transitions of the type s-s, s-p, s-d, p-p* in an approximation analogous to the Bates-Damgaard approximation for tables of oscillator strengths[1,3]. The method of calculation is discussed in greater detail in the following paragraph. Here it is only explained how to use the tables.

The investigated transition is characterized by the effective principal quantum numbers of the initial level ν_0 and the final level ν_1. For a neutral atom

$$\nu_0 = \sqrt{\frac{R_y}{|E_0|}} \qquad \nu_1 = \sqrt{\frac{R_y}{|E_1|}} \qquad (7.1) \quad \ldots (7.1)$$

For transitions with $\ell_1 \geq \ell_0$ i.e. transitions s→s, p→p, s→p and s→d the parameters C, φ and A, χ are given as functions of ν_0, $\nu_1 - \nu_0$.

For transitions with $\ell_1 < \ell_0$ i.e. transitions p→s and d→s the parameters C, φ and A, χ are given as functions of ν_1, $\nu_1 - \nu_0$.

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* For the p-d transition only A, χ are given.

As in the case of the Bates-Damgaard tables, the exchange of one of the arguments ν by the difference $\Delta\nu$ is convenient for interpolation. The step in ν and $\Delta\nu$ adopted in the tables ensures the possibility of a linear interpolation everywhere except for a relatively small number of places where the dependence of the parameters is discontinuous.

The tables give the order and mantissa of the numbers, e.g. -1 179; +1 179 means respectively $0.179 \cdot 10^{-1}$, $0.179 \cdot 10^{+1}$.

8. Cross Section Tables, Method of Calculation

According to (2.1), where it is also assumed that the main contribution to the sum over $\varkappa$ is made by the term with $\varkappa = \varkappa_{min}$, we have

$$\sigma = \sum_{\varkappa} Q_{\varkappa} \sigma_{\varkappa}(\ell_0, \ell_1) \approx Q_{\varkappa\,min} \sum_{\varkappa} \sigma_{\varkappa}(\ell_0, \ell_1) \qquad (8.1) \qquad \ldots (8.1)$$

Comparing (8.1) with (5.6) gives*

$$\Phi = \left(\frac{E_0}{E_1}\right)^{3/2} \left(\frac{\Delta E}{E_1}\right)^2 \sum_{\varkappa} (2\varkappa+1)(2\ell_1+1)(2\ell_0+1) \begin{pmatrix} \ell_0 & \ell_1 & \varkappa \\ 0 & 0 & 0 \end{pmatrix}^2 \frac{8}{k_0^2} \int_{k_0-k_1}^{k_0+k_1} \frac{dq}{q^3} \left[R_{01}^{\varkappa}(q)\right]^2 \qquad (8.2) \qquad \ldots (8.2)$$

The radial integral

$$R_{01}^{\varkappa}(q) = \int_0^{\infty} P_0(r) P_1(r) \left[j_{\varkappa}(qr) - \delta_{\varkappa 0}\right] dr \qquad (8.3) \qquad \ldots (8.3)$$

is calculated in an approximation analogous to the Bates-Damgaard approximation for oscillator strengths. Within the frame work of this approximation, we use semi-empirical coulomb radial wave functions. These represent an asymptotic solution of the Schrödinger equation with coulomb potential and with an experimental energy value. Such functions are given by the power series

$$P(r) = \sum_n b_n r^{\nu-n} e^{-r/\nu} \qquad \ldots (8.4)$$

where ν is the effective principal quantum number (see eq.(7.1)) and the coefficients b_n are determined by the recurrent formula

$$b_n = -\frac{(\nu-\ell-n)(\nu+\ell-n)\,\nu}{2n}\, b_{n-1} \qquad (8.5) \qquad \ldots (8.5)$$

After some simple transformations we get

$$R_{01}^{\varkappa}(q) = \alpha \sum_{\lambda=0}^{\lambda_{max}} C_{\lambda} J_{\varkappa}(\nu_0+\nu_1-\lambda;\ q/\alpha) \qquad \ldots (8.6)$$

$$\alpha = 1/\nu_0 + 1/\nu_1 \ ; \quad \lambda_{max} = \nu_0 + \nu_1 - \ell_0 - \ell_1 \qquad (8.7) \qquad \ldots (8.7)$$

---

* Here and further below in this section atomic units are used for k , q and r.

$$J_\varkappa(x,y) = \int_0^\infty e^{-z} z^x \left[j_\varkappa(yz) - \delta_{\varkappa 0} \right] dz \qquad (8.8) \qquad \ldots (8.8)$$

$$C_\lambda = \sum_{n=1}^{\lambda} a_n^{(0)} a_{\lambda-n}^{(1)} \qquad \ldots (8.9)$$

$$a_0 = \frac{1}{\nu}\left(\frac{2}{\nu\alpha}\right)^\nu \left[\Gamma(\nu+\ell+1)\Gamma(\nu-\ell)\right]^{-1/2} \qquad a_n = -\frac{(\nu+\ell+1-n)(\nu-\ell-n)\nu\alpha}{2n} a_{n-1} \qquad \ldots (8.10)$$

The superscripts (0) and (1) in (8.9) refer as usual to the initial and final states. The definition of λ_{max} is that the function P(r) in (8.4) contains just as many terms as the corresponding hydrogen-like function. The integral (8.8) can be expressed through a hypergeometric function. For $\varkappa \neq 0$

$$J_\varkappa(x,y) = \frac{\sqrt{\pi}}{y} \cdot \frac{\Gamma(\varkappa+x+1)\left(\frac{y}{2}\right)^{\varkappa+1}}{\Gamma(\varkappa+\frac{1}{2})(1+y^2)^{\frac{x+\varkappa+1}{2}}} F\left(\frac{\varkappa+x+1}{2}; \frac{\varkappa-x+1}{2}; \varkappa+\frac{3}{2}; \frac{y^2}{1+y^2}\right) \qquad (8.11) \qquad \ldots (8.11)$$

For $\varkappa = 0$ and 1 one can use the explicit expression through the elementary functions

$$J_0(x,y) = \frac{\Gamma(x)}{y(1+y^2)^{x/2}} \sin xt - x\Gamma(x) \; ; \; t = \operatorname{arctg} y \qquad (8.12) \qquad \ldots (8.12)$$

$$J_1(x,y) = \frac{\Gamma(x-1)}{y(1+y^2)^{x/2}} \left[\frac{1}{y} \sin xt - x \cos xt \right] \qquad (8.13) \qquad \ldots (8.13)$$

Just as in calculating the oscillator strengths the Bates-Damgaard approximation is best justified in those cases where the maxima of both functions P_0, P_1 are situated outside the atomic core. This condition can be formulated explicitly. It is necessary that the following inequalities be fulfilled

$$n_0 > n_{core} \; ; \; n_1 > n_{core} \; ; \; \nu_0 > \ell_0 + \tfrac{1}{2}$$

where n_{core} is the largest of the principal quantum numbers of the core electrons, without going in detail into the accuracy of the Bates-Damgaard approximation, as the error made in calculating the cross sections with this approximation is of the same order as in calculating the oscillator strengths. Suffice it to say that in calculating the cross-sections the accuracy requirements of the wave functions are less stringent than when calculating the oscillator strengths. The characteristic error of the Born method at any given accuracy of the wave functions makes it impossible to guarantee an accuracy of more than a few times ten per cent.

9. Some Remarks On Approximate Methods For Calculating Cross Sections

The above discussions were confined throughout within the frame work of Born's method. In compiling the tables, an additional approximation was made, relating to the form of the atomic wave functions used. The character of this approximation is considered at the end

of this section. First, let us briefly discuss the accuracy of Born's method.

It corresponds to a solution of the problem of a collision between an electron and an atom to a first order approximation in perturbation theory. It is certainly applicable when the velocities of the electron are sufficiently large. The question of the errors at electron energies comparable to the excitation threshold ΔE, is not yet completely resolved.

Two sufficiently obvious and explicit error sources in Born's method are: (1) the violation of the normalization (non-conservation of the electron flux) (2) the effect of the long range coulomb field in considering the excitation of the ions. We shall examine the part played by these effects later in this section. Yet in those cases in which they are unimportant, Born's method, as indicated by the experimental data, gives results which are satisfactory for numerous applications.

The errors of the method even in the region of the cross section maximum $(E \sim 2\Delta E)$ do not fall beyond the limits of a factor $\leqslant 2$, and decrease rapidly as the energy increases. It should be emphasized that this assertion is based mainly on experiments on excitation from the ground state.

The effect of violating the normalization is this. In the exact formulation of the scattering problem the partial cross sections must not exceed some theoretical limit following from the requirement of the electron flux conservation. Born's approximation does not, generally speaking, ensure that this condition is fulfilled. Therefore, in some cases, as a rule in those corresponding to small ΔE, i.e. transitions between adjacent levels, Born's cross sections may be strongly exaggerated. There are different methods for the normalization of Born's cross sections which overcome this fault, such as Seaton's method based on the use of an R-matrix. However, all these methods require calculations based on the partial wave concept, which present a much more complex problem. No normalization of the cross sections was therefore effected while compiling the tables. In the excitation of ions in the region of energies E the attraction of the electron by the long range coulomb field plays an important part. This leads, in particular, to a finite cross section at the excitation threshold. This effect is taken into account in the so-called Born-Coulomb approximation where instead of plane waves, wave functions (the continuous spectrum of the electron in the coulomb field) are used. For the purpose of specific calculations one then has also to resort to the partial wave concept. Since the difference between Born's and the Born-Coulomb cross sections is only significant in the region near the threshold, in those cases in which $\Delta E \lesssim kT$, the above tables can be used for calculating $\langle \upsilon\sigma \rangle$ On the other hand, when $\Delta E > kT$, this may lead to considerable errors.

A table referred to in section 10 gives parameters with which the value of $\langle v\sigma \rangle$ for multiply charged ions in a number of interesting applications can be estimated.

10. Excitation of Ions

Let the effective excitation cross section of the ion be represented in the same form as for a neutral atom (see (5.6))

$$\sigma = \pi a_0^2 \left(\frac{R_y}{\Delta E}\right)^2 \left(\frac{E_1}{E_0}\right)^{3/2} \frac{Q_{x\,min}}{2l_0+1}\, \phi(u) \qquad \text{(10.1)} \quad \ldots (10.1)$$

the function $\varphi(u)$ can be approximated by the following analytical expression

$$\phi(u) = \phi(u, C, \varphi) = \frac{C}{u+\varphi} \qquad \text{(10.2)} \quad \ldots (10.2)$$

$\langle v\sigma \rangle$ is given by eq.(6.1)

$$\langle v\sigma_{01} \rangle = 10^{-8} \left(\frac{R_y}{\Delta E}\frac{E_1}{E_0}\right)^{3/2} e^{-\beta} \frac{Q_{x\,min}}{2l_0+1}\, G(\beta)$$

where

$$G(\beta) = A\, \frac{\sqrt{\beta}\,(\beta+1)}{\beta+\chi} \qquad \ldots (10.3)$$

The parameters C, φ, A, χ are rather weakly dependent on the ion charge Z. In practice, this dependence operates only when the parameter $\frac{Z-1}{Z}$ varies significantly from unity. It would be possible therefore to limit the tables to the parameters C and φ for a number of Z values. Even so, the compiling of such tables, though not presenting any fundamental difficulties, requires a very large expenditure of machine time.

Some relatively small tables are given later showing the parameters C, φ, A, χ for transitions between hydrogen-like levels with $n \leqslant 4$; these tables are based on calculations of the excitation cross sections of the O^{7+} ion (spectrum O VIII); in the light of what was said above these are valid for any given ion. Even for Z = 2 the error in the determination of C, φ, A, χ because the dependence on Z is neglected, does not exceed 25%.

Naturally, we are concerned here only with hydrogen-like levels when the effective principal quantum numbers ν_0, ν_1 take on values close to integers. For interpolations, when the difference from hydrogen "likeness" is significant the tables are unsuitable. However, when $\Delta E < kT$, when calculating the value of $\langle v\sigma \rangle$ reasonably satisfactory results can be obtained by using eq.(6.4)-(6.6) and the tables given referred to in section 7.

APPENDIX I

The expressions for the factor $Q_{\varkappa}$ contain 6j symbols

$$\begin{Bmatrix} j_1 & j_2 & j_3 \\ \ell_1 & \ell_2 & \ell_3 \end{Bmatrix}$$

12j-symbols and 15j-symbols. The two last are expressed through 6j-symbols in the following manner:

$$\begin{bmatrix} j_1 & j_2 & j_3 & j_4 \\ \ell_1 & \ell_2 & \ell_3 & \ell_4 \\ \kappa_1 & \kappa_2 & \kappa_3 & \kappa_4 \end{bmatrix} = (-1)^{\ell_1-\ell_2-\ell_3+\ell_4} \times \sum_{\lambda} (2\lambda+1) \begin{Bmatrix} \kappa_1 & \kappa_2 & \lambda \\ j_3 & j_1 & \ell_1 \end{Bmatrix} \begin{Bmatrix} \kappa_3 & \kappa_4 & \lambda \\ j_3 & j_1 & \ell_2 \end{Bmatrix} \begin{Bmatrix} \kappa_1 & \kappa_2 & \lambda \\ j_4 & j_2 & \ell_3 \end{Bmatrix} \begin{Bmatrix} \kappa_3 & \kappa_4 & \lambda \\ j_4 & j_2 & \ell_4 \end{Bmatrix} \qquad \text{(I.I)} \qquad \ldots \text{(I.1)}$$

$$\begin{bmatrix} j_1 & \ell_1 & j_2 & \ell_2 & j_3 & \ell_3 & j_4 & \ell_4 \\ \kappa_1 & & \kappa_2 & & \kappa_3 & & \kappa_4 & \end{bmatrix} = \sum_{\lambda} (2\lambda+1)(-1)^{R+\lambda} \times \qquad \text{(I.2)} \qquad \ldots \text{(I.2)}$$

$$\times \begin{Bmatrix} j_1 & \kappa_1 & \lambda \\ \kappa_2 & j_2 & \ell_2 \end{Bmatrix} \begin{Bmatrix} j_2 & \kappa_2 & \lambda \\ \kappa_3 & j_3 & \ell_3 \end{Bmatrix} \begin{Bmatrix} j_3 & \kappa_3 & \lambda \\ \kappa_4 & j_4 & \ell_4 \end{Bmatrix} \begin{Bmatrix} j_4 & \kappa_4 & \lambda \\ \kappa_5 & j_5 & \ell_1 \end{Bmatrix} \begin{Bmatrix} j_5 & \kappa_5 & \lambda \\ \kappa_1 & j_1 & \ell_5 \end{Bmatrix}$$

where

$$R = \sum_{i=1}^{5} (j_i + \ell_i + \kappa_i) \qquad \ldots \text{(I.3)}$$

6j symbols are tabulated for a wide range of values of the argument e.g. see[4] (missing).

If at least one of the arguments of the 6j-symbol does not exceed two, the latter can be calculated using the expressions given in[1] and the following symmetry relations: the 6j symbol remains unchanged, however, if its columns are rearranged and also when rearranging the lower and the upper arguments in each of any two columns. For example:

$$\begin{Bmatrix} j_1 & j_2 & j_3 \\ \ell_1 & \ell_2 & \ell_3 \end{Bmatrix} = \begin{Bmatrix} j_2 & j_1 & j_3 \\ \ell_2 & \ell_1 & \ell_3 \end{Bmatrix} = \begin{Bmatrix} j_3 & j_2 & j_1 \\ \ell_3 & \ell_2 & \ell_1 \end{Bmatrix} \qquad \text{(I.4)} \qquad \ldots \text{(I.4)}$$

$$\begin{Bmatrix} j_1 & j_2 & j_3 \\ \ell_1 & \ell_2 & \ell_3 \end{Bmatrix} = \begin{Bmatrix} \ell_1 & \ell_2 & j_3 \\ j_1 & j_2 & \ell_3 \end{Bmatrix} \qquad \ldots \text{(I.5)}$$

The 6j symbol $\begin{Bmatrix} j_1 & j_2 & j_3 \\ \ell_1 & \ell_2 & \ell_3 \end{Bmatrix}$ is different from zero when the following triangle conditions are satisfied

$$\Delta(j_1 j_2 j_3); \quad \Delta(j_1 \ell_2 \ell_3); \quad \Delta(\ell_1 j_2 \ell_3), \quad \Delta(\ell_1 \ell_2 j_3)$$

The triangle condition $\Delta(j_1 j_2 j_3)$ means that the sum (difference) of any two of the arguments $j_1 j_2 j_3$ must be larger (smaller) than, or equal to, the third.

The expressions for the 6j-symbols for which one of the arguments $j, \ell \leq 2$ are summarised in[1].

For a zero argument

$$\begin{Bmatrix} j_1 & j_2 & j_3 \\ 0 & l_2 & l_3 \end{Bmatrix} = (-1)^{j_1+l_2-l_3} \frac{1}{\sqrt{(2j_2+1)(2j_3+1)}} \delta_{j_3 l_2} \delta_{j_2 l_3} \qquad \ldots (I.6)$$

APPENDIX II

Our notation for the genealogical coefficients $G^{SL}_{S_pL_p}$ corresponds to that used in[1]. In the notations of the Racah's originals where these coefficients were first introduced and tabulated

$$G^{SL}_{S_pL_p} = \left(\ell^{n-1}[S_pL_p]\ell SL \,\middle|\, \ell^n SL \right) \qquad \ldots (II.1)$$

Between the genealogical coefficients for the configurations ℓ^{n+1}, ℓ^{n+2}, where $N = 2(2\ell + 1)$ the following relation holds:

$$(-1)^{-S-L}\sqrt{(N-n)(2S+1)(2L+1)}\, G^{SL}_{S_pL_p}(\ell^{N-n}) = \\ = (-1)^{S_p+L_p-\ell-1/2}\sqrt{(n+1)(2S_p+1)(2L_p+1)}\, G^{S_pL_p}_{SL}(\ell^{n+1}) \qquad (II.2) \qquad \ldots (II.2)$$

The tables of the coefficients $G^{SL}_{S_pL_p}$ for the configurations p^n, d^n are contained in[1].

APPENDIX III

The matrix elements $(\ell^n SL_0 \| U^{\varkappa} \| \ell^n SL_1)$ given in eq.(2.14) have even $\varkappa$-values. For $\varkappa = 0$

$$(\ell^n SL_0 \| U^0 \| \ell^n SL_1) = n\left(\frac{2L_0+1}{2\ell+1}\right)^{1/2} \delta_{L_0L_1} \qquad (III.1) \qquad \ldots (III.1)$$

As we are interested in the case $L_0 \neq L_1$, in (5.6) and (6.1) $\varkappa_{min} = 2$.

For the configurations ℓ^{N-n}, where $N = 2(2\ell + 1)$, and ℓ^n, the following relation is valid

$$(\ell^{N-n} SL_0 \| U^2 \| \ell^{N-n} SL_1) = -(\ell^n SL_1 \| U^2 \| \ell^n SL_0) \qquad (III.2) \qquad \ldots (III.2)$$

The factors $(\ell^n SL_0 \| U^{\varkappa} \| \ell^n SL_1)$ for the configurations p^n and d^n are contained in[1].

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σ ; transitions S-S , parameters C .

$\nu_1 - \nu_2$ \ ν_2	0,5	I,0	I,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,I	I 298	0 594	0 856	I II3	I I39	I I64	I I89	I 214	I 239	I 264	I 289
0,2	I 728	I I57	I 20I	I 25I	I 296	I 343	I 389	I 435	I 48I	I 527	I 572
0,3	2 I2I	I 280	I 328	I 392	I 449	I 5I0	I 569	I 63I	I 69I	I 752	I 8I3
0,4	2 I68	I 409	I 446	I 5I4	I 572	I 640	I 705	I 773	I 840	I 9I0	I 979
0,5	2 205	I 5I9	I 535	I 594	I 648	I 7I2	I 774	I 843	I 9I0	I 980	2 I04
0,6	2 273	I 583	I 575	I 6I7	I 659	I 7I5	I 770	I 832	I 892	I 956	
0,7	2 3I9	I 582	I 558	I 580	I 6I0	I 653	I 698	I 748	I 798	I 852	
0,8	2 323	I 5I4	I 487	I 49I	I 5I2	I 54I	I 574	I 6II	I 650	I 690	
0,9	2 272	I 397	I 378	I 372	I 386	I 404	I 427	I 452	I 479	I 500	
I,0	2 I69	I 265	I 254	I 250	I 258	I 269	I 283	I 298	I 3I5	I 33I	
I,I	2 I00	I I52	I I5I	I I50	I I55	I I5I	I I68	I I76	I I85		
I,2	I 438	0 835	0 869	0 9I0	0 90I	0 934	0 96I	0 990	I I0I		
I,3	I I70	0 724	0 674	0 7I4	0 69[illegible]	0 7I4	0 7I9	0 746	0 766		
I,4	I 305	I II6	0 925	0 964	0 907	0 938	0 938	0 975	0 997		
I,5	I 845	I I97	I I48	I I47	I I35	I I36	I I37	I I4I	I I43		
I,6	2 I66	I 28I	I 2I0	I I98	I I82	I I82	I I80	I I84			
I,7	2 248	I 334	I 254	I 230	I 2I2	I 209	I 206	I 209			
I,8	2 292	I 335	I 265	I 23I	I 2I6	I 209	I 207	I 209			
I,9	2 269	I 286	I 238	I 202	I I9I	I I84	I I83	I I83			
2,0	2 I74	I 2I0	I I79	I I56	I I48	I I43	I I4I	I I4I			
2,I	2 II5	I I34	I I2I	I I07	I I02	0 988	0 978				
2,2	I 575	0 795	0 76I	0 702	0 667	0 66I	0 638				
2,3	I 2II	0 664	0 569	0 566	0 500	0 498	0 475				
2,4	I 237	I 700	0 697	0 704	0 604	0 602	0 566				
2,5	I 700	I I68	I II0	I I05	0 888	0 872	0 8I4				
2,6	2 I52	I 245	I I6I	I I45	I I23	I II8					
2,7	2 244	I 297	I 204	I I74	I I49	I I4I					
2,8	2 295	I 303	I 222	I I8I	I I58	I I47					
2,9	2 278	I 26I	I 206	I I63	I I46	I I34					
3,0	2 I80	I I95	I I60	I I30	I II7	I I08					
3,I	2 I24	I I28	I II2	0 929	0 852						
3,2	I 650	0 898	0 726	0 630	0 576						
3,3	I 24I	0 650	0 532	0 5II	0 440						
3,4	I I66	0 957	0 62I	0 620	0 503						
3,5	I 648	I I6I	0 968	0 9I9	0 729						
3,6	2 I47	I 235	I I44	I I27							
3,7	2 240	I 473	I I86	I I54							
3,8	2 300	I 292	I 206	I I6I							
3,9	2 286	I 252	I I94	I I47							
4,0	2 I85	I I88	I I52	I II8							
4,I	2 I30	I I25	I I08								
4,2	I 697	0 765	0 609								
4,3	I 262	0 637	0 5I4								
4,4	I 207	0 939	0 583								
4,5	I 62I	I I58	0 903								
4,6	2 I45	I 23I									
4,7	2 240	I 282									
4,8	2 304	I 287									
4,9	2 29I	I 247									
5,0	2 I88	I I86									
5,I	2 I34										
5,2	I 730										
5,3	I 277										
5,4	I 20I										
5,5	I 604										

σ, transitions $S-S$, parameters φ.

ν_0 / $\nu_1-\nu_0$	0,5	I,0	I,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,I	I 266	I 284	I 244	I 202	I I76	I I54	I I3	I I26	I II7	I I09	I I03
0,2	I I7I	I I70	I I43	I I22	I I07	0 977	0 909	0 802	0 822	0 806	0 790
0,3	I I37	I I30	I I09	0 958	0 87I	0 823	0 793	0 779	0 774	0 777	0 785
0,4	I I20	I I09	0 923	0 844	0 795	0 778	0 775	0 786	0 804	0 829	0 859
0,5	I I00	0 970	0 845	0 793	0 780	0 788	0 809	0 844	0 886	0 935	0 989
0,6	I I02	0 89I	0 80I	0 78I	0 794	0 833	0 884	0 948	I I02	I I09	
0,7	0 976	0 840	0 788	0 800	0 849	0 922	I I0I	I III	I I22	I I34	
0,8	0 934	0 8II	0 802	0 857	0 953	I I07	I I2I	I I37	I I54	I I7I	
0,9	0 897	0 808	0 856	0 975	I II4	I I34	I I56	I I80	I 204	I 229	
I,0	0 865	0 859	0 996	I I23	I I5I	I I83	I 2I0	I 240	I 280	I 3I2	
I,I	0 862	I I06	I I35	I I77	I 2I5	I 252	I 290	I 332	I 379		
I,2	0 993	I I95	I 2I0	I 234	I 242	I 254	I 277	I 275	I 27I		
I,3	I 254	I 243	I I79	I I37	I III	0 935	0 832	0 777	0 756		
I,4	I 2I7	I I4I	0 924	0 687	0 560	0 508	0 48I	0 482	0 49I		
I,5	I I25	0 96I	0 676	0 560	0 498	0 488	0 492	0 5I6	0 546		
I,6	I I04	0 8II	0 624	0 56I	0 540	0 560	0 594	0 644			
I,7	0 96I	0 747	0 629	0 605	0 626	0 680	0 750	0 834			
I,8	0 9I3	0 720	0 663	0 683	0 754	0 855	0 975	I II0			
I,9	0 878	0 728	0 730	0 8I4	0 955	I II2	I I37	I I49			
2,0	0 845	0 778	0 858	I I06	I I29	I I55	I I80	I 205			
2,I	0 847	0 966	I II8	I I52	I I82	I 2I2	I 242				
2,2	0 920	I I70	I I79	I I95	I 2I5	I 239	I 258				
2,3	I I70	I 236	I I78	I I42	I I2I	I I02	0 930				
2,4	I 263	I I49	0 976	0 696	0 562	0 5I0	0 486				
2,5	I I32	0 974	0 658	0 532	0 462	0 455	0 459				
2,6	I I05	0 80I	0 59I	0 52I	0 493	0 5I4					
2,7	0 969	0 730	0 593	0 562	0 576	0 627					
2,8	0 9I0	0 700	0 628	0 639	0 703	0 798					
2,9	0 875	0 702	0 696	0 770	0 899	I I05					
3,0	0 842	0 755	0 829	I I00	I I22	I I46					
3,I	0 843	0 936	I II2	I I44	I I7I						
3,2	0 903	I 2I0	I I70	I I85	I 206						
3,3	I I47	I 223	I I76	I I42	I I25						
3,4	I 279	I I5I	I I00	0 702	0 567						
3,5	I I36	0 977	0 652	0 523	0 449						
3,6	I I05	0 797	0 577	0 507							
3,7	0 958	0 592	0 579	0 545							
3,8	0 909	0 692	0 6I4	0 620							
3,9	0 875	0 692	0 68I	0 749							
4,0	0 84I	I I00	0 8I2	0 984							
4,I	0 842	0 923	I I09								
4,2	0 896	I I59	I I55								
4,3	I I32	I 23I	I I75								
4,4	I 286	I I5I	I I0I								
4,5	I I30	0 978	0 650								
4,6	I I05	0 796									
4,7	0 958	0 72I									
4,8	0 908	0 689									
4,9	0 875	0 689									
5,0	0 84I	0 779									
5,I	0 84I										
5,2	0 892										
5,3	I I33										
5,4	I 290										
5,5	I I40										

σ, transitions $S - P$, parameters C.

$\nu_1 - \nu_0$ \ ν_0	0,5	1,0	1,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,1			1 325	1 165	1 213	1 253	1 289	1 325	1 357	1 391	1 421
0,2			1 574	1 347	1 434	1 463	1 554	1 610	1 664	1 718	1 768
0,3			1 772	1 541	1 661	1 717	1 797	1 858	1 927	1 989	2 105
0,4			1 907	1 726	1 864	1 898	1 988	2 103	2 111	2 117	2 124
0,5		2 143	1 968	1 873	2 101	2 100	2 109	2 112	2 120	2 123	2 130
0,6		2 163	2 114	1 959	2 107	2 102	2 110	2 110	2 116	2 118	
0,7		2 176	2 123	1 967	2 103	1 955	2 100	1 983	2 103	2 103	
0,8		2 178	2 118	1 892	1 900	1 804	1 829	1 794	1 824	1 815	
0,9		2 166	2 101	1 742	1 682	1 607	1 606	1 574	1 585	1 571	
1,0	2 553	2 139	1 756	1 541	1 460	1 398	1 373	1 335	1 327	1 305	
1,1	2 460	2 127	1 487	1 334	1 240	1 182	1 156	1 135	1 128		
1,2	2 388	2 104	1 241	1 143	0 815	0 652	0 558	0 511	0 490		
1,3	2 323	1 742	0 663	0 456	0 385	0 367	0 422	0 438	0 482		
1,4	2 259	1 418	0 508	0 369	0 707	0 640	0 824	0 807	0 919		
1,5	2 194	1 150	1 134	0 827	1 149	1 122	1 154	1 140	1 159		
1,6	2 156	0 206	1 285	1 164	1 248	1 193	1 230	1 202			
1,7	2 102	0 976	1 449	1 257	1 331	1 249	1 284	1 243			
1,8	1 449	1 342	1 564	1 331	1 367	1 274	1 295	1 251			
1,9	0 483	1 679	1 583	1 359	1 341	1 260	1 261	1 223			
2,0	1 138	1 954	1 505	1 327	1 267	1 209	1 163	1 161			
2,1	1 441	2 108	1 384	1 247	1 172	1 124	1 104				
2,2	1 881	2 106	1 228	1 145	0 738	0 558	0 445				
2,3	2 137	1 905	0 824	0 580	0 308	0 262	0 256				
2,4	2 179	1 628	0 381	0 247	0 403	0 312	0 424				
2,5	2 201	1 316	0 867	0 371	0 879	0 565	0 841				
2,6	2 193	0 721	1 202	0 830	1 160	1 102					
2,7	2 152	0 365	1 347	1 152	1 231	1 146					
2,8	1 876	1 207	1 461	1 223	1 272	1 176					
2,9	1 247	1 531	1 496	1 270	1 265	1 182					
3,0	0 298	1 847	1 445	1 268	1 217	1 159					
3,1	1 213	2 104	1 356	1 220	1 150						
3,2	1 599	2 110	1 223	1 146	0 703						
3,3	2 112	2 100	0 879	0 666	0 288						
3,4	2 164	1 755	0 358	0 259	0 319						
3,5	2 202	1 427	0 737	0 251	0 608						
3,6	2 208	1 137	1 178	0 561							
3,7	2 177	0 250	1 316	1 112							
3,8	2 112	1 155	1 427	1 179							
3,9	1 398	1 467	1 466	1 232							
4,0	0 144	1 803	1 423	1 242							
4,1	1 130	2 103	1 346								
4,2	1 470	2 114	1 223								
4,3	1 988	2 107	0 913								
4,4	2 156	1 845	0 350								
4,5	2 201	1 507	0 682								
4,6	2 217	1 186									
4,7	2 192	0 244									
4,8	2 128	1 128									
4,9	1 506	1 432									
5,0	0 173	1 780									
5,1	0 908										
5,2	1 397										
5,3	1 907										
5,4	2 150										
5,5	2 201										

σ; transitions $S-P$, parameters φ.

$\nu_1-\nu_0$ \ ν_0	0,5	I,0	I,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,I			I I26	I I3I	I I36	I I43	I I5I	I I59	I I68	I I76	I I86
0,2			I I46	I I63	I I79	I I98	I 2I8	I 239	I 262	I 285	I 3I0
0,3			I I7I	I 204	I 23I	I 268	I 303	I 342	I 38I	I 422	I 462
0,4			I 202	I 256	I 296	I 355	I 405	I 466	I 5I9	I 577	I 63I
0,5		I 2I3	I 239	I 3I9	I 374	I 460	I 525	I 606	I 67I	I 747	I 8II
0,6		I 239	I 283	I 396	I 469	I 583	I 66I	I 763	I 84I	I 936	
0,7		I 266	I 339	I 480	I 584	I 795	I 8I9	I 946	2 I04	2 II6	
0,8		I 297	I 4I4	I 603	I 726	I 893	2 I0I	2 II8	2 I3I	2 I49	
0,9		I 333	I 5I8	I 739	I 903	2 II2	2 I30	2 I52	2 I7I	2 I9I	
I,0	I 357	I 378	I 663	I 9II	2 II6	2 I40	2 I55	2 I53	2 I63	2 I58	
I,I	I 387	I 436	I 840	2 II5	2 II2	I 802	I 662	I 537	I 540		
I,2	I 4I6	I 5I4	I 989	I 666	I 2I9	I I57	I I20	I I05	0 965		
I,3	I 446	I 629	I I57	0 9I7	0 272	0 282	0 285	0 323	0 364		
I,4	I 480	I 820	0 I82	0 205	0 38I	0 480	0 677	0 796	0 966		
I,5	I 522	2 II5	0 503	0 599	I I05	I I29	I I65	I I89	I 220		
I,6	I 579	0 39I	I III	I I45	I 205	I 25I	I 299	I 342			
I,7	I 674	0 654	I I85	I 257	I 326	I 399	I 458	I 529			
I,8	I 879	I I58	I 27I	I 386	I 468	I 573	I 649	I 762			
I,9	I 973	I 237	I 377	I 527	I 637	I 788	I 90I	2 I04			
2,0	I I37	I 305	I 5I4	I 69I	I 864	2 I02	2 II4	2 II3			
2,I	I 252	I 374	I 676	I 906	I 986	I 774	I 7I6				
2,2	I 333	I 453	I 856	I 893	I 3I4	I 237	I I83				
2,3	I 396	I 555	I 290	I 239	0 456	0 488	0 343				
2,4	I 450	I 702	0 220	0 340	0 250	0 289	0 426				
2,5	I 504	I 94I	0 338	0 296	0 730	0 802	I II6				
2,6	I 565	I 63I	0 876	0 923	I I59	I I80					
2,7	I 647	0 233	I I57	I I97	I 270	I 3I6					
2,8	I 789	I II3	I 240	I 324	I 402	I 48I					
2,9	2 II5	I 208	I 342	I 464	I 559	I 684					
3,0	0 358	I 285	I 47I	I 623	I 769	I 902					
3,I	I I75	I 358	I 626	I 824	I 929						
3,2	I 289	I 438	I 804	I 929	I 368						
3,3	I 370	I 536	I 358	I 370	0 587						
3,4	I 436	I 670	0 267	0 64I	0 22I						
3,5	I 467	I 878	0 292	0 22I	0 623						
3,6	I 56I	2 II3	0 80I	0 684							
3,7	I 64I	0 20I	I I49	I I66							
3,8	I 766	0 909	I 230	I 293							
3,9	2 I05	I I93	I 328	I 434							
4,0	0 235	I 277	I 452	I 59I							
4,I	I I27	I 352	I 604								
4,2	I 260	I 433	I 779								
4,3	I 355	I 529	I 398								
4,4	I 428	I 657	0 300								
4,5	I 494	I 85I	0 274								
4,6	I 560	2 II8									
4,7	I 639	0 335									
4,8	I 757	0 770									
4,9	2 I0I	I I85									
5,0	0 770	I 272									
5,I	0 965										
5,2	I 240										
5,3	I 344										
5,4	I 423										
5,5	I 492										

σ; transitions $s \to d$, parameters C

$\nu_1 - \nu_0$ \ ν_0	0,5	1,0	1,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5	6,0
0,1					1 101	0 477	0 678	0 802	0 952	1 108	1 121	
0,2					1 192	1 117	1 157	1 180	1 210	1 234	1 259	
0,3					1 271	1 206	1 264	1 295	1 337	1 368	1 403	
0,4				2 100	1 333	1 310	1 378	1 412	1 460	1 495	1 536	
0,5				2 106	1 373	1 418	1 484	1 516	1 565	1 598	1 640	
0,6				2 107	1 472	1 515	1 567	1 593	1 630	1 662		
0,7				2 102	1 551	1 589	1 614	1 630	1 656	1 675		
0,8				1 928	1 600	1 623	1 617	1 620	1 629	1 635		
0,9				1 785	1 609	1 611	1 572	1 563	1 555	1 550		
1,0			2 173	1 750	1 575	1 551	1 491	1 471	1 451	1 441		
1,1			2 149	1 657	1 497	1 455	1 383	1 359	1 336			
1,2			2 127	1 520	1 393	1 340	1 274	1 249	1 221			
1,3			2 104	1 365	1 282	1 229	1 173	1 148	1 131			
1,4			1 824	1 221	1 183	1 135	1 105	0 930	0 928			
1,5			1 604	1 121	1 108	0 826	0 853	0 821				
1,6		1 532	1 484	0 893	0 792	0 811	0 995	1 102				
1,7		1 482	1 329	1 130	0 902	1 115	1 133	1 140				
1,8		1 421	1 175	1 217	1 128	1 168	1 175	1 180				
1,9		1 345	0 653	1 313	1 178	1 221	1 207	1 208				
2,0	1 179	1 256	0 424	1 389	1 223	1 265	1 220	1 217				
2,1	1 129	1 164	0 967	1 424	1 244	1 261	1 208					
2,2	0 962	1 108	1 200	1 406	1 238	1 236	1 178					
2,3	0 713	0 580	1 329	1 339	1 208	1 190	1 135					
2,4	0 502	0 210	1 447	1 242	1 163	1 135	0 919					
2,5	0 318	-1 459	1 518	1 149	1 114	0 828	0 675					
2,6	0 208	0 158	1 513	0 894	0 746	0 604						
2,7	-1 896	0 527	1 429	0 906	0 618	0 701						
2,8	-1 140	1 107	1 288	1 144	0 742	1 103						
2,9	-1 229	1 163	1 142	1 224	1 105	1 146						
3,0	0 154	1 198	0 495	1 302	1 143	1 183						
3,1	0 250	1 194	0 490	1 356	1 171							
3,2	0 348	1 158	1 115	1 366	1 182							
3,3	0 422	1 110	1 232	1 327	1 173							
3,4	0 460	0 607	1 359	1 249	1 148							
3,5	0 431	0 214	1 480	1 162	1 112							
3,6	0 338	-1 601	1 525	0 958								
3,7	0 204	0 242	1 480	0 808								
3,8	-1 721	0 719	1 355	1 119								
3,9	-2 632	1 135	1 197	1 190								
4,0	-1 797	1 189	0 740									
4,1	0 173	1 205	0 416									
4,2	0 287	1 184	0 836									
4,3	0 397	1 143	1 188									
4,4	0 472	0 906	1 329									
4,5	0 482	0 408	1 461									
4,6	0 414	0 100										
4,7	0 280	0 140										
4,8	0 124	0 539										
4,9	-1 172	1 118										
5,0	-1 486	1 182										
5,1	0 132	1 210										
5,2	0 249											
5,3	0 374											
5,4	0 472											
5,5	0 508											

σ_j transitions $s \to d$, parameters φ

$\nu_1-\nu_0$ \ ν_0	0,5	I,0	I,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,I					I I29	I I00	0 899	0 8I2	0 760	0 720	0 692
0,2					0 807	0 698	0 668	0 649	0 647	0 653	0 666
0,3					0 692	0 658	0 665	0 687	0 72I	0 765	0 8I6
0,4					0 677	0 692	0 734	0 800	0 874	0 967	I I06
0,5				0 702	0 704	0 769	0 853	0 973	I I09	I I25	I I40
0,6				0 7I4	0 768	0 883	I I02	I I20	I I39	I I6I	
0,7				0 745	0 856	I I03	I I25	I I5I	I I77	I 205	
0,8				0 796	I I00	I I24	I I56	I I89	I 222	I 255	
0,9			0 834	0 869	I II8	I I5I	I I94	I 234	I 273	I 3I3	
I,0			0 890	0 97I	I I44	I I87	I 240	I 285	I 335	I 387	
I,I			0 957	I III	I I79	I 23I	I 29I	I 350	I 4I6		
I,2			I I04	I I32	I 220	I 28I	I 35I	I 4I2	I 387		
I,3			I II4	I I64	I 26I	I 339	I 293	I 252	I I74		
I,4			I I28	I 2I2	I 287	I 265	I II2	0 949	0 756		
I,5		I II0	I I49	I 258	I I63	0 837	0 503	0 504	I I00		
I,6		I II7	I I84	I 22I	0 573	0 404	0 4I4	0 49I			
I,7		I I29	I 249	0 646	0 369	0 4I7	0 533	0 673			
I,8		I I33	I 299	0 397	0 43I	0 58I	0 776	0 972			
I,9		I I44	0 5I0	0 456	0 604	0 83I	I II0	I I35			
2,0	I I49	I I6I	0 457	0 582	0 855	I II5	I I49	I I79			
2,I	I I57	I I88	0 604	0 745	I II7	I I54	I I95				
2,2	I I64	I 235	0 763	0 958	I I55	I I98	I 25I				
2,3	I I72	I 33I	0 924	I I29	I I95	I 252	I 272				
2,4	I I82	I I02	I I09	I I63	I 235	I 297	I I54				
2,5	I I97	0 520	I I30	I 2I0	I 226	I I60	0 705				
2,6	I 222	0 803	I I59	I 239	I I04	0 579					
2,7	I 277	I I0I	I 205	I I2I	0 460	0 384					
2,8	I 45I	I II9	I 275	0 436	0 367	0 464					
2,9	0 660	I I35	I I80	0 389	0 47I	0 666					
3,0	I II8	I I53	0 43I	0 489	0 685	0 950					
3,I	I I38	I I76	0 477	0 643	0 980						
3,2	I I53	I 2I0	0 650	0 845	I I33						
3,3	I I66	I 268	0 838	I III	I I7I						
3,4	I I79	I 369	I I02	I I47	I 2II						
3,5	I I95	0 624	I I24	I I92	I 23I						
3,6	I 2I5	0 565	I I5I	I 229							
3,7	I 253	0 87I	I I9I	I I58							
3,8	I 34I	I II0	I 254	0 502							
3,9	0 834	I I30	I 289	0 370							
4,0	0 95I	I I50	0 6I8	0 45I							
4,I	I I24	I I72	0 4I8								
4,2	I I44	I 203	0 587								
4,3	I I6I	I 250	0 789								
4,4	I I77	I 333	0 995								
4,5	I I97	I 256									
4,6	I 2I5	0 440									
4,7	I 247	0 766									
4,8	I 3I3	I I05									
4,9	I 464	I I27									
5,0	0 772	I I48									
5,I	I II3										
5,2	I I38										
5,3	I I58										
5,4	I I76										
5,5	I I93										

σ_1 transitions $p-s$, parameters C

ν_1 / $\nu_1-\nu_0$	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5	6,0
4,5									2 I30
4,4									I 624
4,3									I 257
4,2									0 845
4,I									0 237
4,0									0 206
3,9								I I45	0 503
3,8								I I93	0 676
3,7								I I30	I II9
3,6								I I53	I I30
3,5								I I02	I I05
3,4							2 I2I	0 574	0 807
3,3							I 583	0 348	0 502
3,2							I 240	0 I92	0 268
3,I							0 796	0 I3I	0 I68
3,0						I I26	0 238	0 I70	0 253
2,9						I I77	0 226	0 3II	0 493
2,8						I I84	0 547	0 595	0 8I0
2,7						I I56	0 946	0 865	I I00
2,6						I II2	I I22	0 972	I I03
2,5					2 III	0 685	I I3I	0 9I0	0 9I6
2,4					I 539	0 446	I II7	0 7I7	0 687
2,3					I 224	0 256	0 883	0 490	0 438
2,2					0 752	0 I62	0 550	0 293	0 258
2,I					0 247	0 I87	0 297	0 I85	0 2I2
2,0				I II3	0 272	0 360	0 200	0 203	0 374
I,9				I I72	0 667	0 73I	0 334	0 389	0 735
I,8				I I65	I II5	I II3	0 687	0 763	I I2I
I,7				I I8I	I I52	I I35	I II6	I I2I	I I53
I,6				I I44	I I66	I I37	I I47	I I47	I I6I
I,5			2 I03	0 966	I I53	I II7	I I57	I I48	I I44
I,4			I 5I6	0 7I6	I II7	0 859	I I42	I I28	I II0
I,3			I 220	0 434	0 74I	0 530	I I09	0 949	0 7I0
I,2			0 769	0 253	0 40I	0 3I3	0 699	0 594	0 424
I,I			0 265	0 255	0 297	0 322	0 403	0 358	0 406
I,0		I I28	0 440	0 587	0 637	0 747	0 353	0 379	0 930
0,9		I 24I	I I24	I I47	I I6I	I I83	0 79I	0 887	I 226
0,8		I 334	I 235	I 268	I 309	I 345	I I93	I 2I5	I 44I
0,7		I 388	I 354	I 389	I 453	I 497	I 377	I 4I2	I 643
0,6		I 389	I 458	I 467	I 585	I 633	I 550	I 596	I 820
0,5	2 I54	I 375	I 524	I 568	I 672	I 725	I 704	I 756	I 945
0,4	2 I03	I 389	I 536	I 584	I 693	I 748	I 8I2	I 867	I 98I
0,3	I 660	I 36I	I 487	I 537	I 634	I 687	I 840	I 897	I 905
0,2	I 377	I 289	I 379	I 425	I 498	I 543	I 772	I 827	I 7I4
0,I	I I68	I I73	I 22I	I 253	I 294	I 323	I 609	I 654	I 423
							I 360.	I 388	

σ, transitions $p \to s$, parameters φ

$\nu_1 - \nu_0$ \ ν_1	2.0	2,5	3,0	3,5	4,0	4,5	5,0	5,5	6,0
4,5									I 200
4,4									I I47
4,3									0 933
4,2									0 432
4,I									0 I52
4,0								I 390	0 899
3,9								I 566	I 496
3,8								I 456	I 552
3,7								I 379	I 420
3,6								I 268	I 305
3,5							I I93	I I6I	I 207
3,4							I I40	0 782	I I26
3,3							0 872	0 266	0 639
3,2							0 392	0 20I	0 260
3,I							0 I53	0 584	0 23I
3,0						I 3I5	0 983	I I87	I I09
2,9						I 557	I 5I8	I 537	I 390
2,8						I 482	I 572	I 636	I 674
2,7						I 387	I 435	I 489	I 549
2,6						I 278	I 3I5	I 342	I 38I
2,5					I I85	I I73	I 2I2	I 2I5	I 247
2,4					I I32	0 894	I I27	I II4	I I4I
2,3					0 80I	0 358	0 630	0 478	0 662
2,2					0 348	0 I87	0 253	0 242	0 280
2,I					0 I63	0 488	0 264	0 58I	0 432
2,0				I 245	I II7	I I83	I I30	I 203	I I82
I,9				I 564	I 584	I 580	I 480	I 579	I 542
I,8				I 524	I 624	I 7I0	I 784	I 848	I 897
I,7				I 420	I 478	I 550	I 622	I 696	I 764
I,6				I 308	I 348	I 395	I 439	I 487	I 53I
I,5			I I80	I 202	I 235	I 260	I 29I	I 3I5	I 343
I,4			I I27	I II9	I I40	I I46	I I69	I I76	I I95
I,3			0 750	0 494	0 684	0 64I	0 784	0 77I	0 882
I,2			0 3I2	0 202	0 263	0 263	0 3I0	0 326	0 362
I,I			0 205	0 439	0 336	0 562	0 5I9	0 757	0 739
I,0		I 235	I I63	I 240	I 208	I 266	I 265	I 338	I 354
0,9		I 723	I 875	I 9I6	I 892	I 969	I 963	2 II0	2 II5
0,8		I 697	I 839	2 I00	2 II6	2 I3I	2 I45	2 I59	2 I73
0,7		I 589	I 684	I 8I5	I 927	2 I05	2 II7	2 I30	2 I42
0,6		I 477	I 548	I 664	I 745	I 843	I 926	2 I02	2 II0
0,5	I 256	I 378	I 433	I 529	I 592	I 674	I 737	I 8I2	I 876
0,4	I 22I	I 297	I 337	I 407	I 455	I 52I	I 57I	I 632	I 68I
0,3	I I88	I 23I	I 259	I 303	I 336	I 382	I 4I8	I 463	I 500
0,2	I I57	I I78	I I94	I 2I8	I 237	I 262	I 283	I 3I0	I 333
0,I	I I30	I I36	I I43	I I5I	I I58	I I67	I I76	I I86	I I95

σ, transitions $p \to p$, parameters C

$\nu - \nu_0$ \ ν_0	1,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,1	1 817	1 276	1 372	1 500	1 590	1 699	1 787	1 887	1 974
0,2	2 170	1 539	1 801	2 105	2 121	2 142	2 158	2 177	2 193
0,3	2 253	2 103	2 123	2 152	2 178	2 207	2 227	2 254	2 274
0,4	2 324	2 140	2 159	2 202	2 222	2 257	2 278	2 309	2 331
0,5	2 379	2 160	2 185	2 228	2 244	2 283	2 303	2 335	2 357
0,6	2 498	2 180	2 195	2 234	2 249	2 282	2 299	2 330	
0,7	2 608	2 174	2 185	2 215	2 230	2 257	2 271	2 297	
0,8	2 676	2 152	2 169	2 183	2 195	2 213	2 225	2 244	
0,9	2 697	2 119	2 138	2 139	2 151	2 160	2 170	2 181	
1,0	2 653	1 819	2 102	1 954	2 105	2 108	2 116	2 121	
1,1	2 328	1 526	1 604	1 599	1 643	1 666	1 706		
1,2	2 208	1 334	1 354	1 357	1 371	1 388	1 393		
1,3	2 111	1 273	1 225	1 290	1 254	1 307	1 287		
1,4	1 628	1 345	1 225	1 362	1 292	1 384	1 341		
1,5	1 778	1 505	1 339	1 515	1 417	1 538	1 477		
1,6	2 164	1 679	1 497	1 672	1 561	1 691			
1,7	2 311	1 792	1 649	1 769	1 673	1 782			
1,8	2 488	1 795	1 750	1 767	1 718	1 776			
1,9	2 650	1 688	1 772	1 669	1 682	1 677			
2,0	2 747	1 514	1 704	1 515	1 572	1 523			
2,1	2 379	1 372	1 442	1 372	1 396				
2,2	2 286	1 264	1 299	1 260	1 262				
2,3	2 181	1 230	1 192	1 218	1 174				
2,4	1 972	1 291	1 153	1 265	1 170				
2,5	1 671	1 426	1 199	1 373	1 230				
2,6	2 117	1 577	1 305	1 493					
2,7	2 258	1 677	1 440	1 573					
2,8	2 457	1 681	1 565	1 579					
2,9	2 694	1 584	1 645	1 509					
3,0	2 869	1 429	1 649	1 394					
3,1	2 440	1 318	1 412						
3,2	2 358	1 233	1 293						
3,3	2 246	1 214	1 192						
3,4	2 138	1 281	1 137						
3,5	1 779	1 417	1 153						
3,6	2 102	1 565							
3,7	2 235	1 660							
3,8	2 465	1 656							
3,9	2 740	1 550							
4,0	2 977	1 391							
4,1	2 495								
4,2	2 421								
4,3	2 304								
4,4	2 179								
4,5	1 944								

δ, transitions $p \to p$, parameters φ

$\nu_1 - \nu_0$ \ ν_0	1,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,1	1 293	1 235	1 181	1 155	1 134	1 122	1 111	1 104	0 986
0,2	1 174	1 137	1 109	0 977	0 883	0 843	0 806	0 788	0 773
0,3	1 131	1 104	0 878	0 822	0 782	0 773	0 768	0 778	0 789
0,4	1 110	0 899	0 797	0 778	0 772	0 790	0 813	0 847	0 814
0,5	0 990	0 824	0 772	0 787	0 814	0 858	0 911	0 972	1 103
0,6	0 919	0 792	0 791	0 834	0 892	0 974	1 106	1 115	
0,7	0 879	0 791	0 840	0 922	1 103	1 115	1 128	1 142	
0,8	0 859	0 823	0 925	1 107	1 123	1 141	1 161	1 180	
0,9	0 855	0 905	1 107	1 131	1 155	1 183	1 209	1 237	
1,0	0 865	1 109	1 131	1 173	1 204	1 243	1 278	1 316	
1,1	0 909	1 147	1 185	1 224	1 270	1 304	1 353		
1,2	1 105	1 191	1 231	1 205	1 246	1 194	1 216		
1,3	1 152	1 143	1 158	0 856	0 874	0 702	0 745		
1,4	1 237	0 795	0 640	0 502	0 472	0 476	0 488		
1,5	1 142	0 610	0 480	0 480	0 466	0 516	0 538		
1,6	0 873	0 576	0 507	0 546	0 568	0 646			
1,7	0 774	0 593	0 589	0 657	0 727	0 836			
1,8	0 762	0 639	0 705	0 817	0 945	1 109			
1,9	0 776	0 726	0 862	1 105	1 124	1 145			
2,0	0 801	0 901	1 107	1 141	1 164	1 195			
2,1	0 824	1 122	1 151	1 181	1 222				
2,2	0 933	1 157	1 201	1 171	1 243				
2,3	1 118	1 127	1 202	0 819	1 113				
2,4	1 187	0 756	0 855	0 485	0 520				
2,5	1 197	0 583	0 474	0 452	0 435				
2,6	0 967	0 548	0 454	0 508					
2,7	0 760	0 562	0 529	0 610					
2,8	0 745	0 603	0 648	0 757					
2,9	0 766	0 680	0 805	0 974					
3,0	0 796	0 841	1 100	1 130					
3,1	0 816	1 114	1 140						
3,2	0 917	1 144	1 189						
3,3	1 112	1 116	1 220						
3,4	1 153	0 721	1 116						
3,5	1 215	0 573	0 518						
3,6	1 107	0 544							
3,7	0 752	0 553							
3,8	0 740	0 594							
3,9	0 766	0 662							
4,0	0 800	0 814							
4,1	0 821								
4,2	0 921								
4,3	1 110								
4,4	1 153								
4,5	1 219								

σ, transitions $d \to s$, parameters C

$\nu_1 - \nu_2$ \ ν_1	3,0	3,5	4,0	4,5	5,0	5,5	6,0
3,5							I 282
3,4							I I69
3,3							0 96I
3,2							0 520
3,I							0 279
3,0						I I23	0 I83
2,9						0 68I	0 220
2,6						0 68I	0 287
2,7						0 35I	0 357
2,6						0 298	0 408
2,5					I 229	0 256	0 424
2,4					I I40	0 274	0 405
2,3					0 822	0 276	0 365
2,2					0 468	0 268	0 323
2,I					0 282	0 254	0 299
2,0				I I30	0 2I4	0 285	0 3I6
I,9				0 745	0 267	0 34I	0 392
I,8				0 5I0	0 350	0 4I9	0 498
I,7				0 4I8	0 439	0 487	0 588
I,6				0 375	0 505	0 528	0 640
I,5			I I80	0 337	0 528	0 533	0 645
I,4			I II7	0 356	0 506	0 5II	0 606
I,3			0 735	0 354	0 456	0 470	0 547
I,2			0 46I	0 345	0 4I3	0 444	0 5I0
I,I			0 328	0 358	0 4I9	0 477	0 549
I,0		I I28	0 308	0 436	0 524	0 624	0 72I
0,9		0 900	0 444	0 6I7	0 778	0 936	I I06
0,8		0 804	0 653	0 880	I II3	I I36	I I60
0,7		0 837	0 9I2	I II8	I I52	I I8I	I 2I2
0,6		0 879	I II6	I I48	I I88	I 222	I 258
0,5	I 223	0 880	I I35	I I66	I 2I2	I 248	I 289
0,4	I I75	0 984	I I42	I I77	I 2I7	I 252	I 272
0,3	I I27	0 972	I I33	I I64	I I99	I 229	I 262
0,2	0 8I9	0 806	I I06	I I30	I I55	I I78	I 202
0,I	0 392	0 483	0 6I5	0 750	0 882	I I00	I II3

σ; transitions $d \to s$, parameters φ

$\nu_1 - \nu_0$ \ ν_1	3,0	3,5	4,0	4,5	5,0	5,5	6,0
3,5							0 653
3,4							0 529
3,3							0 423
3,2							0 348
3,I							0 34I
3,0						0 466	0 582
2,9						0 590	I I06
2,8						0 788	I I27
2,7						0 879	I II2
2,6						0 826	0 904
2,5					0 6I8	0 642	0 686
2,4					0 498	0 469	0 5I0
2,3					0 40I	0 366	0 394
2,2					0 346	0 333	0 347
2,I					0 383	0 387	0 395
2,0				0 502	0 68I	0 590	0 648
I,9				0 662	I I20	I I00	I II6
I,8				0 899	I I37	I I34	I I6I
I,7				I I00	I I2I	I I25	I I46
I,6				0 9I9	0 966	I I03	I II4
I,5			0 596	0 676	0 7I4	0 79I	0 866
I,4			0 478	0 482	0 5I7	0 577	0 633
I,3			0 395	0 377	0 397	0 438	0 482
I,2			0 375	0 360	0 370	0 408	0 440
I,I			0 507	0 483	0 503	0 55I	0 592
I,0		0 69I	I I04	0 924	I I03	I I07	I II4
0,9		I II2	I I82	I I79	I 2I4	I 224	I 238
0,8		I I55	I I96	I 2I3	I 252	I 284	I 3I9
0,7		I I64	I I75	I I97	I 22I	I 246	I 274
0,6		I I3I	I I39	I I63	I I8I	I 202	I 222
0,5	0 807	0 975	I I06	I I24	I I38	I I56	I I73
0,4	0 708	0 773	0 835	0 933	I I02	I II4	I I00
0,3	0 66I	0 669	0 694	0 736	0 782	0 846	0 90I
0,2	0 694	0 659	0 644	0 644	0 653	0 668	0 687
0,I	0 993	0 886	0 804	0 752	0 7I4	0 687	0 668

$\langle v6 \rangle$, transitions $S-S$, parameters $A \cdot \sqrt{\frac{\Delta E}{R_y}}$

$\nu_1 - \nu_0$ \ ν_0	0,5	I,0	I,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,I	I 225	0 I55	0 I42	0 I45	0 I49	0 I53	0 I56	0 I59	0 I62	0 I63	0 I65
0,2	2 I09	0 916	0 779	0 750	0 729	0 7I6	0 70I	0 686	0 669	0 65I	0 632
0,3	2 253	I 248	I I97	I I79	I I65	I I55	I I45	I I37	I I28	I I20	I II2
0,4	2 428	I 474	I 352	I 303	I 266	I 238	I 2I4	I I93	I I74	I I58	I I43
0,5	2 598	I 724	I 505	I 4I0	I 342	I 292	I 25I	I 2I8	I I90	I I66	I I46
0,6	2 872	I 930	I 6I2	I 469	I 370	I 30I	I 248	I 206	I I73	I I46	
0,7	3 I09	2 I02	I 640	I 459	I 342	I 264	I 207	I I65	I I32	I I08	
0,8	3 II8	I 97I	I 576	I 382	I 268	I I94	I I44	I I09	0 842	0 66I	
0,9	3 I04	I 777	I 436	I 263	I I7I	I II5	0 798	0 567	0 4I5	0 3I0	
I,0	2 685	I 507	I 260	I I40	0 82I	0 498	0 3I8	0 2II	0 I48	0 I08	
I,I	2 4I0	I 24I	I I09	0 497	0 26I	0 I52	0 I00	-I 723	-I 549		
I,2	2 I6I	0 608	0 266	0 I49	0 II7	0 II4	0 II7	0 I22	0 I22		
I,3	I I88	0 233	0 233	0 329	0 369	0 405	0 399	0 382	0 347		
I,4	I 390	I II8	0 96I	I I04	0 965	0 898	0 784	0 679	0 57I		
I,5	2 234	I 330	I 223	I I96	I I59	I I33	I I06	0 867	0 693		
I,6	2 566	I 574	I 354	I 27I	I 20I	I I54	I II6	0 894			
I,7	2 923	I 753	I 438	I 300	I 206	I I47	I I04	0 768			
I,8	3 II5	I 796	I 444	I 273	I I75	I II5	0 78I	0 543			
I,9	3 II0	I 688	I 369	I 202	I I20	0 730	0 464	0 304			
2,0	2 749	I 482	I 237	I II5	0 624	0 346	0 206	0 I30			
2,I	2 499	I 252	I II3	0 464	0 232	0 I28	-I 820				
2,2	2 232	0 748	0 330	0 I59	0 II3	0 I0I	-I 945				
2,3	I 445	0 226	0 I95	0 269	0 287	0 3I0	0 288				
2,4	I I98	0 956	0 724	0 843	0 753	0 69I	0 569				
2,5	2 I85	I 289	I I83	I I65	I I28	I I03	0 786				
2,6	2 520	I 527	I 306	I 234	I I64	I I2I					
2,7	2 9II	I 7I0	I 394	I 264	I I72	I II7					
2,8	3 II8	I 762	I 4I3	I 244	I I48	0 937					
2,9	3 II6	I 666	I 352	I I82	I I04	0 599					
3,0	2 786	I 474	I 230	I I06	0 553	0 292					
3,I	2 544	I 255	I II4	0 444	0 2I7						
3,2	2 269	0 789	0 357	0 I60	0 I09						
3,3	I 606	0 229	0 I86	0 253	0 256						
3,4	I I49	0 900	0 639	0 778	0 67I						
3,5	2 I66	I 278	I I67	I I54	I II5						
3,6	2 505	I 5I5	I 287	I 220							
3,7	2 9I4	I 699	I 377	I 250							
3,8	3 I20	I 752	I 400	I 23I							
3,9	3 II9	I 658	I 345	I I74							
4,0	2 8I0	I 470	I 228	I I02							
4,I	2 57I	I 255	I II5								
4,2	2 29I	0 805	0 374								
4,3	I 7I2	0 230	0 I83								
4,4	I I30	0 883	0 596								
4,5	2 I56	I 275	I I59								
4,6	2 497	I 5I2									
4,7	2 9I9	I 696									
4,8	3 I22	I 749									
4,9	3 I22	I 655									
5,0	2 826	I 468									
5,I	2 590										
5,2	2 307										
5,3	I 786										
5,4	I I2I										
5,5	2 I50										

$\langle r6 \rangle$ transitions $S-S$, parameters χ.

$\nu_1 - \nu_0$ \ ν_0	0,5	I,0	I,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,I	0 35I	0 3I3	0 35I	0 405	0 467	0 529	0 59I	0 649	0 705	0 758	0 808
0,2	0 555	0 534	0 6I0	0 698	0 792	0 877	0 954	I I02	I I07	I II2	I II6
0,3	0 69I	0 702	0 806	0 9II	I I0I	I I09	I II5	I II9	I I22	I I23	I I23
0,4	0 787	0 834	0 956	I I06	I II4	I I20	I I23	I I23	I I22	I II9	I II6
0,5	0 859	0 940	I I06	I II5	I I2I	I I23	I I2I	I II7	I II2	I I06	I I00
0,6	0 9I6	I I02	I II4	I I20	I I22	I II9	I II3	I I05	0 969	0 882	
0,7	0 963	I I09	I II9	I I2I	I II7	I I08	0 984	0 873	0 764	0 663	
0,8	I I00	I II4	I II9	I II6	I I05	0 9I9	0 777	0 644	0 525	0 423	
0,9	I I04	I II7	I II5	I I02	0 855	0 673	0 5I0	0 373	0 263	0 I76	
I,0	I I09	I II4	I I0I	0 777	0 546	0 349	0 202	-I 978	-I 275	-I I25	
I,I	I II0	0 958	0 674	0 359	0 I63	-I 486	-I I25	-I I25	-I I25		
I,2	I I0I	0 357	0 I27	-I 336	-I 605	0 I67	0 320	0 494	0 639		
I,3	0 207	-I I25	0 I37	0 5I4	0 972	I I42	I I77	I I98	I 207		
I,4	0 244	0 49I	0 858	I I33	I I78	I 205	I 2II	I 2I6	I 205		
I,5	0 7I7	0 893	I I27	I I6I	I I88	I I95	I I98	I I77	I I59		
I,6	0 888	I I09	I I42	I I64	I I74	I I68	I I54	I I35			
I,7	0 970	I I20	I I45	I I56	I I53	I I38	I II8	0 982			
I,8	I I02	I I26	I I42	I I42	I I27	I I06	0 838	0 640			
I,9	I I06	I I29	I I33	I I20	0 964	0 7II	0 495	0 324			
2,0	I III	I I25	I II4	0 867	0 583	0 343	0 I78	-I 698			
2,I	I II2	I I05	0 777	0 4II	0 I92	-I 662	-I I25				
2,2	I I07	0 466	0 222	-I 72I	-I 85I	0 I84	0 3I0				
2,3	0 545	-I I25	-I 898	0 457	0 922	I I4I	I I75				
2,4	-I 69I	0 409	0 779	I I37	I I93	I 225	I 238				
2,5	0 662	0 866	I I3I	I I75	I 2I0	I 2I6	I 209				
2,6	0 878	I II0	I I50	I I78	I I93	I I83					
2,7	0 972	I I22	I I53	I I69	I I66	I I47					
2,8	I I02	I I30	I I50	I I5I	I I35	I II0					
2,9	I I06	I I33	I I39	I I26	I I00	0 7I7					
3,0	I III	I I28	I II9	0 900	0 595	0 339					
3,I	I II2	I I08	0 8I9	0 430	0 205						
3,2	I I08	0 500	0 264	-I 895	-I 98I						
3,3	0 665	-I I25	-I 8I2	0 449	0 906						
3,4	-I I25	0 386	0 740	I I39	I 200						
3,5	0 635	0 858	I I32	I I80	I 22I						
3,6	0 874	I II0	I I53	I I85							
3,7	0 972	I I23	I I57	I I74							
3,8	I I02	I I3I	I I53	I I56							
3,9	I I07	I I34	I I42	I I29							
4,0	I III	I I30	I I2I	0 9I7							
4,I	I II2	I I09	0 84I								
4,2	I I09	0 5I5	0 289								
4,3	0 72I	-I I25	-I 782								
4,4	-I I25	0 377	0 7I7								
4,5	0 6I9	0 855	I I33								
4,6	0 872	I II0									
4,7	0 973	I I24									
4,8	I I02	I I32									
4,9	I I07	I I35									
5,0	I III	I I30									
5,I	I II2										
5,2	I I09										
5,3	0 754										
5,4	-I I25										
5,5	0 608										

$\langle v6 \rangle$ transitions, $s \to p$, parameters $A\sqrt{\frac{\Delta E}{R_y}}$

$\nu_1-\nu_0$ \ ν_0	0,5	I,0	I,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,I			I I09	0 363	0 329	0 290	0 254	0 226	0 I99	0 I79	0 I59
0,2			I 240	0 894	0 750	0 594	0 486	0 397	0 327	0 273	0 228
0,3			I 334	I I34	I I05	0 746	0 572	0 430	0 335	0 262	0 209
0,4			I 374	I I58	I II6	0 734	0 534	0 369	0 276	0 203	0 I58
0,5		2 I02	I 363	I I58	I I08	0 606	0 422	0 289	0 I98	0 I4I	0 II0
0,6		2 I08	I 376	I I37	0 870	0 430	0 290	0 I78	0 I33	-I 969	
0,7		2 I07	I 337	I I03	0 594	0 270	0 I84	0 II5	-I 893	-I 680	
0,8		I 987	I 255	0 669	0 345	0 I8I	0 III	-I 70I	-I 522	-I 389	
0,9		I 82I	I I56	0 667	0 I82	-I 93I	-I 626	-I 542	-I 445	-I 443	
I,0	2 558	I 595	0 722	0 I95	-I 968	-I 900	-I 849	-I 869	-I 723	-I 663	
I,I	2 422	I 452	0 290	0 I2I	0 I59	0 I76	0 I56	0 I38	0 I06		
I,2	2 325	I 292	0 I95	0 254	0 367	0 302	0 238	0 I75	0 I24		
I,3	2 248	I I46	0 706	0 549	0 579	0 360	0 26I	0 I68	0 II8		
I,4	2 I80	0 469	I I59	0 754	0 67I	0 245	0 245	0 I43	0 I03		
I,5	2 II9	0 II9	I 23I	0 8II	0 66I	0 288	0 208	0 II3	-I 862		
I,6	I 82I	0 833	I 273	0 764	0 57I	0 2I9	0 I60	-I 872			
I,7	I 4I3	I 225	I 270	0 636	0 426	0 I56	0 II5	-I 66I			
I,8	I I03	I 393	I 222	0 47I	0 272	0 I09	-I 789	-I 46I			
I,9	0 267	I 527	I I47	0 3I0	0 I88	-I 754	-I 509	-I 455			
2,0	I 375	I 559	0 750	0 I88	-I 920	-I 797	-I 65I	-I 645			
2,I	I 67I	I 49I	0 334	0 II9	0 I26	0 I34	0 I08				
2,2	I 985	I 372	0 I83	0 I77	0 272	0 2I4	0 I63				
2,3	2 I24	I 228	0 5I8	0 359	0 469	0 262	0 I88				
2,4	2 I37	I I00	I I35	0 559	0 560	0 250	0 I83				
2,5	2 I32	0 279	I 208	0 6I8	0 564	0 2II	0 I62				
2,6	2 I06	0 32I	I 253	0 593	0 50I	0 I64					
2,7	I 666	I I6I	I 257	0 5I3	0 386	0 I23					
2,8	I 26I	I 327	I 2I6	0 40I	0 256	-I 9I7					
2,9	0 343	I 483	I I48	0 284	0 I52	-I 687					
3,0	I 207	I 547	0 769	0 I84	-I 897	-I 734					
3,I	I 467	I 509	0 356	0 II9	0 III						
3,2	I 792	I 4I0	0 I85	0 I5I	0 233						
3,3	2 II0	I 272	0 455	0 283	0 4I7						
3,4	2 I32	I I34	I I25	0 482	0 5I2						
3,5	2 I35	0 426	I I99	0 528	0 524						
3,6	2 II6	0 203	I 246	0 5II							
3,7	I 837	I I32	I 253	0 46I							
3,8	I 359	I 296	I 2I5	0 364							
3,9	0 638	I 46I	I I47	0 269							
4,0	I I43	I 542	0 786	0 I82							
4,I	I 377	I 52I	0 37I								
4,2	I 696	I 434	0 I89								
4,3	2 I03	I 300	0 425								
4,4	2 I28	I I58	I I20								
4,5	2 I36	0 547	I I95								
4,6	2 I2I	0 I76									
4,7	I 866	I II5									
4,8	I 423	I 278									
4,9	0 884	I 448									
5,0	I I07	I 539									
5,I	I 328										
5,2	I 639										
5,3	I 982										
5,4	2 I25										
5,5	2 I37										

$\langle v\sigma \rangle$ transitions $s \rightarrow p$, parameters χ

$\nu_0 - \nu_1$ \ ν_0	0,5	I,0	I,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,I			0 738	0 75I	0 750	0 742	0 729	0 496	0 689	0 666	0 64I
0,2			0 723	0 694	0 655	0 605	0 552	0 289	0 444	0 394	0 345
0,3			0 663	0 584	0 5I8	0 43I	0 350	0 I26	0 229	0 I74	0 I28
0,4			0 583	0 459	0 375	0 270	0 I98	-I I38	-I 764	-I 3I6	-I I25
0,5		0 55I	0 495	0 334	0 244	0 I34	-I 740	-I I25	-I I25	-I I25	-I I25
0,6		0 492	0 402	0 2I6	0 I30	-I 293	-I I25	-I I25	-I I25	-I I25	
0,7		0 434	0 304	0 I09	-I 335	-I I25	-I I25	-I I25	-I I25	-I I25	
0,8		0 377	0 202	-I I95	-I I25	-I I25	-I I25	-I I25	-I I25	-I I25	
0,9		0 3I9	-I 940	-I I25	-I I25	-I I25	-I I25	0 I88	-I I25	-I I25	
I,0	0 290	0 257	-I I25	-I I25	-I I25	-I I25	-I 695	0 972	0 2I3	0 273	
I,I	0 263	0 I90	-I I25	-I I25	0 223	0 590	0 808	I I35	0 898		
I,2	0 22I	0 II7	-I I25	0 542	I I72	I I92	I I72	0 706	0 992		
I,3	0 I9I	-I 344	I I50	I 226	I 2I0	I I56	I I07	0 255	0 449		
I,4	0 I6I	-I I25	I 200	I I86	I II7	-I I25	0 473	-I 5I4	0 I36		
I,5	0 I27	-I I25	I I29	I I00	0 603	0 3I4	0 I68	-I I25	-I I28		
I,6	-I 864	I 203	0 832	0 508	0 287	-I 897	-I 206	-I I25			
I,7	-I 3II	I II3	0 542	0 23I	0 I0I	-I I25	-I I25	-I I25			
I,8	-I I25	0 667	0 334	-I 709	-I I25	-I I25	-I I25	-I I25			
I,9	0 292	0 469	0 I67	-I I28	-I I25	-I I25	-I I25	0 I89			
2,0	0 725	0 334	-I 289	-I I25	-I I25	-I I79	-I 62I				
2,I	0 43I	0 237	-I I25	-I I25	0 I48	0 473	0 597				
2,2	0 306	0 I52	-I I25	0 238	I I30	I I59	I I62				
2,3	0 233	-I 690	0 973	I I56	I 236	I I79	I II9				
2,4	0 I80	-I I25	I 228	I 236	I I46	0 94I	0 547				
2,5	0 I36	-I I25	I I58	I I38	0 739	0 387	0 200				
2,6	-I 929	0 480	0 977	0 666	0 349	0 II7					
2,7	-I 436	I I7I	0 62I	0 290	0 I3I	-I I25					
2,8	-I I25	0 838	0 379	-I 945	-I I25	-I I25					
2,9	-I I25	0 5I9	0 I94	-I I25	-I I25	-I I25					
3,0	I I38	0 360	-I 458	-I I25	-I I25	-I 245					
3,I	0 597	0 252	-I I25	-I I25	0 II0						
3,2	0 388	0 I62	-I I25	0 I42	I II0						
3,3	0 257	-I 795	0 777	I II0	I 240						
3,4	0 I90	-I I25	I 236	I 242	I I59						
3,5	0 I39	-I I25	I I68	I I66	0 805						
3,6	-I 945	-I 48I	I I03	0 776							
3,7	-I 404	I 204	0 652	0 329							
3,8	-I I25	0 956	0 398	0 I08							
3,9	-I I25	0 553	0 207	-I I25							
4,0	I I96	0 373	-I 546	-I I25							
4,I	0 747	0 256	-I I25								
4,2	0 409	0 I66	-I I25								
4,3	0 274	-I 867	0 678								
4,4	0 I97	-I I25	I 238								
4,5	0 I4I	-I I25	I I73								
4,6	-I 950	-I I25									
4,7	-I 48I	I 2I4									
4,8	-I I25	I I04									
4,9	-I I25	0 574									
5,0	I I95	0 379									
5,I	0 879										
5,2	0 443										
5,3	0 286										
5,4	0 20I										
5,5	0 I43										

$\langle v\sigma \rangle$ transitions $s \to d$, parameters $A\sqrt{\frac{\Delta E}{R_y}}$

$\nu_1-\nu_0$ \ ν_0	0,5	I,0	I,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,I					0 I40	-I 646	-I 8II	-I 886	-I 954	-I 990	0 I0I
0,2					0 603	0 332	0 379	0 379	0 379	0 365	0 349
0,3					I I23	0 789	0 8I9	0 748	0 695	0 620	0 555
0,4					I I8I	I I32	I I24	I I04	0 90I	0 747	0 628
0,5				I 773	I 2I9	I I80	I I52	I II7	0 940	0 725	0 575
0,6				I 874	I 278	I 209	I I57	I III	0 827	0 596	
0,7				I 904	I 308	I 2II	I I4I	0 9I9	0 627	0 424	
0,8				I 857	I 300	I I88	I I09	0 657	0 4I4	0 270	
0,9				I 740	I 258	I I46	0 727	0 4I0	0 248	0 I64	
I,0			2 2I0	I 576	I I94	0 969	0 4I9	0 235	0 I47	0 I03	
I,I			2 I74	I 485	I I2I	0 54I	0 230	0 I40	0 I09		
I,2			2 I40	I 35I	0 642	0 273	0 I60	0 I39	0 I70		
I,3			2 I07	I 208	0 32I	0 I69	0 260	0 262	0 308		
I,4			I 773	0 933	0 245	0 285	0 522	0 458	0 450		
I,5		I 829	I 500	0 342	0 488	0 650	0 809	0 602	0 50I		
I,6		I 7I3	I 335	0 359	I I02	I I06	0 94I	0 625			
I,7		I 585	I I69	I I20	I I53	I I30	0 909	0 560			
I,8		I 445	0 506	I 255	I I79	I I33	0 764	0 445			
I,9		I 30I	0 I47	I 374	I I77	I II8	0 563	0 3I8			
2,0	I 426	I I68	0 970	I 438	I I5I	0 896	0 370	0 2I2			
2,I	I 287	0 898	I 230	I 430	I I08	0 584	0 230				
2,2	I 202	0 333	I 377	I 360	0 675	0 336	0 I63				
2,3	I I4I	-I 557	I 500	I 250	0 386	0 I95	0 203				
2,4	0 923	0 I00	I 563	I I37	0 255	0 I85	0 365				
2,5	0 527	0 53I	I 542	0 573	0 320	0 380	0 584				
2,6	0 283	I II8	I 439	0 302	0 633	0 738					
2,7	-I 842	I I90	I 282	0 709	I I07	I I02					
2,8	-2 55I	I 244	I I26	I I86	I I38	I II2					
2,9	0 I28	I 257	0 3I7	I 3I0	I I44	I I05					
3,0	0 476	I 2I6	0 339	I 39I	I I30	0 847					
3,I	0 654	I I46	I I35	I 407	0 982						
3,2	0 805	0 786	I 280	I 360	0 650						
3,3	0 889	0 274	I 425	I 266	0 399						
3,4	0 868	-I 480	I 528	I I57	0 266						
3,5	0 726	0 206	I 554	0 7I5	0 279						
3,6	0 490	0 767	I 486	0 334							
3,7	0 229	I I5I	I 344	0 556							
3,8	-I 434	I 222	I I77	I I56							
3,9	-I 362	I 257	0 542	I 28I							
4,0	0 3II	I 236	0 2I6	I 369							
4,I	0 5II	I I76	0 930								
4,2	0 7I0	I I08	I 233								
4,3	0 859	0 476	I 385								
4,4	0 906	0 III	I 508								
4,5	0 8I9	-I 867	I 559								
4,6	0 607	0 564									
4,7	0 330	I I30									
4,8	-I 926	I 207									
4,9	-I III	I 255									
5,0	0 233	I 247									
5,I	0 43I										
5,2	0 648										
5,3	0 830										
5,4	0 9I8										
5,5	0 868										

$\langle v\sigma \rangle$ transitions $s \to d$, parameters χ

$\nu_1 - \nu_0$ \ ν_0	0,5	I,0	I,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,I					0 575	0 73I	0 823	0 926	I I00	I I08	I II5
0,2					0 972	I II6	I I25	I I34	I I39	I I42	I I43
0,3					I I2I	I I36	I I40	I I4I	I I38	I I33	I I26
0,4					I I33	I I39	I I36	I I28	I II8	I I05	0 935
0,5					I I35	I I3I	I I20	I I04	0 898	0 739	0 60I
0,6					I I30	I II6	0 986	0 783	0 6II	0 448	
0,7					I II8	0 97I	0 74I	0 523	0 354	0 2I5	
0,8					I I0I	0 758	0 495	0 293	0 I5I	-I 545	
0,9					0 8I3	0 535	0 269	0 III	-I I79	-I I25	
I,0				I I27	0 589	0 3I6	-I 906	-I I25	-I I25	-I I25	
I,I				I I30	0 382	0 I25	-I I25	-I I25	-I I25		
I,2				I I28	0 I40	-I I25	-I I7I	0 III	0 392		
I,3				I I23	-I 205	-I I25	0 524	0 900	I I46		
I,4				I II5	-I 987	0 595	I I9I	I 223	I 228		
I,5			I II7	I I03	0 956	I 224	I 275	I 237	I I85		
I,6			I III	0 887	I 242	I 278	I 226	I I64			
I,7			I I04	0 697	I 266	I 2I5	I I5I	0 968			
I,8			0 958	0 465	I 2II	I I47	0 905	0 509			
I,9			0 859	0 203	I I50	0 95I	0 478	0 222			
2,0	0 6I4	0 890	0 740	-I I83	0 992	0 557	0 202	-I 627			
2,I	0 569	0 837	0 59I	0 300	0 583	0 269	-I 579				
2,2	0 530	0 773	0 387	I I76	0 277	-I 837	-I 4II				
2,3	0 49I	0 7I3	0 II2	I 222	-I 952	-I I25	0 339				
2,4	0 444	0 635	-I 500	I I97	-I 659	0 I82	I I32				
2,5	0 383	0 534	I I95	I I62	0 422	I I25	I 256				
2,6	0 293	0 400	I I90	I I29	I I67	I 278					
2,7	0 I32	0 2I3	I I55	0 985	I 286	I 264					
2,8	-I I25	-I I25	I I27	0 674	I 264	I I84					
2,9	I I4I	I I46	I I06	0 365	I I89	I I7[illegible]					
3,0	0 808	I I7I	0 874	0 I03	I I22	0 689					
3,I	0 674	I I20	0 694	-I 660	0 7I0						
3,2	0 585	0 959	0 496	I I02	0 350						
3,3	0 5I7	0 803	0 257	I 232	0 I38						
3,4	0 454	0 68I	-I I25	I 229	-I 774						
3,5	0 389	0 566	0 630	I I89	0 290						
3,6	0 3I0	0 443	I 2I9	I I48							
3,7	0 I98	0 299	I I88	I III							
3,8	-I I25	0 II0	I I46	0 768							
3,9	I I84	-I I25	I II6	0 439							
4,0	I I0I	I 20I	0 935	0 I55							
4,I	0 764	I I60	0 734	-I 482							
4,2	0 623	I III	0 534	0 686							
4,3	0 536	0 868	0 3I0	I 223							
4,4	0 462	0 709	-I 622	I 244							
4,5	0 392	0 58I	0 I23	I 203							
4,6	0 3I5	0 458	I I95								
4,7	0 2I6	0 325	I 2I0								
4,8	-I 58I	0 I62	I I59								
4,9	0 I06	-I I25	I I23								
5,0	I I22	0 590	0 967								
5,I	0 842	I I97									
5,2	0 663	I I24									
5,3	0 55I	0 9I8									
5,4	0 468	0 727									
5,5	0 394	0 589									

$\langle v6 \rangle$ transitions $p \to s$, parameters $A\sqrt{\frac{\Delta E}{Ry}}$

ν_1 / $\nu_1 - \nu_0$	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5	6,0
4,5									I 832
4,4									I 503
4,3									I 293
4,2									I I60
4,I									0 789
4,0								0 523	0 287
3,9								0 234	0 I03
3,8								0 227	-I 703
3,7								0 244	0 II2
3,6								0 25I	0 I83
3,5							I 79I	0 244	0 263
3,4							I 482	0 280	0 327
3,3							I 282	0 304	0 367
3,2							I I55	0 308	0 348
3,I							0 77I	0 272	0 3I4
3,0						0 585	0 284	0 I90	0 20I
2,9						0 227	0 I03	0 I02	0 I3[illegible]
2,8						0 209	-I 703	-I 695	-I 5[illegible]
2,7						0 235	0 II2	-I 6I2	-I 444
2,6						0 259	0 I85	-I 763	-I 582
2,5					I 734	0 267	0 289	-I 955	-I 799
2,4					I 452	0 3I6	0 338	0 II9	0 I05
2,3					I 268	0 346	0 373	0 I44	0 I29
2,2					I I49	0 350	0 366	0 I64	0 I44
2,I					0 745	0 307	0 3I5	0 I67	0 I43
2,0				0 668	0 277	0 2I0	0 2I2	0 I38	0 II7
I,9				0 222	0 I0I	0 I23	0 II5	-I 889	-I 800
I,8				0 I95	-I 7I5	-I 640	-I 598	-I 543	-I 49I
I,7				0 237	0 II7	-I 667	-I 497	-I 402	-I 328
I,6				0 288	0 I98	-I 905	-I 695	-I 467	-I 366
I,5			I 65I	0 320	0 295	0 I23	-I 990	-I 602	-I 493
I,4			I 4II	0 392	0 377	0 I64	0 I35	-I 77I	-I 636
I,3			I 248	0 43I	0 42I	0 203	0 I70	-I 972	-I 80I
I,2			I I40	0 428	0 4I5	0 229	0 I93	0 I05	-I 955
I,I			0 699	0 362	0 353	0 228	0 I93	0 I27	0 I03
I,0		0 7I8	0 25I	0 224	0 225	0 I73	0 I5I	0 II2	-I 934
0,9		0 20I	I 865	0 I02	0 I09	-I 986	-I 933	-I 963	-I 679
0,8		0 202	I 8I0	-I 63I	-I 558	-I 582	-I 824	-I 463	-I 429
0,7		0 307	0 I53	-I 948	-I 729	-I 55I	-I 44I	-I 366	-I 3I4
0,6		0 439	0 287	0 I59	0 I2I	-I 869	-I 702	-I 559	-I 467
0,5	I 538	0 533	0 45I	0 259	0 200	0 I38	0 I08	-I 826	-I 690
0,4	I 360	0 665	0 576	0 384	0 295	0 207	0 I66	0 I24	0 I02
0,3	I 22I	0 696	0 6I5	0 437	0 365	0 29I	0 227	0 I77	0 I48
0,2	I II6	0 565	0 5I5	0 406	0 364	0 287	0 249	0 206	0 I78
0,I	0 399	0 285	0 268	0 233	0 2I2	0 I87	0 I70	0 I5I	0 I38

$\langle v6 \rangle$; transitions $p \to s$, parameters χ

ν_1 / $\nu_1 - \nu_0$	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5	6,0
4,5									0 551
4,4									0 733
4,3									1 103
4,2									1 157
4,1									1 245
4,0									1 206
3,9								0 370	0 324
3,8								-1 125	-1 128
3,7								-1 125	-1 125
3,6								-1 340	-1 835
3,5								0 150	0 240
3,4							0 568	0 368	0 484
3,3							0 757	0 760	0 873
3,2							1 106	1 142	1 151
3,1							1 161	1 231	1 234
3,0							1 245	1 268	1 230
2,9						0 515	1 197	1 169	1 107
2,8						-1 125	0 307	0 457	0 137
2,7						-1 125	-1 125	-1 818	-1 128
2,6					0 589	-1 298	-1 125	-1 125	-1 125
2,5					0 785	0 148	-1 803	-1 125	-1 232
2,4					1 110	0 369	0 239	-1 788	0 151
2,3					1 165	0 722	0 487	0 257	0 402
2,2					1 242	1 132	0 884	0 614	0 856
2,1					1 179	1 217	1 156	1 124	1 150
2,0				0 694	0 252	1 267	1 239	1 194	1 180
1,9				-1 277	-1 125	1 173	1 216	1 169	0 733
1,8				-1 125	-1 125	0 531	0 727	0 636	0 163
1,7				-1 211	-1 727	-1 210	-1 815	0 121	-1 125
1,6				0 140	0 231	-1 125	-1 125	-1 125	-1 125
1,5			0 601	0 339	0 475	-1 125	-1 125	-1 125	-1 125
1,4			0 796	0 655	0 865	-1 727	-1 208	-1 125	-1 152
1,3			1 111	1 116	1 150	0 256	0 159	-1 596	0 159
1,2			1 163	1 191	1 229	0 611	0 429	0 253	0 470
1,1			1 228	1 248	1 177	1 124	0 928	0 434	0 996
1,0		0 772	1 136	1 148	0 374	1 200	1 184	1 128	1 112
0,9		-1 125	-1 860	0 228	-1 125	1 159	1 155	1 127	0 434
0,8		-1 125	-1 125	-1 125	-1 125	0 406	0 476	0 667	-1 325
0,7		-1 125	-1 125	-1 125	-1 125	-1 125	0 166	-1 177	-1 125
0,6		0 107	-1 475	-1 125	-1 169	-1 125	-1 125	-1 125	-1 125
0,5	0 458	0 233	0 160	-1 603	0 135	-1 125	-1 125	-1 125	-1 125
0,4	0 538	0 372	0 299	0 179	0 299	-1 691	-1 323	-1 125	-1 125
0,3	0 624	0 517	0 463	0 359	0 505	0 181	0 178	0 125	1 893
0,2	0 706	0 686	0 615	0 554	0 713	0 445	0 398	0 345	0 303
0,1	0 750	0 751	0 744	0 730	0 906	0 691	0 666	0 642	0 616

$\langle v\sigma \rangle$ transitions $p \to p$, parameters $A\sqrt{\frac{\Delta E}{R_y}}$

$\nu_1 - \nu_0$ \ ν_0	I,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,I	I II4	0 3I2	0 387	0 464	0 50I5	0 538	0 558	0 577	0 586
0,2	I 55I	I I70	I I93	I 2I9	I 2236	I 229	I 226	I 224	I 2I8
0,3	2 I27	I 432	I 448	I 484	I 4632	I 455	I 427	I 408	I 380
0,4	2 2I7	I 773	I 737	I 753	I 6784	I 640	I 57I	I 526	I 470
0,5	2 307	2 II0	I 977	I 938	I 7972	I 720	I 6I3	I 546	I 470
0,6	2 462	2 I33	2 I09	I 983	I 7885	I 680	I 554	I 477	
0,7	2 6I5	2 I38	2 I07	I 878	I 6670	I 545	I 425	I 353	
0,8	2 735	2 I22	I 905	I 66I	I 4796	I 366	I 275	I 2I8	
0,9	2 788	I 903	I 655	I 406	I 2856	I I99	I I46	I II0	
I,0	2 752	I 524	I 390	I I93	I I363	0 872	0 653	0 484	
I,I	2 372	I 23I	I I4I	0 797	0 5447	0 465	0 364		
I,2	2 206	0 855	0 524	0 723	0 5705	0 774	0 635		
I,3	I 720	I III	0 780	I I77	I 1384	I I7I	I I32		
I,4	I I42	I 3I0	I 220	I 35I	I 2534	I 269	I I96		
I,5	I 494	I 6I3	I 4I3	I 506	I 34I0	I 328	I 228		
I,6	2 I96	I 893	I 578	I 583	I 3735	I 33I			
I,7	2 43I	2 I03	I 664	I 558	I 3478	I 282			
I,8	2 700	I 989	I 650	I 443	I 2775	I 202			
I,9	2 929	I 766	I 546	I 287	I I877	I II9			
2,0	3 I04	I 458	I 389	I I46	I I07I	0 6II			
2,I	2 526	I 222	I I49	0 74I	0 4750				
2,2	2 354	0 963	0 586	0 750	0 4254				
2,3	2 I72	I II9	0 486	I I64	0 888I				
2,4	I 459	I 306	I I33	I 3I3	I I685				
2,5	I 239	I 596	I 288	I 447	I 2368				
2,6	2 I34	I 869	I 442	I 5I5					
2,7	2 386	2 I0I	I 547	I 493					
2,8	2 722	I 962	I 576	I 39I					
2,9	3 I05	I 738	I 525	I 252					
3,0	3 I28	I 43I	I 4I2	I I29					
3,I	2 64I	I 2I4	I I60						
3,2	2 466	0 992	0 655						
3,3	2 258	I I3I	0 390						
3,4	I 87I	I 324	0 927						
3,5	I 235	I 620	I 224						
3,6	2 I05	I 895							
3,7	2 36I	2 I03							
3,8	2 742	I 972							
3,9	3 II5	I 735							
4,0	3 I46	I 4I8							
4,I	2 730								
4,2	2 556								
4,3	2 329								
4,4	2 I26								
4,5	I 295								

$\langle v\sigma \rangle$ transitions $\rho \to \rho$, parameters χ

$\nu_1 - \nu_0$ \ ν_0	1,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,1	0 299	0 361	0 453	0 528	0 606	0 673	0 739	0 796	0 852
0,2	0 520	0 632	0 776	0 876	0 975	1 104	1 111	1 115	1 119
0,3	0 690	0 838	0 996	1 108	1 116	1 121	1 123	1 124	1 123
0,4	0 823	0 992	1 113	1 119	1 123	1 123	1 121	1 117	1 112
0,5	0 926	1 110	1 120	1 122	1 120	1 116	1 109	1 102	0 943
0,6	1 100	1 117	1 121	1 118	1 111	1 102	0 918	0 825	
0,7	1 105	1 119	1 117	1 108	0 955	0 835	0 711	0 608	
0,8	1 109	1 118	1 107	0 913	0 754	0 613	0 487	0 387	
0,9	1 110	1 109	0 913	0 689	0 517	0 371	0 266	0 183	
1,0	1 110	0 894	0 692	0 402	0 274	0 157	-1 962	-1 504	
1,1	1 108	0 548	0 325	0 177	0 105	0 135	0 112		
1,2	0 938	0 189	0 104	0 411	0 461	0 876	0 901		
1,3	0 562	0 415	0 589	1 151	1 179	1 210	1 211		
1,4	-1 194	1 109	1 165	1 207	1 229	1 217	1 205		
1,5	0 476	1 145	1 194	1 198	1 199	1 175	1 155		
1,6	1 101	1 156	1 182	1 172	1 157	1 132			
1,7	1 117	1 155	1 160	1 142	1 119	0 959			
1,8	1 121	1 147	1 135	1 111	0 856	0 637			
1,9	1 121	1 132	1 109	0 780	0 555	0 363			
2,0	1 118	1 105	0 827	0 445	0 306	0 173			
2,1	1 117	0 646	0 412	0 248	0 129				
2,2	1 105	0 278	0 135	0 540	0 357				
2,3	0 799	0 487	0 292	1 164	1 154				
2,4	0 290	1 115	1 146	1 227	1 247				
2,5	0 130	1 154	1 216	1 218	1 223				
2,6	0 904	1 165	1 207	1 186					
2,7	1 119	1 164	1 178	1 152					
2,8	1 124	1 156	1 146	1 117					
2,9	1 123	1 141	1 116	0 814					
3,0	1 119	1 111	0 885	0 465					
3,1	1 119	0 687	0 457						
3,2	1 106	0 325	0 156						
3,3	0 854	0 567	0 147						
3,4	0 443	1 121	1 111						
3,5	-1 648	1 157	1 218						
3,6	0 780	1 168							
3,7	1 120	1 167							
3,8	1 125	1 159							
3,9	1 123	1 144							
4,0	1 119	1 114							
4,1	1 118								
4,2	1 106								
4,3	0 867								
4,4	0 511								
4,5	-1 770								

$\langle v6 \rangle$ transitions $p \rightarrow d$, parameters $A\sqrt{\frac{\Delta E}{R_y}}$

$\nu_1-\nu_0$ \ ν_0	1,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,1			1 130	0 413	0 441	0 398	0 374	0 340	0 310
0,2			1 266	0 971	0 973	0 783	0 696	0 581	0 503
0,3			1 345	1 141	1 134	0 968	0 830	0 636	0 533
0,4			1 364	1 165	1 150	0 965	0 808	0 570	0 470
0,5		1 991	1 335	1 166	1 144	0 832	0 688	0 445	0 370
0,6		1 934	1 334	1 148	1 121	0 641	0 522	0 322	
0,7		1 842	1 294	1 120	0 914	0 453	0 359	0 220	
0,8		1 727	1 227	0 901	0 606	0 302	0 229	0 147	
0,9		1 598	1 151	0 622	0 360	0 200	0 141	0 110	
1,0	2 101	1 465	0 666	0 402	0 215	0 151	0 123	0 119	
1,1	2 288	1 352	0 472	0 244	0 231	0 183	0 192		
1,2	2 215	1 233	0 398	0 216	0 398	0 270	0 300		
1,3	2 157	1 131	0 697	0 316	0 654	0 359	0 384		
1,4	2 110	0 632	1 128	0 488	0 817	0 382	0 408		
1,5	1 750	0 386	1 175	0 592	0 872	0 359	0 392		
1,6	1 581	0 129	1 197	0 627	0 830	0 315			
1,7	1 409	1 150	1 194	0 622	0 702	0 265			
1,8	1 249	1 238	1 166	0 583	0 523	0 217			
1,9	1 119	1 329	1 123	0 515	0 345	0 176			
2,0	0 354	1 400	0 796	0 421	0 223	0 144			
2,1	1 377	1 364	0 508	0 292	0 213				
2,2	1 533	1 295	0 413	0 214	0 313				
2,3	1 667	1 211	0 577	0 201	0 515				
2,4	1 756	1 130	1 101	0 248	0 699				
2,5	1 786	0 726	1 146	0 330	0 788				
2,6	1 753	0 557	1 171	0 386					
2,7	1 661	1 100	1 173	0 424					
2,8	1 517	1 180	1 151	0 454					
2,9	1 342	1 279	1 114	0 464					
3,0	1 169	1 376	0 760	0 433					
3,1	1 263	1 373	0 513						
3,2	1 385	1 032	0 416						
3,3	1 528	1 263	0 543						
3,4	1 665	1 183	0 928						
3,5	1 767	1 111	1 137						
3,6	1 817	0 690							
3,7	1 796	0 821							
3,8	1 696	1 155							
3,9	1 522	1 254							
4,0	1 307	1 362							
4,1	1 240								
4,2	1 332								
4,3	1 458								
4,4	1 606								
4,5	1 745								

$\langle v\sigma \rangle$ transitions $p \to d$, parameters χ

$v_1 - v_0$ \ v_0	I,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,I			0 74I	0 744	0 739	0 718	0 700	0 678	0 654
0,2			0 707	0 648	0 607	0 546	0 499	0 445	0 400
0,3			0 626	0 5I3	0 457	0 367	0 3I5	0 249	0 205
0,4			0 528	0 380	0 32I	0 22I	0 I75	0 II0	-I 765
0,5		0 529	0 428	0 262	0 207	0 I08	-I 730	-I I69	-I I25
0,6		0 457	0 329	0 I63	0 II4	-I 258	-I I25	-I I25	
0,7		0 388	0 234	-I 824	-I 382	-I I25	-I I25	-I I25	
0,8		0 325	0 I44	-I 204	-I I25	-I I25	-I I25	-I I25	
0,9		0 267	-I 630	-I I25	-I I25	-I I25	-I I25	-I I25	
I,0	0 253	0 2II	-I I25	-I I25	-I I25	-I I25	-I I25	-I 295	
I,I	0 248	0 I48	-I I25	-I I25	-I 839	0 I3I	0 305		
I,2	0 204	-I 877	-I 79I	-I 432	0 767	0 720	I I07		
I,3	0 I64	-I 33I	0 82I	0 56I	I I66	I I27	I II0		
I,4	0 I29	-I I25	I I94	I I49	I I25	0 856	0 62I		
I,5	-I 98I	0 I07	I I56	I II2	0 716	0 4I6	0 296		
I,6	-I 697	I I4I	0 985	0 582	0 389	0 I76			
I,7	-I 423	I I58	0 604	0 290	0 I94	-I 567			
I,8	-I I25	0 853	0 358	0 I39	-I 7I4	-I I25			
I,9	-I I25	0 520	0 I9I	-I 552	-I I25	-I I25			
2,0	-I I25	0 345	-I 828	-I I25	-I I25	-I I25			
2,I	0 66I	0 24I	-I 309	-I I25	-I 907				
2,2	0 373	0 I64	0 II0	-I I25	0 563				
2,3	0 242	0 I05	0 60I	0 I20	I I55				
2,4	0 I67	-I 624	I I75	0 566	I I56				
2,5	0 II9	-I 606	I I87	I II7	I I00				
2,6	-I 959	0 3I3	I I28	0 859					
2,7	-I 586	I I77	0 806	0 446					
2,8	-I 3I9	I I29	0 486	0 228					
2,9	-I I25	0 682	0 272	0 II3					
3,0	-I I25	0 408	0 I42	-I 369					
3,I	I I34	0 285	-I 8I6						
3,2	0 589	0 202	0 I42						
3,3	0 3I0	0 I42	0 578						
3,4	0 I9I	0 I00	I I66						
3,5	0 I28	-I 833	I I97						
3,6	-I 899	0 I78							
3,7	-I 623	I I07							
3,8	-I 368	I I60							
3,9	-I I25	0 798							
4,0	-I I25	0 442							
4,I	I I60								
4,2	0 84I								
4,3	0 379								
4,4	0 209								
4,5	0 I32								

$\langle v\sigma \rangle$ transitions $d \to s$, parameters $A\sqrt{\frac{\Delta E}{R_y}}$

$\nu_1-\nu_0$ \ ν_1	3,0	3,5	4,0	4,5	5,0	5,5	6,0
3,5							I 305
3,4							I 2I5
3,3							I I45
3,2							0 908
3,I							0 490
3,0						I I57	0 I96
2,9						0 586	0 I03
2,8						0 2I3	-I 740
2,7						0 I20	-I 937
2,6						0 I28	0 I48
2,5					I 248	0 I77	0 225
2,4					I I79	0 282	0 305
2,3					I I22	0 367	0 364
2,2					0 768	0 394	0 380
2,I					0 4I7	0 347	0 334
2,0				I I40	0 I78	0 248	0 228
I,9				0 509	-I 946	0 I52	0 I4I
I,8				0 I79	-I 709	-I 950	-I 87I
I,7				0 III	-I 955	-I 838	-I 742
I,6				0 I4I	0 I58	0 I06	-I 938
I,5			I I82	0 209	0 246	0 I57	0 I37
I,4			I I37	0 3I9	0 334	0 230	0 I87
I,3			0 957	0 394	0 39I	0 298	0 257
I,2			0 597	0 395	0 390	0 328	0 292
I,I			0 3I2	0 3I5	0 3I6	0 292	0 273
I,0		0 809	0 I29	0 I94	0 I94	0 20I	0 I96
0,9		0 249	-I 656	0 I00	0 I0I	0 II3	0 II5
0,8		0 I09	-I 649	-I 700	-I 673	-I 687	-I 676
0,7		0 I32	0 II6	-I 954	-I 877	-I 770	-I 684
0,6		0 223	0 2I7	0 I7I	0 I53	0 I25	0 I06
0,5	I I20	0 300	0 332	0 28I	0 254	0 2I0	0 I80
0,4	0 909	0 373	0 403	0 370	0 345	0 302	0 267
0,3	0 570	0 346	0 378	0 372	0 36I	0 335	0 3I0
0,2	0 259	0 2I7	0 243	0 254	0 259	0 254	0 248
0,I	-I 562	-I 6I6	-I 7I2	-I 786	-I 838	-I 87I	-I 895

$\langle v\sigma \rangle$ transitions $d \rightarrow s$, parameters χ

$\nu_1 - \nu_0$ \ ν_1	3,0	3,5	4,0	4,5	5,0	5,5	6,0
3,5							I I54
3,4							I I89
3,3							I 23I
3,2							I 275
3,I							I 294
3,0						I I64	I 207
2,9						I I09	0 86I
2,8						0 489	0 3I5
2,7						0 284	0 3I5
2,6						0 5I0	0 573
2,5					I I6I	I III	I I0I
2,4					I I98	I I88	I I60
2,3					I 239	I 26I	I 230
2,2					I 275	I 3I2	I 297
2,I					I 27I	I 3I2	I 324
2,0				I I47	I I74	I 235	I 252
I,9				0 907	0 66I	I I22	I I30
I,8				0 344	0 237	0 479	0 478
I,7				0 2I7	0 282	0 255	0 209
I,6				0 535	0 575	0 345	0 258
I,5			I I66	I II8	I I04	0 677	0 5I5
I,4			I 20I	I I89	I I65	I I25	0 992
I,3			I 236	I 252	I 233	I 200	I I67
I,2			I 252	I 285	I 288	I 27I	I 242
I,I			I 2I2	I 256	I 28I	I 283	I 272
I,0		0 99I	I I04	I I52	I I7I	I I87	I I93
0,9		0 349	0 236	0 480	0 54I	0 676	0 756
0,8		-I 683	-I 859	-I 965	-I 886	0 II7	0 I36
0,7		0 2I4	0 243	0 I2I	-I 789	-I 433	-I I90
0,6		0 636	0 568	0 36I	0 264	0 I64	0 I02
0,5	I I29	I I05	0 933	0 727	0 594	0 449	0 344
0,4	I I40	I I33	I I24	I II0	0 983	0 843	0 722
0,3	I I38	I I43	I I42	I I38	I I32	I I23	I II5
0,2	I II8	I I28	I I36	I I4I	I I44	I I45	I I43
0,I	0 737	0 834	0 935	I I02	I I09	I II6	I I22

$\langle \tau\sigma \rangle$ transitions $d \to p$, parameters $A\sqrt{\frac{\Delta E}{R_y}}$

$\nu_1 - \nu_0$ \ ν_1	3,0	3,5	4,0	4,5	5,0	5,5	6,0
3,5							I 709
3,4							I 453
3,3							I 274
3,2							I I54
3,I							0 806
3,0						I II7	0 366
2,9						I I23	0 204
2,8						0 592	0 I5I
2,7						0 3I6	0 I86
2,6						0 206	0 27I
2,5					I 620	0 I6I	0 368
2,4					I 408	0 I84	0 444
2,3					I 255	0 222	0 476
2,2					I I50	0 26I	0 457
2,I					0 8II	0 284	0 394
2,0				I I4I	0 375	0 275	0 296
I,9				I I32	0 208	0 256	0 203
I,8				0 586	0 I40	0 I87	0 I33
I,7				0 287	0 I59	0 I47	0 I06
I,6				0 I97	0 234	0 I35	0 II8
I,5			I 490	0 I85	0 333	0 I45	0 I56
I,4			I 340	0 244	0 423	0 I72	0 204
I,3			I 226	0 3II	0 480	0 209	0 248
I,2			I I4I	0 364	0 487	0 246	0 235
I,I			0 806	0 380	0 440	0 269	0 275
I,0		I I72	0 38I	0 335	0 332	0 256	0 238
0,9		I II3	0 I98	0 266	0 2I3	0 I96	0 I74
0,8		0 405	0 II8	0 I64	0 I28	0 I32	0 II4
0,7		0 202	0 I4I	0 I24	0 I04	-I 997	-I 839
0,6		0 220	0 240	0 I52	0 I43	0 III	-I 975
0,5	I 329	0 306	0 388	0 230	0 225	0 I60	0 I46
0,4	I 255	0 468	0 543	0 345	0 337	0 239	0 220
0,3	I I8I	0 587	0 638	0 453	0 438	0 328	0 304
0,2	I I08	0 567	0 594	0 474	0 457	0 327	0 347
0,I	0 426	0 334	0 346	0 309	0 302	0 269	0 257

$\langle v_6 \rangle$ transitions $d \to p$, parameters X

$\nu_1 - \nu_0$ \ ν_1	3,0	3,5	4,0	4,5	5,0	5,5	6,0
3,5							0 453
3,4							0 564
3,3							0 737
3,2							I I04
3,I							I I63
3,0							I 2I2
2,9						0 992	I I04
2,8						I I87	0 303
2,7						I I04	0 I76
2,6						0 5I3	0 2I7
2,5						0 325	0 32I
2,4					0 462	0 34I	0 479
2,3					0 580	0 487	0 7II
2,2					0 766	0 433	I I06
2,I					I I09	I I36	I I58
2,0					I I68	I I82	I I88
I,9				I I62	I 2I0	I I77	I I2I
I,8				I I99	I I0I	I I38	0 426
I,7				I II2	0 25I	0 662	0 I2I
I,6				0 440	0 I06	0 29I	-I 595
I,5			0 470	0 226	0 I37	0 I62	-I 977
I,4			0 603	0 25I	0 236	0 I63	0 204
I,3			0 8I2	0 422	0 392	0 25I	0 394
I,2			I II6	0 752	0 633	0 468	0 7II
I,I			I I75	I I26	I I0I	0 860	I II7
I,0		I I85	I I95	I I82	I I56	I I37	I I43
0,9		I I59	0 725	I I8I	I I79	I I53	0 60I
0,8		0 5I5	-I 800	I I08	0 877	0 853	0 I93
0,7		-I 627	-I I25	0 282	0 I70	0 228	-I I25
0,6		-I 338	-I 256	-I I74	-I I25	-I I25	-I I25
0,5	0 360	0 II9	0 I09	-I I25	-I I25	-I I25	-I I25
0,4	0 450	0 255	0 226	-I 249	-I I25	-I I25	-I I25
0,3	0 553	0 4I7	0 374	0 I23	0 I00	-I 428	-I 242
0,2	0 663	0 592	0 550	0 276	0 243	0 I74	0 I47
0,I	0 744	0 733	0 7I9	0 480	0 443	0 382	0 348
				0 697	0 678	0 650	0 629
							0 I43

⟨v6⟩ Intercombinational transitions S - S, parameters $A\sqrt{\frac{\Delta E}{R_y}}$

$\nu_1-\nu_0$ \ ν_0	0,5	I,0	I,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,I	I 750	0 565	0 483	0 446	0 4I2	0 384	0 359	0 337	0 3I7	0 300	0 264
0,2	2 25I	I 220	I I65	I I46	I I26	I II2	I I00	0 9II	0 829	0 760	0 698
0,3	2 473	I 466	I 329	I 267	I 220	I I87	I I6I	I I4I	I I25	I III	0 995
0,4	2 695	I 744	I 488	I 374	I 294	I 240	I 200	I I69	I I45	I I25	I I09
0,5	2 872	I 987	I 606	2 360	I 329	I 258	I 207	I I65	I I40	I II8	
0,6	3 II6	2 II2	I 683	I 446	I 3I8	I 238	I I83	I I44	I II6	0 954	
0,7	3 I36	2 II2	I 6I7	I 394	I 266	I I89	I I39	I I05	0 8I5	0 647	
0,8	3 I36	I 966	I 5I0	I 302	I I90	I I26	0 874	0 626	0 462	0 352	
0,9	3 III	I 7I6	I 364	I I98	I II3	0 684	0 428	0 280	0 I9I	0 I36	
I,0	2 660	I 45I	I 2I5	0 000	0 527	0 27I	0 I45	-I 806	-I 394		
I,I	2 366	I I53	0 552	0 2I3	0 II6	-I 744	-I 53I	-I 4II	-I 330		
I,2	2 I32	0 508	0 368	0 333	0 280	0 207	0 I40	0 I44	0 I2I		
I,3	I 3II	I I59	0 99I	0 820	0 60I	0 48I	0 380	0 309	0 250		
I,4	2 I73	I 354	I I98	I I48	I I03	0 784	0 59I	0 46I	0 362		
I,5	2 473	I 590	I 309	I 2I0	I I39	0 998	0 72I	0 543	0 338		
I,6	2 866	I 765	I 392	I 246	I I53	I I04	0 724	0 526			
I,7	3 I2I	I 863	I 42I	I 24I	I I43	0 9I6	0 605	0 423			
I,8	3 I36	I 807	I 386	I 20I	I III	0 682	0 4I2	0 273			
I,9	3 I20	I 638	I 300	I I42	0 7I3	0 360	0 2I5	0 I30			
2,0	2 733	2 264	I I57	0 8I8	0 357	0 I6I	-I 787	-I 4I4			
2,I	2 450	I I65	0 6I3	0 20I	-I 994	-I 563	-I 364				
2,2	2 202	0 487	0 303	0 289	0 I8I	0 I43	0 I09				
2,3	I 225	I I4I	0 779	0 648	0 434	0 335	0 247				
2,4	2 I28	I 320	I I8I	I II9	0 766	0 558	0 393				
2,5	2 4I0	I 545	I 282	I I73	I I05	0 726	0 492				
2,6	2 8I9	I 739	I 34I	I 206	I II9	0 777					
2,7	3 I2I	I 827	I 377	I 206	I II3	0 694					
2,8	3 I4I	I 777	I 355	I I75	0 907	0 509					
2,9	3 I26	I 6I8	I 283	I I25	0 589	0 296					
3,0	2 773	I 229	I I86	0 735	0 300	0 I28					
3,I	2 492	I I87	0 647	0 I93	-I 9I8						
3,2	2 234	0 485	0 280	0 247	0 I55						
3,3	I 26I	I I37	0 697	0 590	0 372						
3,4	2 III	I 3II	I I46	I I09	0 662						
3,5	2 385	I 534	2 324	I I89	0 922						
3,6	2 803	I 728	I 320	I I9I							
3,7	3 I22	I 8I7	I 389	I I92							
3,8	3 I44	I 768	I 343	I I63							
3,9	3 I30	I 6II	I 276	I III							
4,0	2 799	I 420	2 II4	0 695							
4,I	2 5I8	I I77	0 67I								
4,2	2 253	0 485	0 268								
4,3	I 307	I I35	0 683								
4,4	2 I02	2 I06	I I38								
4,5	2 372	I 53I	I 229								
4,6	2 795	I 608									
4,7	3 I22	I 8I5									
4,8	3 I46	I 765									
4,9	3 I33	I 606									
5,0	2 8I6	2 II3									
5,I	2 536										
5,2	2 266										
5,3	I 347										
5,4	I 973										
5,5	2 363										

⟨V6⟩ Intercombinational transitions $S - S$, parameters λ

$\nu_1-\nu_0$ \ ν_0	0,5	I,0	I,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,I	-I I25	-I I25	-I I25	-I I25	-I I25	-I I87	-I 368	-I 523	-I 684	-I 839	-I 992
0,2	-I I25	-I I25	-I 225	-I 534	-I 87I	0 II7	0 I46	0 I73	0 I98	0 22I	0 242
0,3	-I I69	-I 326	-I 767	0 I22	0 I70	0 208	0 245	0 274	0 30I	0 322	0 34I
0,4	-I 4I8	-I 696	0 I34	0 I94	0 253	0 294	0 333	0 369	0 38I	0 395	0 407
0,5	-I 633	0 II0	0 I90	-I 855	0 34I	0 380	0 4I5	0 393	0 439	0 449	
0,6	-I 849	0 I60	0 277	0 368	0 440	0 472	0 498	0 500	0 502	0 490	
0,7	0 I08	0 227	0 383	0 497	0 567	0 586	0 594	0 575	0 558	0 530	
0,8	0 I38	0 334	0 549	0 7I0	0 763	0 763	0 732	0 68[illegible]	0 632	0 582	
0,9	0 I85	0 548	0 887	I II7	I II8	I II4	I I02	0 906	0 765	0 028	
I,0	0 294	I I08	I I45	I I00	I 226	I 207	I I75	I I44	0 7II		
I,I	0 529	0 943	0 766	0 403	0 36I	0 3I2	0 324	0 3I3	0 33I		
I,2	I I28	-I I25	-I 47I	0 II7	0 I95	0 236	0 298	0 327	0 362		
I,3	-I I25	-I I25	-I 925	0 I77	0 27I	0 3I6	0 375	0 388	0 4I0		
I,4	-I I25	-I 5I2	0 I93	0 259	0 356	0 392	0 439	0 434	0 444		
I,5	-I 367	0 I03	0 244	0 348	0 445	0 462	0 494	0 472	-I 223		
I,6	-I 722	0 I62	0 337	0 45I	0 539	0 536	0 548	0 508			
I,7	0 I02	0 240	0 456	0 590	0 666	0 63I	0 6I2	0 552			
I,8	0 I35	0 36I	0 637	0 822	0 835	0 783	0 708	0 624			
I,9	0 I80	0 597	0 993	I I33	I I2I	I III	0 9I0	0 783			
2,0	0 276	0 660	I II2	I 243	I 2I7	I I84	I I43	I II5			
2,I	0 456	I I07	I II2	0 562	0 570	0 4II	0 424				
2,2	I II4	-I I25	-I 788	0 I53	0 250	0 278	0 348				
2,3	-I I25	-I I25	0 I08	0 203	0 3I4	0 345	0 408				
2,4	-I I25	-I 5II	0 I79	0 283	0 397	0 4I2	0 460				
2,5	-I 335	0 I03	0 I84	0 37I	0 460	0 474	0 505				
2,6	-I 699	0 I64	0 360	0 473	0 568	0 540					
2,7	0 I02	0 244	0 48I	0 6I3	0 677	0 626					
2,8	0 I35	0 368	0 682	0 849	0 84I	0 768					
2,9	0 I79	0 6I2	I I0I	I I37	I II8	I I08					
3,0	0 270	-I I25	I I94	I 246	I 208	I I73					
3,I	0 430	I II0	I I33	0 627	0 668						
3,2	I I02	-I I25	-I 99I	0 I70	0 279						
3,3	-I 406	-I I25	0 II7	0 2I5	0 336						
3,4	-I I25	-I 5I5	0 I67	0 293	0 4I7						
3,5	-I 3I2	0 I04	-I I25	0 360	0 497						
3,6	-I 69I	0 I65	0 37I	0 48I							
3,7	0 I02	0 245	0 493	0 620							
3,8	0 I35	0 370	0 289	0 857							
3,9	0 I78	0 6I8	I I0I	I I38							
4,0	0 266	I 479	0 303	I 248							
4,I	0 4I7	I I20	I I46								
4,2	0 954	-I I25	0 II3								
4,3	0 I06	-I I25	0 468								
4,4	-I I25	0 7I6	-I 8I7								
4,5	-I 299	0 I04	0 346								
4,6	-I 667	-I 988									
4,7	0 I02	0 246									
4,8	0 I35	0 87									
4,9	0 I78	0 62I									
5,0	0 264	0 349									
5,I	0 409										
5,2	0 9I3										
5,3	0 I65										
5,4	-I I25										
5,5	-I 29I										

(56) Intercombinational transitions $S \to P$ parameters $A\sqrt{\frac{\Delta E}{R_y}}$

$\nu_1 - \nu_0$ \ ν_0	0,5	1,0	1,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,1			1 323	1 104	0 925	0 799	0 687	0 600	0 521	0 460	0 408
0,2			1 644	1 283	1 191	1 147	1 117	0 928	0 740	0 596	0 479
0,3			1 845	1 329	1 249	1 166	1 122	0 860	0 624	0 482	0 331
0,4			1 909	1 364	1 253	1 144	0 959	0 587	0 391	0 252	0 172
0,5		2 241	1 850	1 332	1 210	0 981	0 596	0 313	0 195	0 114	-1 759
0,6		2 249	1 844	1 250	1 141	0 527	0 295	0 142	-1 865	-1 538	
0,7		2 241	1 711	1 153	0 744	0 245	0 131	-1 797	-1 492	-1 423	
0,8		2 215	1 482	0 765	0 310	0 153	-1 876	-1 891	-1 617	-1 670	
0,9		2 175	1 229	0 375	0 185	0 189	0 140	0 155	0 115	0 107	
1,0		2 122	0 722	0 331	0 303	0 331	0 269	0 236	0 170	0 133	
1,1	3 117	1 881	0 549	0 536	0 500	0 525	0 385	0 285	0 187		
1,2	2 869	1 518	1 113	0 936	0 965	0 652	0 435	0 276	0 171		
1,3	2 657	1 207	1 243	1 135	1 123	0 652	0 408	0 224	0 136		
1,4	2 490	0 991	1 411	1 158	1 129	0 540	0 327	0 157	-1 958		
1,5	2 347	0 580	1 559	1 154	1 113	0 377	0 225	-1 987	-1 616		
1,6	2 222	1 232	1 626	1 126	0 827	0 234	0 134	-1 634			
1,7	2 144	1 546	1 577	0 878	0 488	0 151	-1 778	-1 583			
1,8	1 641	1 900	1 422	0 543	0 242	0 199	-1 607	-1 599			
1,9	0 937	2 115	1 221	0 346	0 157	0 165	-1 947	0 107			
2,0	1 111	2 116	0 799	0 306	0 238	0 257	0 175	0 145			
2,1	1 862	1 968	0 582	0 425	0 454	0 378	0 243				
2,2	2 146	1 673	0 953	0 679	0 731	0 449	0 275				
2,3	2 205	1 358	1 203	0 958	0 949	0 439	0 264				
2,4	2 250	1 104	1 357	1 112	1 102	0 353	0 222				
2,5	2 267	0 863	1 504	1 110	0 920	0 260	0 164				
2,6	2 246	1 533	1 580	0 932	0 698	0 145					
2,7	2 187	1 199	1 548	0 621	0 433	0 138					
2,8	2 106	1 401	1 410	0 472	0 226	0 120					
2,9	1 919	1 751	1 222	0 331	0 144	0 153					
3,0	0 388	2 106	0 839	0 294	0 206	0 222					
3,1	1 495	2 144	0 556	0 380	0 387						
3,2	2 104	1 100	0 885	0 573	0 630						
3,3	2 158	1 747	1 188	0 790	0 830						
3,4	2 225	1 431	1 337	0 920	0 908						
3,5	2 257	1 154	1 483	0 909	0 835						
3,6	2 252	0 883	1 565	0 781							
3,7	2 205	0 995	1 539	0 603							
3,8	2 198	1 332	1 408	0 436							
3,9	1 468	1 594	1 224	0 323							
4,0	0 427	2 193	0 868	0 287							
4,1	1 354	2 113	0 529								
4,2	1 858	2 103	0 849								
4,3	2 148	1 701	1 180								
4,4	2 210	1 480	1 326								
4,5	2 251	1 189	1 473								
4,6	2 255	0 441									
4,7	2 215	0 834									
4,8	2 140	1 301									
4,9	1 566	1 655									
5,0	0 576	1 994									
5,1	1 283	2 113									
5,2	1 753										
5,3	2 138										
5,4	2 201										
5,5	2 246										
	2 256										

⟨56⟩ Intercombinational transitions $s \to p$, parameters λ

$\nu_1 - \nu_0$ \ ν_0	0,5	1,0	1,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,1			0 257	0 414	0 547	0 684	0 821	0 949	1 108	1 119	1 132
0,2			0 533	0 879	1 111	1 137	1 158	1 176	1 190	1 201	1 209
0,3			0 806	1 132	1 160	1 189	1 203	1 213	1 213	1 210	1 201
0,4			1 107	1 170	1 193	1 212	1 210	1 202	1 186	1 169	1 150
0,5		0 984	1 134	1 194	1 208	1 201	1 184	1 157	1 135	1 113	0 966
0,6		1 112	1 161	1 195	1 199	1 156	1 135	1 105	0 883	0 786	
0,7		1 125	1 186	1 167	1 161	1 101	0 890	0 817	0 751	0 902	
0,8		1 138	1 199	1 114	1 101	0 800	0 834	1 115	1 131	1 172	
0,9		1 151	1 162	0 670	0 748	1 110	1 151	1 204	1 241	1 255	
1,0	1 140	1 166	0 626	0 623	1 114	1 183	1 243	1 271	1 286	1 269	
1,1	1 147	1 181	0 339	0 966	1 180	1 247	1 281	1 279	1 265		
1,2	1 153	1 192	0 543	1 150	1 227	1 274	1 271	1 250	1 219		
1,3	1 158	1 175	0 902	1 195	1 247	1 265	1 236	1 206	1 169		
1,4	1 163	0 583	1 120	1 217	1 245	1 232	1 192	1 159	1 125		
1,5	1 169	0 451	1 158	1 215	1 227	1 183	1 147	1 117	0 921		
1,6	1 175	0 887	1 186	1 190	1 195	1 133	1 107	0 922			
1,7	1 180	1 120	1 208	1 151	1 151	1 101	0 817	0 964			
1,8	1 110	1 142	1 213	1 108	1 104	1 101	0 867	1 147			
1,9	0 650	1 158	1 173	0 787	0 872	1 144	1 167	1 226			
2,0	1 124	1 172	0 786	0 764	1 134	1 219	1 265	1 274			
2,1	1 141	1 185	0 410	1 107	1 207	1 278	1 292				
2,2	1 151	1 194	0 569	1 159	1 254	1 292	1 267				
2,3	1 158	1 190	0 934	1 202	1 264	1 269	1 223				
2,4	1 164	1 122	1 132	1 218	1 251	1 224	1 177				
2,5	1 170	0 383	1 166	1 208	1 226	1 171	1 135				
2,6	1 175	0 735	1 194	1 179	1 190	1 127					
2,7	1 179	1 115	1 214	1 141	1 148	1 105					
2,8	1 161	1 142	1 218	1 106	1 105	1 112					
2,9	0 370	1 160	1 178	0 832	0 892	1 156					
3,0	1 111	1 175	0 862	0 818	1 137	1 228					
3,1	1 136	1 187	0 444	1 109	1 214						
3,2	1 149	1 195	0 580	1 159	1 263						
3,3	1 158	1 192	0 946	1 200	1 270						
3,4	1 164	1 144	1 134	1 213	1 253						
3,5	1 170	0 444	1 169	1 200	1 224						
3,6	1 175	0 647	1 197	1 170							
3,7	1 179	1 111	1 217	1 135							
3,8	1 168	1 141	1 220	1 104							
3,9	0 451	1 161	1 181	0 853							
4,0	1 102	1 175	0 907	0 844							
4,1	1 132	1 187	0 464								
4,2	1 148	1 195	0 585								
4,3	1 158	1 193	0 951								
4,4	1 165	1 154	1 136								
4,5	1 170	0 523	1 171								
4,6	1 175	0 594									
4,7	1 178	1 108									
4,8	1 170	1 141									
4,9	0 600	1 161									
5,0	0 958	1 176									
5,1	1 130										
5,2	1 147										
5,3	1 158										
5,4	1 165										
5,5	1 170										

⟨V6⟩ Intercombinational transitions $s \to d$, parameters $A\sqrt{\frac{\Delta E}{R_y}}$

$\nu_1 - \nu_0$ \ ν_0	0,5	I,0	I,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,I					0 342	0 I32	0 I5I	0 I50	0 I50	0 I46	0 I42
0,2					0 947	0 45I	0 477	0 443	0 420	0 386	0 354
0,3					I I54	0 882	0 859	0 740	0 655	0 56I	0 482
0,4					I I98	I I32	I II7	0 927	0 756	0 595	0 47I
0,5				I 849	I 2I8	I I65	I I3I	0 940	0 698	0 498	0 36I
0,6				I 89I	I 258	I I78	I I23	0 783	0 527	0 338	
0,7				I 869	I 267	I I66	0 986	0 556	0 327	0 I90	
0,8				I 785	I 240	I I33	0 648	0 322	0 I7I	-I 269	
0,9				I 65I	I I85	0 886	0 348	0 I63	-I 905	-I 606	
I,0			2 I89	I 485	I II7	0 474	0 I76	-I 977	-I 760	-I 66I	
I,I			2 I52	I 385	0 597	0 220	0 I4I	0 I06	0 II5		
I,2			2 II9	I 252	0 324	0 I50	0 206	0 I78	0 I92		
I,3			I 890	I II8	0 3I6	0 2I7	0 352	0 285	0 266		
I,4			I 6I9	0 4I2	0 470	0 404	0 59I	0 374	0 303		
I,5		I 674	I 385	0 387	0 754	0 655	0 636	0 404	0 290		
I,6		I 57I	I 222	0 8I5	I I08	0 865	0 653	0 369			
I,7		I 46I	I I03	I I63	I I32	0 949	0 564	0 289			
I,8		I 344	0 204	I 264	I I37	0 876	0 4II	0 I96			
I,9		I 226	0 3I6	I 346	I I2I	0 677	0 258	0 I2I			
2,0	I 32I	I I2I	I II7	I 377	0 899	0 433	0 I55	-I 802			
2,I	I 2I3	0 600	I 223	I 346	0 552	0 237	0 I23				
2,2	I I48	0 I80	I 336	I 263	0 344	0 I4I	0 I55				
2,3	I I0I	-I 256	I 423	I I53	0 296	0 I42	0 252				
2,4	0 65I	0 I32	I 456	0 64I	0 364	0 24I	0 372				
2,5	0 360	0 480	I 42I	0 36I	0 532	0 422	0 460				
2,6	0 I8I	0 998	I 32I	0 580	0 760	0 609					
2,7	-I 429	I I53	I I84	I II9	0 956	0 720					
2,8	-2 789	I I90	0 6I3	I 208	I I03	0 7I0					
2,9	0 I09	I I93	0 I97	I 293	0 955	0 588					
3,0	0 373	I I56	0 6I9	I 339	0 756	0 406					
3,I	0 497	0 965	I I46	I 329	0 503						
3,2	0 597	0 477	I 258	I 265	0 339						
3,3	0 644	0 II8	I 365	I I67	0 289						
3,4	0 6I3	-I 422	I 43I	0 768	0 329						
3,5	0 496	0 227	I 43I	0 383	0 450						
3,6	0 3I8	0 670	I 356	0 509							
3,7	0 I32	I I24	I 229	I I02							
3,8	-I I47	I I74	0 94I	I I84							
3,9	-I 394	I I94	0 230	I 269							
4,0	0 25I	I I7I	0 436	I 32I							
4,I	0 395	I I20	I II2								
4,2	0 532	0 672	I 2I9								
4,3	0 625	0 235	I 333								
4,4	0 64I	-I 424	I 4I6								
4,5	0 560	0 I36	I 435								
4,6	0 395	0 509									
4,7	0 I95	I I07									
4,8	-I 39I	I I63									
4,9	-I I86	I I93									
5,0	0 I92	I I79									
5,I	0 338										
5,2	0 489										
5,3	0 606										
5,4	0 650										
5,5	0 594										

⟨v6⟩ Intercombination transitions $S \to a$, parameters λ

$\nu_1 - \nu_0$ \ ν_0	0,5	1,0	1,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,1					1 596						
0,2					0 266	0 144	0 198	0 272	0 338	0 412	0 486
0,3					0 524	0 477	0 614	0 809	0 964	1 114	1 130
0,4					0 827	0 869	1 108	1 139	1 160	1 184	1 201
0,5				0 622	1 116	1 128	1 156	1 192	1 210	1 230	1 237
0,6				0 813	1 151	1 168	1 198	1 229	1 235	1 242	1 231
0,7				1 102	1 185	1 202	1 228	1 242	1 233	1 220	
0,8				1 125	1 210	1 225	1 239	1 227	1 201	1 172	
0,9				1 150	1 215	1 232	1 221	1 185	1 150	1 123	
1,0			1 111	1 180	1 188	1 215	1 170	1 131	1 109	1 103	
1,1			1 127	1 209	1 122	1 167	1 111	1 100	1 112	1 137	
1,2			1 142	1 224	0 693	1 105	0 950	1 128	1 170		
1,3			1 158	1 176	0 641	0 812	1 127	1 194	1 198		
1,4			1 176	0 678	0 890	1 111	1 183	1 262	1 278		
1,5		1 148	1 196	0 419	1 131	1 172	1 234	1 294	1 275		
1,6		1 156	1 217	0 627	1 177	1 225	1 267	1 282	1 256		
1,7		1 164	1 213	0 959	1 214	1 255	1 277	1 266			
1,8		1 172	0 707	1 130	1 231	1 263	1 263	1 225			
1,9		1 183	0 493	1 164	1 225	1 251	1 228	1 178			
2,0	1 171	1 196	0 887	1 196	1 193	1 223	1 176	1 135			
2,1	1 176	1 210	1 119	1 225	1 137	1 127	1 128	1 110			
2,2	1 179	1 198	1 144	1 239	0 913	0 936	1 111				
2,3	1 182	0 484	1 165	1 209	0 794	1 105	1 138				
2,4	1 186	0 854	1 184	1 115	0 966	1 166	1 195				
2,5	1 192	1 126	1 202	0 528	1 135	1 232	1 249				
2,6	1 200	1 149	1 220	0 613	1 182	1 268	1 282				
2,7	1 188	1 164	1 227	0 941	1 218	1 272					
2,8	0 557	1 176	1 162	1 132	1 233	1 255					
2,9	1 137	1 187	0 474	1 170	1 293	1 224					
3,0	1 163	1 198	0 734	1 204	1 190	1 181					
3,1	1 173	1 209	1 111	1 232	0 939						
3,2	1 178	1 212	1 142	1 245	0 991						
3,3	1 183	1 152	1 167	1 221	0 871						
3,4	1 188	0 508	1 187	1 137	1 101						
3,5	1 193	1 103	1 205	0 626	1 136						
3,6	1 198	1 141	1 221	0 620							
3,7	1 200	1 163	1 230	0 931							
3,8	1 108	1 177	1 191	1 133							
3,9	1 103	1 189	0 636	1 172							
4,0	1 157	1 199	0 650	1 207							
4,1	1 170	1 209	1 105								
4,2	1 178	1 213	1 140								
4,3	1 183	1 185	1 167								
4,4	1 188	0 593	1 189								
4,5	1 193	0 851	1 207								
4,6	1 198	1 134									
4,7	1 200	1 161									
4,8	1 158	1 177									
4,9	0 746	1 190									
5,0	1 151	1 200									
5,1	1 168										
5,2	1 177										
5,3	1 183										
5,4	1 188										
5,5	1 193										

⟨v6⟩ Intercombinational transitions $p \to S$, parameters $A\sqrt{\frac{\Delta E}{R_y}}$

$\nu_1 - \nu_0$ \ ν_1	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5	6,0
4,5									2 183
4,4									2 115
4,3									1 694
4,2									1 393
4,1									1 203
4,0								1 306	0 917
3,9								1 140	0 476
3,8								0 751	0 229
3,7								0 481	0 154
3,6								0 389	0 198
3,5							2 175	0 331	0 323
3,4							2 110	0 406	0 471
3,3							1 671	0 498	0 580
3,2							1 383	0 576	0 613
3,1							1 200	0 597	0 560
3,0						1 328	0 924	0 533	0 423
2,9						1 148	0 487	0 374	0 319
2,8						0 766	0 239	0 244	0 194
2,7						0 476	0 160	0 165	0 105
2,6						0 371	0 204	0 132	-1 692
2,5					2 163	0 357	0 339	0 129	-1 735
2,4					2 104	0 467	0 503	0 150	0 104
2,3					1 642	0 581	0 629	0 192	0 128
2,2					1 370	0 683	0 672	0 243	0 189
2,1					1 196	0 694	0 621	0 283	0 210
2,0				1 354	0 934	0 604	0 497	0 284	0 203
1,9				1 156	0 500	0 418	0 357	0 234	0 176
1,8				0 773	0 251	0 266	0 216	0 166	0 129
1,7				0 463	0 170	0 175	0 118	0 106	-1 791
1,6				0 383	0 224	0 141	-1 821	-1 724	-1 462
1,5			2 147	0 428	0 393	0 153	-1 950	-1 641	-1 386
1,4			1 922	0 617	0 603	0 207	0 146	-1 762	-1 503
1,3			1 603	0 805	0 769	0 296	0 221	0 107	-1 763
1,2			1 355	0 908	0 829	0 387	0 293	0 152	0 110
1,1			1 191	0 872	0 765	0 438	0 331	0 195	0 141
1,0		1 371	0 927	0 705	0 602	0 416	0 320	0 214	0 157
0,9		1 154	0 490	0 455	0 405	0 317	0 262	0 193	0 151
0,8		0 666	0 248	0 264	0 226	0 199	0 172	0 141	0 117
0,7		0 427	0 190	0 171	0 126	0 114	-1 947	-1 838	-1 714
0,6		0 531	0 345	0 178	0 120	-1 908	-1 653	-1 541	-1 490
0,5	2 124	0 843	0 721	0 326	0 229	0 134	-1 934	-1 645	-1 465
0,4	1 862	1 133	1 115	0 618	0 464	0 278	0 202	0 131	1 962
0,3	1 554	1 160	1 140	0 914	0 730	0 499	0 389	0 275	0 213
0,2	1 305	1 144	1 128	0 979	0 831	0 648	0 543	0 430	0 358
0,1	1 115	0 802	0 739	0 629	0 565	0 489	0 438	0 383	0 344

(V6) Intercombinational transitions $p \rightarrow s$, parameters x

ν_1 / $\nu_1 - \nu_0$	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5	6,0
4,5									I 196
4,4									I 196
4,3									I 194
4,2									I 189
4,1									I 180
4,0									I 160
3,9								0 557	I 130
3,8								0 445	0 953
3,7								0 392	0 815
3,6								0 403	I 107
3,5								0 501	I 154
3,4							I 195	0 735	I 197
3,3							I 194	I 115	I 229
3,2							I 191	I 169	I 255
3,1							I 185	I 221	I 274
3,0							I 174	I 246	I 285
2,9						0 555	I 154	I 239	I 274
2,8						0 436	I 124	I 207	I 232
2,7						0 373	0 913	I 162	I 162
2,6						0 376	0 789	I 123	I 110
2,5						0 485	I 106	I 104	I 104
2,4					I 192	0 768	I 157	I 106	I 126
2,3					I 180	I 124	I 202	I 130	I 161
2,2					I 186	I 180	I 234	I 174	I 198
2,1					I 177	I 224	I 257	I 227	I 236
2,0					I 163	I 239	I 271	I 273	I 271
1,9				0 538	I 141	I 223	I 273	I 295	I 289
1,8				0 410	I 111	I 187	I 253	I 290	I 274
1,7				0 335	0 817	I 142	I 207	I 249	I 211
1,6				0 330	0 725	I 106	I 143	I 182	I 130
1,5			I 185	0 471	I 104	0 918	I 104	I 126	0 939
1,4			I 180	0 856	I 162	I 102	I 108	I 104	I 100
1,3			I 171	I 141	I 210	I 140	I 141	I 115	I 128
1,2			I 157	I 192	I 239	I 195	I 185	I 150	I 168
1,1			I 138	I 217	I 251	I 245	I 226	I 199	I 213
1,0			I 111	I 209	I 249	I 273	I 259	I 247	I 256
0,9		0 460	I 798	I 177	I 229	I 270	I 277	I 280	I 279
0,8		0 318	0 551	I 133	I 188	I 236	I 265	I 285	I 261
0,7		0 231	0 547	0 899	I 132	I 173	I 213	I 244	I 184
0,6		0 249	I 109	0 646	0 867	I 108	I 135	I 160	I 102
0,5	I 154	0 605	I 180	0 711	0 826	I 816	0 878	0 947	0 855
0,4	I 134	I 127	I 204	I 123	I 132	I 104	I 101	0 897	I 125
0,3	I 109	I 166	I 183	I 184	I 192	I 165	I 158	I 136	I 189
0,2	0 773	I 198	I 134	I 200	I 211	I 210	I 208	I 198	I 213
0,1	0 380	I 113	0 674	I 160	I 175	I 193	I 202	I 211	I 142
		0 551		0 827	0 945	I 108	I 119	I 132	

⟨v 6⟩ Intercombinational transitions $p \to p$, parameters $A\sqrt{\frac{\Delta E}{Ry}}$

$\nu_1 - \nu_0$ \ ν_0	1,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,1	1 431	1 103	1 109	1 116	1 112	1 110	1 105	1 101	0 863
0,2	2 136	1 361	1 343	1 346	1 315	1 297	1 271	1 252	1 231
0,3	2 244	1 697	1 610	1 586	1 506	1 461	1 404	1 365	1 324
0,4	2 346	2 102	1 836	1 763	1 627	1 550	1 465	1 407	1 350
0,5	2 426	2 127	1 966	1 833	1 652	1 550	1 447	1 380	1 318
0,6	2 573	2 136	1 972	1 783	1 584	1 472	1 370	1 305	
0,7	2 666	2 127	1 861	1 637	1 452	1 347	1 262	1 209	
0,8	2 768	2 104	1 666	1 442	1 299	1 214	1 156	1 119	
0,9	2 768	1 797	1 441	1 257	1 163	1 109	0 767	0 555	
1,0	2 688	1 391	1 239	1 125	0 764	0 534	0 362	0 281	
1,1	2 301	1 137	0 346	0 653	0 442	0 406	0 308		
1,2	2 166	1 144	0 687	1 105	0 690	0 733	0 531		
1,3	1 309	1 296	1 146	1 199	1 126	1 126	0 883		
1,4	1 446	1 523	1 267	1 304	1 187	1 173	1 118		
1,5	2 144	1 756	1 388	1 379	1 228	1 138	1 133		
1,6	2 317	1 913	1 470	1 337	1 235	1 190			
1,7	2 536	1 936	1 487	1 352	1 206	1 154			
1,8	2 753	1 816	1 436	1 262	1 154	1 104			
1,9	2 910	1 598	1 334	1 164	0 972	0 593			
2,0	2 961	1 332	1 215	0 993	0 527	0 361			
2,1	2 420	1 136	0 806	0 599	0 342				
2,2	2 271	1 143	0 472	0 904	0 435				
2,3	2 125	1 280	0 858	1 163	0 764				
2,4	1 247	1 491	1 168	1 247	1 116				
2,5	1 899	1 714	1 267	1 312	1 149				
2,6	2 250	1 869	1 348	1 330					
2,7	2 496	1 896	1 387	1 295					
2,8	2 778	1 780	1 372	1 221					
2,9	3 102	1 568	1 311	1 138					
3,0	3 116	1 309	1 223	0 804					
3,1	2 509	1 134	0 774						
3,2	2 351	1 146	0 389						
3,3	2 195	1 284	0 598						
3,4	1 348	1 487	1 124						
3,5	1 661	1 722	1 210						
3,6	2 215	1 878							
3,7	2 474	1 902							
3,8	2 799	1 781							
3,9	3 111	1 561							
4,0	3 132	1 298							
4,1	2 578								
4,2	2 414								
4,3	2 248								
4,4	1 587								
4,5	1 533								

⟨ν6⟩ Intercombinational transitions $p \to p$, parameters χ

$\nu_1 - \nu_0$ \ ν_0	1,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5
0,1	-1 125	1 125	-1 125	-1 182	-1 413	-1 603	-1 810	-1 986	0 117
0,2	-1 125	1 298	-1 825	0 118	0 160	0 189	0 223	0 246	0 274
0,3	-1 309	1 881	0 167	0 211	0 267	0 294	0 335	0 351	0 379
0,4	-1 657	0 150	0 253	0 296	0 362	0 379	0 420	0 420	0 444
0,5	0 100	0 222	0 342	0 382	0 447	0 447	0 483	0 464	0 484
0,6	0 136	0 307	0 435	0 469	0 529	0 507	0 536	0 495	
0,7	0 172	0 422	0 536	0 572	0 613	0 569	0 587	0 523	
0,8	0 210	0 587	0 649	0 724	0 711	0 662	0 653	0 574	
0,9	0 250	0 916	0 781	1 102	0 854	0 888	0 791	0 753	
1,0	0 282	1 127	0 927	1 148	1 113	1 151	1 128	1 155	
1,1	0 733	0 401	1 106	0 621	1 103	0 815	1 116		
1,2	1 155	0 117	0 366	0 370	0 595	0 523	0 690		
1,3	0 367	0 149	0 356	0 387	0 560	0 487	0 598		
1,4	-1 189	0 218	0 426	0 434	0 576	0 486	0 573		
1,5	-1 693	0 300	0 499	0 485	0 603	0 492	0 566		
1,6	0 124	0 396	0 566	0 540	0 634	0 503			
1,7	0 174	0 520	0 624	0 611	0 665	0 525			
1,8	0 219	0 709	0 668	0 729	0 696	0 583			
1,9	0 258	1 105	0 625	1 100	0 726	0 789			
2,0	0 283	1 136	0 654	1 154	0 785	1 156			
2,1	0 619	0 481	1 126	0 834	1 154				
2,2	1 107	0 169	0 647	0 482	0 922				
2,3	1 202	0 189	0 478	0 454	0 723				
2,4	-1 539	0 256	0 514	0 477	0 677				
2,5	-1 575	0 338	0 569	0 509	0 665				
2,6	0 118	0 433	0 615	0 548					
2,7	0 175	0 555	0 645	0 601					
2,8	0 223	0 741	0 652	0 700					
2,9	0 263	1 108	0 624	0 958					
3,0	0 296	1 140	0 546	1 156					
3,1	0 573	0 503	1 106						
3,2	0 905	0 183	0 795						
3,3	1 187	0 211	0 556						
3,4	0 333	0 278	0 567						
3,5	-1 521	0 358	0 609						
3,6	0 113	0 451							
3,7	0 174	0 570							
3,8	0 225	0 751							
3,9	0 266	1 109							
4,0	0 298	1 142							
4,1	0 549								
4,2	0 822								
4,3	1 160								
4,4	0 881								
4,5	-1 510								

⟨ν6⟩ Intercombinational transitions $d \to s$, parameters $A\sqrt{\frac{\Delta E}{R_y}}$

$\nu_1 - \nu_0$ \ ν_1	3,0	3,5	4,0	4,5	5,0	5,5	6,0
3,5							I 216
3,4							I 162
3,3							I 116
3,2							0 787
3,1						I 253	0 478
3,0						I 129	0 242
2,9						0 648	0 170
2,8						0 330	0 115
2,7						0 179	-I 886
2,6					I 171	0 122	-I 893
2,5					I 133	0 164	0 119
2,4					0 983	0 244	0 172
2,3					0 680	0 308	0 230
2,2					0 433	0 319	0 269
2,1				I 241	0 244	0 283	0 269
2,0				I 123	0 175	0 224	0 223
1,9				0 613	0 121	0 165	0 177
1,8				0 305	-I 938	0 120	0 126
1,7				0 164	-I 958	-I 961	-I 877
1,6			I 120	0 127	0 134	-I 954	-I 701
1,5			I 101	0 192	0 201	0 126	-I 743
1,4			0 791	0 287	0 271	0 182	0 101
1,3			0 574	0 347	0 310	0 233	0 147
1,2			0 381	0 341	0 299	0 248	0 191
1,1		I 178	0 231	0 283	0 242	0 220	0 211
1,0		0 882	0 163	0 207	0 175	0 167	0 193
0,9		0 420	0 112	0 142	0 115	0 112	0 151
0,8		0 202	-I 896	0 101	-I 828	-I 780	0 102
0,7		0 133	0 116	-I 986	-I 845	-I 721	-I 680
0,6	0 843	0 177	0 206	0 158	0 141	0 110	-I 604
0,5	0 782	0 292	0 316	0 267	0 243	0 198	-I 907
0,4	0 596	0 341	0 356	0 332	0 313	0 277	0 168
0,3	0 344	0 267	0 279	0 277	0 270	0 255	0 248
0,2	0 114	0 114	0 120	0 123	0 123	0 121	0 241
0,1							0 119

⟨v6⟩ Intercombinational transitions $d - s$, parameters χ

ν_1 / $\nu - \nu_1$	3,0	3,5	4,0	4,5	5,0	5,5	6,0
3,5							I 197
3,4							I 200
3,3							I 198
3,2							I 189
3,1							I 171
3,0						0 870	I 139
2,9						0 740	I 118
2,8						0 623	0 988
2,7						0 538	0 907
2,6						0 507	I 104
2,5					I 171	0 640	I 146
2,4					I 177	I 119	I 203
2,3					I 175	I 194	I 252
2,2					I 167	I 231	I 277
2,1					I 150	I 226	I 279
2,0				0 758	I 125	I 198	I 259
1,9				0 627	I 104	I 161	I 225
1,8				0 511	0 853	I 127	I 181
1,7				0 427	0 776	I 102	I 143
1,6				0 402	0 913	0 925	I 125
1,5			I 129	0 596	I 136	I 106	I 137
1,4			I 140	I 121	I 195	I 158	I 182
1,3			I 141	I 186	I 238	I 226	I 239
1,2			I 132	I 202	I 249	I 268	I 279
1,1			I 114	I 179	I 229	I 267	I 288
1,0		0 513	0 909	I 139	I 190	I 231	I 266
0,9		0 363	0 682	I 100	I 142	I 176	I 215
0,8		0 279	0 513	0 709	I 100	I 122	I 153
0,7		0 209	0 462	0 548	0 770	0 876	I 106
0,6		0 271	0 725	0 617	0 843	0 837	0 949
0,5	0 859	0 733	I 131	I 113	I 139	I 127	I 135
0,4	0 952	I 122	I 164	I 171	I 196	I 195	I 204
0,3	0 794	I 112	I 141	I 164	I 188	I 204	I 219
0,2	0 479	0 664	0 846	I 103	I 120	I 138	I 154
0,1	0 148	0 208	0 281	0 352	0 425	0 503	0 580

Effective ion excitation cross-sections ($Z \geq 3$).
parameters C, φ, A, X

Переход	C	φ	A	X
1s - 2s	I 267	I I07	I 506	0 840
3s	I 2I3	I I03	I 407	0 860
4s	I 206	I I08	I 40I	0 870
2s - 3s	I 256	I I09	I 488	0 870
4s	I I6I	I I05	I 3I8	0 890
3s - 4s	I 260	I I06	I 509	0 890
1s - 2p	2 467	I 50I	2 200	0 260
3p	2 346	I 435	2 I60	0 300
4p	2 289	I 4I6	2 I48	0 3I0
2s - 3p	2 I77	I 875	I 434	0 I70
4p	2 II9	I 799	I 3I7	0 I80
3s - 4p	2 I03	I 934	I 228	0 I50
1s - 3d	I I73	I 3I0	I I23	0 370
4d	I 202	I 287	I I47	0 364
2s - 3d	I 740	I I60	I 950	0 640
4d	I 3I5	I I33	I 495	0 760
3s - 4d	I 450	I I78	I 486	0 580
1s - 4f	-I 3I3	I I88	-I 343	0 5I0
2s - 4f	I I66	I I25	I 276	0 790
3s - 4f	I 349	0 950	I 522	0 980
2p - 3s	I I50	I 539	0 567	0 260
4s	0 843	I 343	0 507	0 360
3p - 4s	I I88	I 6II	0 598	0 230
2p - 3p	I 826	I II6	2 I44	0 780
4p	I 52I	I II0	I 952	0 800
3p - 4p	I 902	I I2I	2 I5I	0 760
2p - 3d	2 923	I 383	2 499	0 340
4d	2 458	I 307	2 3I0	0 4I0
3p - 4d	2 443	I 507	2 I80	0 290
2p - 4f	I 684	I 242	I 583	0 450
3p - 4f	2 I49	I I4I	2 2I3	0 720
3d - 4s	0 274	I I24	0 436	0 790
3d - 4p	I I77	I 265	I I40	0 470
3d - 4d	2 I24	I I09	2 227	0 820
3d - 4f	3 I34	I 308	2 883	0 430

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