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EXCITATION AND IONIZATION CROSS SECTIONS FOR HE I FROM NORMALIZED BORN AND K-MATRIX CALCULATIONS: $\Delta S = 0$ TRANSITIONS FROM $n = 2, 3$ EXCITED STATES

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Two approximate methods, K-matrix (91 channels) and Normalized Born (13 channels), are discussed and applied to the calculation of excitation cross sections and rate coefficients for transitions from excited states $n = 2, 3$ to states with $n' = 2, 3, 4$ in He atoms. The ionization cross sections are also calculated by the Normalized Born method. Cross sections and rate coefficients for transitions from $n = 2$ are compared with those obtained by the simple Born and the more sophisticated convergent close-coupling method.

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CONTENTS

INTRODUCTION

Neutral helium is of interest for many diagnostic applications in laboratory and astrophysical plasmas. Its unique characteristics, such as high ionization potential and excitation energies, make it a very useful tool for spectroscopic studies of plasmas in tokamaks, various pulsed power devices, the solar photosphere, etc. It is, therefore, not surprising that there are many theoretical and experimental papers devoted to excitation and ionization of He atoms (see, for example, [1–5] and references therein). However, these publications do not cover all needs (transitions, energy range) for atomic databases in diagnostic codes.

There are two types of methods for the calculation of excitation and ionization of atoms and ions by electrons.

A. Sophisticated close-coupling type methods, such as R-matrix [6] and convergent close-coupling (CCC) calculations [7]. Although they usually provide sufficiently accurate results, most of the R-matrix calculations are, however, limited to the "low-energy region" below the

ionization threshold (see, for example, [8]). The more recent applications of these methods—R-matrix with pseudostates (RMPS) [9] and CCC [2]—have been successfully employed in intermediate and in low-energy regions. These two methods are rather different in their approach, but both explore an expansion over square integrable functions (which are not the wave functions of an isolated atom) to account for a contribution of the high-n and continuum channels.

Calculations for e-He scattering [3, 4] show generally good agreement between the available experimental data for the excitation from the ground state and the theoretical RMPS and CCC results. However, there are important discrepancies for transitions from the metastable states.

B. Rather simple Born (B) type (first-order) methods with possible account for exchange and normalization (N). For ions the Coulomb field is also included (Coulomb–Born).

Generally, the cross sections obtained by the A-methods are more accurate. However, these sophisticated methods need significant computer resources and can encounter difficulties when expanded to transitions between higher excited states. Fast calculations with the A-methods for the many transitions required for atomic databases in diagnostic codes are as yet hardly feasible. Therefore, the use of the B-methods is still a necessity.

The B-methods are generally valid in the high-energy region. Unfortunately, at the low and intermediate energies the accuracy of calculations has been insufficient. To create realistic databases it is important to understand the physical reasons behind possible errors and to develop sufficiently simple ways of making reliable corrections. One very efficient approach is the use of the K-matrix method [10]. It is based on the first-order B-method calculation of the matrix **K** for a given set of transitions.

Usually the full matrix **K** (for p channels) is used. We prefer a different approach, namely, keep only the elements responsible for the physical effects at hand. In particular, we omit the diagonal elements since they correspond to the distorted-wave approach (rather than Born), that is, describe an attraction of the external electron to the atom which is more than compensated for by atom polarization (see [11, Section 3.2.1] for more details). To describe the normalization effects we omit all the elements responsible for channel interaction. Exchange was included but its contribution is small for the transitions considered here. The method used is outlined in the next section.

The B-methods and full K-matrix approach are implemented in the coupled programs ATOM-AKM [12, 13]. They can run on PC-486 or higher and require less than 10 minutes of computer time for 10 channels (transitions) with 10–20 energy points.

In this paper we present results of calculations of excitation and ionization cross sections from He I singly excited states (nl, $n = 2, 3$ without change of spin). Calculated cross sections, σ, and rate coefficients $\langle v\sigma\rangle$, as well as the adjusted parameters for fitting formulas, are presented in Tables I and II. Comparisons of σ and $\langle v\sigma\rangle$ obtained by two A-methods and two B-methods for transitions from $2s$ and $2p$ states are shown in Figure Sets I and II.

Throughout this paper, units used are Ry = 13.60 eV for energy and $\pi a_0^2 = 0.8797 \times 10^{-16}\text{cm}^2$ for cross sections. We also use the abbreviated notation

$$[j_1 j_2 \ldots] = [(2j_1 + 1)(2j_2 + 1)\ldots]^{1/2}.$$

Calculation Methods

The Born and K-matrix Methods

The cross section for the collisional transition a_0–a_1 in the Born (or any first-order) approximation can be written in the form [11]

$$\sigma(a_0 - a_1) = \sum_\kappa [Q'_\kappa(a_0 - a_1)\sigma'_\kappa(n_0 l_0, n_1 l_1) + Q''_\kappa(a_0 - a_1)\sigma''_\kappa(n_0 l_0, n_1 l_1) + Q''_{\kappa+1}(a_0 - a_1)\sigma''_{\kappa+1}(n_0 l_0, n_1 l_1)] \quad (1)$$

with

$$\kappa = \kappa_{\min}, \kappa_{\min} + 2, \ldots, \kappa_{\max}$$

$$\kappa_{\min} = |l_0 - l_1|, \quad \kappa_{\max} = l_0 + l_1.$$

Here $\sigma_\kappa(n_0 l_0, n_1 l_1)$ are the cross sections for the one-electron atom, which depend only on the radial wave functions of the bound and incident electrons. σ'_κ includes direct and mixed terms and σ''_κ is an exchange cross section. $a = a_c(S_c L_c) nlSL$ is the set of target quantum numbers. The dependence on the angular momenta of the core $S_c L_c$ and atom SL is given by the angular factors Q' and Q''. The general formulas are given in [11, 12]. For transitions from the excited states $1snl$ of He considered in the present paper $L_c = 0$ and

$$Q' = \delta(S_0, S_1), \quad Q'' = \frac{2S_1 + 1}{2(2S_c + 1)}. \quad (2)$$

The one-electron cross sections are given by

$$\sigma'_\kappa(n_0 l_0, n_1 l_1) = \sum_{\lambda_0 \lambda_1} \sigma'_\kappa(\lambda_0 \lambda_1) = \frac{4}{[\kappa l_0]^2 \mathscr{C}} \sum_{\lambda_0 \lambda_1} R^d_\kappa (R^d_\kappa - R''_\kappa)\phi \quad (3a)$$

and

$$\sigma''_\kappa(n_0 l_0,\, n_1 l_1) = \sum_{\lambda_0 \lambda_1} \sigma''_\kappa(\lambda_0 \lambda_1) = \frac{4}{[\kappa l_0]^2 \mathscr{E}} \sum_{\lambda_0 \lambda_1} (R''_\kappa)^2 \phi, \tag{3b}$$

where λ_0, λ_1 are orbital angular momenta of the incident and scattered electron, and $\mathscr{E}$ is the incident electron energy. R^d_κ and R''_κ are direct and exchange radial integrals; exchange integrals are calculated by the orthogonalized function method [11, 12]. The correction factor ϕ is defined in Eq. (12) below.

The simplest method for calculating the cross sections $\sigma_\kappa(n_0 l_0,\, n_1 l_1)$ is the Born approximation. An efficient way to improve the Born results is the K-matrix method [10] based on the first-order (Born) matrix **K,** where

$$K(\Gamma_0,\, \Gamma_1) = \langle \Gamma_0 | U | \Gamma_1 \rangle \tag{4}$$

with

$$\Gamma = a \epsilon \lambda S_T L_T, \quad \mathbf{S}_T = \mathbf{S}_0 + \mathbf{s} = \mathbf{S}_1 + \mathbf{s},$$

$$\mathbf{L}_T = \mathbf{L}_0 + \boldsymbol{\lambda}_0 = \mathbf{L}_1 + \boldsymbol{\lambda}_1.$$

Here U is the interaction potential of the incident electron and atom, ϵ is the electron energy ($\epsilon_0 = \mathscr{E}$), and S_T and L_T are the total spin and orbital angular momenta. As mentioned above, the diagonal elements of the matrix **K** are omitted in our calculations.

In the Born approximation

$$\sigma(a_0 - a_1|B) = \sum_{\lambda_0 \lambda_1 S_T L_T} \frac{[S_T L_T]^2}{[S_0 L_0]^2}\, \sigma(\Gamma_0,\, \Gamma_1|B)$$

$$= \frac{2}{\mathscr{E}} \sum_{\lambda_0 \lambda_1 S_T L_T} \left| \frac{[S_T L_T]}{[S_0 L_0]}\, K(\Gamma_0,\, \Gamma_1) \right|^2, \tag{5}$$

and after summation over $S_T L_T$ we obtain Eqs. (1) and (3) with $\phi^B = 1$. The element of the **K**-matrix for the transition $l_c^m l - l_c^m l'$ is

$$K(\Gamma,\, \Gamma') = \sum_\kappa K_\kappa(\Gamma,\, \Gamma'), \tag{6}$$

with

$$K_\kappa\,(\Gamma,\, \Gamma') = (R^d_\kappa - B_{SS'} R''_\kappa)\, A_\kappa(LL'L_T)$$

$$B_{SS'} = [SS'] \begin{Bmatrix} \frac{1}{2} & S & S_T \\ \frac{1}{2} & S' & S_c \end{Bmatrix} (-1)^{1-S-S'}$$

$$A_\kappa(LL'L_T) = C[LL'] \begin{Bmatrix} L & L' & \kappa \\ l' & l & L_c \end{Bmatrix}$$

$$\times \begin{Bmatrix} L & L' & \kappa \\ \lambda' & \lambda & L_T \end{Bmatrix} (-1)^{L_T + L + L' + L_c}$$

and

$$C = \begin{cases} 1 & nl \neq n_c l_c \\ G^{SL}_{S_c L_c} \sqrt{m+1} & nl = n_c l_c \end{cases}.$$

Here, $G^{SL}_{S_c L_c}$ is the fractional parentage coefficient and the expressions in the curly brackets are 6-j symbols, m is the number of the core electrons, and for He I, $m = 1$. If $Q'(L)$ is the orbital part of Q', then

$$A_\kappa(LL'L_T)^2 = C^2 \frac{[L]^2}{[l]^2} \begin{Bmatrix} L & L' & \kappa \\ \lambda' & \lambda & L_T \end{Bmatrix}^2 Q'(L). \tag{7}$$

The Born **K**-matrix is used for calculation of a unitary **S**-matrix according to the matrix equation

$$\mathbf{S}(K) = \frac{\mathbf{I} + i\mathbf{K}}{\mathbf{I} - i\mathbf{K}}, \tag{8}$$

where **I** is the unit matrix. The corrected cross section $\sigma(a_0 - a_1|K)$ is given by

$$\sigma(a_0 - a_1|K) = \frac{1}{\mathscr{E}} \sum_{\lambda_0 \lambda_1 S_T L_T} \frac{[S_T L_T]^2}{2[S_0 L_0]^2}$$

$$\times\, |S(\Gamma_0,\, \Gamma_1|K) - I(\Gamma_0,\, \Gamma_1)|^2. \tag{9}$$

An important feature of the Born (or any first-order) approximation is the possibility of summing over S_T and L_T in analytical form. Due to the nonlinearity of Eq. (8), a numerical summation for the corrected cross section $\sigma(a_0 - a_1|K)$ in Eq. (9) is necessary.

Eqs. (6), (8), and (9) define the K-matrix approach. This approach will be referred to as Kp, where p is the number of channels. If all levels with $n = 2$–5 are included, then p is equal to 91 and the method is referred to as K91.

Normalization and Interaction of Channels

The effect of normalization is related to the unitarity of the S-matrix (conservation of incident particle flux). It can considerably decrease the cross sections of the strong transitions, such as the nl_0–nl_1 ones. Less evident is a similar decrease for all other nl_0–$n'l'$ transitions, in particular for weak ones.

The pure normalization effect for the transitions from a state a_0 can be described by an approximate one-row, one-column **K**-matrix

$$\mathbf{K} = \begin{Bmatrix} 0 & \Gamma_0,\, \Gamma' & \Gamma_0,\, \Gamma'' & \dots \\ \Gamma',\, \Gamma_0 & 0 & 0 & 0 \\ \Gamma'',\, \Gamma_0 & 0 & 0 & 0 \\ \dots & 0 & 0 & 0 \end{Bmatrix}. \tag{10}$$

In this case Eqs. (8) and (9) can be solved, and we obtain

$$\sigma(a_0 - a_1|N) = \sum_{\lambda_0\lambda_1 S_T L_T} \frac{[S_T L_T]^2}{[S_0 L_0]^2} \frac{\sigma(\Gamma_0, \Gamma_1|B)}{[1 + D(\Gamma_0)]^2} \quad (11)$$

with

$$D(\Gamma_0) = \sum_{a'\lambda'} K^2(\Gamma_0, \Gamma').$$

Separation of angular and radial (one-electron) factors in the form of Eq. (1) is possible only with additional approximations. In calculating K^2 (cf. Eq. (6)), we assume that $[\sum_\kappa K_\kappa(\Gamma, \Gamma')]^2$ can be approximately replaced by $\sum_\kappa [K_\kappa(\Gamma, \Gamma')]^2$ (usually only one term provides the main contribution) and average $D(\Gamma_0)$ over S_T. Then the normalized cross section can be expressed in the form of Eqs. (1) and (3) with the normalization correction factor

$$\phi = \phi^N(n_0 l_0, n_1 l_1) = \sum_{L_T} \begin{Bmatrix} L_0 & L_1 & \kappa \\ \lambda' & \lambda_0 & L_T \end{Bmatrix}^2 \frac{1}{[1 + D(L_T)]^2}, \quad (12)$$

wherein

$$D(L_T) = \frac{m}{[\lambda_0 \kappa]^2} \sum_{\kappa a' \lambda'} \begin{Bmatrix} L_0 & L' & \kappa \\ \lambda' & \lambda_0 & L_T \end{Bmatrix}^2 \times [R^d_\kappa (R^d_\kappa - R''_\kappa) + (R''_\kappa)^2].$$

For a He atom we have $L_c = 0$, $L_0 = l_0$, $L_1 = l_1$, and $m = 2$ for $1s^2$, $m = 1$ for $1snl$.

Then the problem is divided into two parts:

i. Calculation of $D(L_T) \equiv D(a_0 \epsilon_0 \lambda_0 L_T)$ for a given a_0 and all $\epsilon_0 \lambda_0 L_T$ and some set of a' (the choice of states a' in the sum depends on the state a_0).

ii. Calculation of $\sigma(a_0 - a_1|N)$ for any a_1 using $D(L_T)$ obtained earlier according to Eqs. (1), (3), and (12).

We call the approximation given by Eq. (11) Normalized Born Nm, where m is the number of states a' included in the sum for D. If all levels with $n = 2$–5 are included, $m = 13$ and the approximation is referred to as N13.

From Eq. (12) one can see the influence of strong transitions on the weak ones due to the sum in D. One important consequence is the normalization effect for all transitions from the excited states.

The effect of normalization is always to decrease the cross sections. The use of the full K-matrix (without diagonal elements) in Eq. (9) provides a more detailed description. In addition to the normalization, it contains a channel coupling, which manifests itself in particular via transitions through intermediate levels: a_0–a'–a_1. An important example is the transition $1s$–$3d$ in H I or He I ($a' = 2p$): here the dipole interaction matrix elements $1s$–$2p$ and $2p$–$3d$ are large, and the direct quadrupole matrix element $1s$–$3d$ is small. The main contribution to $\sigma(1s\text{–}3d|K)$ is given by the two-stage transition $1s$–$2p$–$3d$.

The case of transitions $2l$–nl' ($n > 2$) is more complicated. Here the effect of the two-stage transition is partly compensated for by the normalization effect due to the strong transition $2s$–$2p$ (which is absent for transitions from the $1s$ state). Interference of many channels is important in this case and a drastic change of $\sigma(E)$ dependence is possible.

Ionization Cross Section

For ionization, $Q'_\kappa = Q''_\kappa = Q_i$, and is independent of κ. The total cross section is

$$\sigma = Q_i \sum_{\kappa l} \int_0^{E_m} \sigma_\kappa(a_0 - a) dE, \quad (13)$$

with

$$E_m = \frac{\mathscr{E} - \Delta E}{2}, \quad \Delta E = |E(n_0 l_0)|,$$

where $a = a_i E l$, a_i is a set of the ion quantum numbers, and E and l are the energy and the orbital momentum of the ejected electron. The partial cross section $\sigma_\kappa(a_0 - a)$ may be in the B or N approximation.

Contribution of Partial Waves with Large Orbital Angular Momentum λ

The sum over λ in Eqs. (3) and (9) converges slowly. The contribution of $\lambda > \lambda_m$ not included in a real summation, $\Delta\sigma(a_0 - a_1)$, is calculated in the Born approximation:

$$\Delta\sigma(a_0 - a_1) = \sum_\kappa Q_\kappa [\sigma^b_\kappa(n_0 l_0, n_1 l_1) - \sum_{\lambda_0\lambda_1 \le \lambda_m} \sigma^b_\kappa(\lambda_0 \lambda_1)]. \quad (14)$$

The $\sigma^b_\kappa(\lambda_0\lambda_1)$ are calculated in the same way as $\sigma_\kappa(\lambda_0\lambda_1)$ with the free-particle-without-exchange solutions, and the one-electron Born cross section $\sigma^b_\kappa(n_0 l_0, n_1 l_1)$ may be calculated in the q-representation [11, 12]

$$\sigma^b_\kappa(n_0 l_0, n_1 l_1) = \frac{8}{(2l_0 + 1)\mathscr{E}} \int_{k_0 - k_1}^{k_0 + k_1} |R^b_\kappa(q)|^2 \frac{dq}{q^3} \quad (15)$$

with

$$k_0 = \mathscr{E}^{1/2}, \quad k_1 = (\mathscr{E} - \Delta E)^{1/2},$$
$$\mathbf{q} = \mathbf{k}_0 - \mathbf{k}_1, \quad \Delta E = E_1 - E_0,$$

where k_0, k_1 are wave numbers of incident and scattered electron and ΔE is the threshold energy.

A similar approach is also used in the CCC method to ensure that partial wave sums extend to infinity.

Rate Coefficients and Fitting Formulas

The excitation or ionization rate coefficient is obtained by averaging the cross sections over a Maxwellian energy distribution of electrons,

$$\langle v\sigma\rangle = K \cdot \beta \int_0^\infty (u + \Delta E/\mathrm{Ry}) \times \sigma(u) e^{-\beta u} du \, \exp(-\Delta E/T) \quad (16)$$

with

$$K = \frac{2\sqrt{\pi}\hbar a_0}{m} = 2.172 \times 10^{-8}\ \mathrm{cm^3 s^{-1}},$$
$$u = \frac{\epsilon - \Delta E}{\mathrm{Ry}}, \quad \beta = \mathrm{Ry}/T,$$

where T is the electron temperature in energy units.

The code ATOM calculates the adjusted parameters A, χ, D for the fitting formulas for $\langle v\sigma\rangle$,

$$\langle v\sigma\rangle = \frac{A}{g_0(\beta + \chi)} G(\beta, D) \exp(-\Delta E/T) \times 10^{-8}\ \mathrm{cm^3 s^{-1}}, \quad (17)$$

where $g_0 = (2S_0 + 1)(2L_0 + 1)$ is the statistical weight of the initial state.

For excitation,

$$G(\beta, D) = \beta^{1/2}(\beta + 1 + D)(1 + \Delta E/T)^{-1/2}. \quad (18)$$

For ionization,

$$G(\beta, D) = \beta^{1/2} \frac{\beta + 1 + D}{\beta + 1} (1 + \Delta E/T)^{-1/2}. \quad (19)$$

To estimate the fit quality the values of R are calculated as

$$R(\beta) = \langle v\sigma\rangle / \langle v\sigma_{fit}\rangle. \quad (20)$$

Computed Data

i. Excitation cross sections for the following 30 transitions without spin change,

$$n_0 l_0 - n_1 l_1,\ n_0 = 2, 3,\ n_1 = 2, 3, 4; \quad S = 0, 1,\ \Delta S = 0, \quad (21)$$

were calculated in the Born approximation (B) and in the Normalized Born approximation for 13 channels (N13: $n' = 2$–5, all l'; Eqs. (1), (3), (12).

ii. Ionization cross sections from states $n_0 l_0$ were calculated by the B and N13 approximations.

iii. Excitation cross sections were calculated by the K-matrix method for 91 channels (K91, Eqs. (6), (8), (9). The matrix **K** contained all channels $n'l'$–$n''l''$ for n', $n'' =$ 2–5.

Cross sections σ and rate coefficients $\langle v\sigma\rangle$ obtained by N13 and K91 for the transitions described in (21) are presented in Tables I and II, respectively, for transitions between singlet and triplet states. Also the adjusted parameters for the fitting formulas (17)–(19) are given.

Discussion

Convergent Close-Coupling Method

The CCC method is a computationally very expensive approach for the calculation of electron–atom scattering, but yields results that are expected to be of high accuracy. The CCC theory and its applications to electron impact excitation and ionization of He have been reviewed by Fursa and Bray [3]. Briefly, the primary approximation involves the expansion of the total wave function in a finite set of square-integrable target-space states. These target-space states are obtained by diagonalizing the target Hamiltonian utilizing an orthonormal Laguerre basis. In this way we can be sure that increasing the basis size results in improved "completeness" of the expansion of the total wave function.

The target-space expansion states have both negative and positive energy relative to the He^+ 1*s* core. The former should be an accurate approximation of the true target discrete eigenstates, and the latter provide a quadrature rule for the integration over the true target continuum. The reason for the high accuracy of the CCC method is that it treats both the discrete and the continuous target spectrum simultaneously.

Once the N expansion states have been defined the close-coupling equations are formed, utilizing the partial-wave expansion, and solved in momentum space. Convergence in the results of interest is tested by variation of N. Thus, we typically can estimate the error in the CCC results by their systematic study as a function of N.

In the present calculation made for comparison purposes, a further approximation is employed in the structure

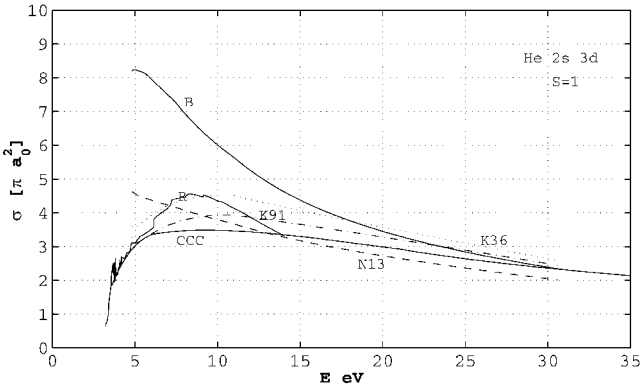

FIG. 1. Excitation cross section for the transition $1s2s\ ^3S–1s3d\ ^3D$. (B, —) Born approximation; (N13, - - -) Normalized Born approximation with 13 transitions ($2 \rightarrow 2$–5); (K91, - · - · -) K-matrix method for 91 channels ($n = 2$–5); (K36, · · ·) K-matrix method for 36 channels ($n = 2$–4); (CCC, —) convergent close coupling method; (R, —) R-matrix method [8].

description of the helium atom. We choose to model all helium states by the frozen-core approximation, where one of the electrons is described by the He^+ $1s$ orbital. This is very convenient and sufficiently accurate for the present purposes. The CCC results have been obtained using a total of 75 expansion states. These include 12 singlet and 11 triplet S-states, and 11, 9, and 6 P-, D-, and F-states both of singlet and triplet type. After comparison with smaller and larger sets of expansion states at selected energies we generally believe the results to be accurate to within 10%. An exception is the excitation of F-states, which are likely to be 20% too high in the intermediate energy range due to the absence of G-states in the close-coupling expansion. Ionization cross sections are calculated in a similar way.

Comparison with Other Methods

In all calculations (except σ(B)) exchange was taken into account. It should be noted that the exchange part is more sensitive to the approximate method than the direct one. A well-known example is the Born–Oppenheimer method, which often overestimates the cross section by a factor of 10 or more. For most transitions considered in the present work, exchange is not important. However, its influence increases for transitions with large Δl. Unfortunately neither available experimental data nor results of the sophisticated calculations are sufficient for drawing final conclusions.

The effect of normalization can be illustrated by the transition $2s$–$3d$ (Fig. 1). Here σ(N13) is much smaller than σ(B) at $E < 25$ eV. The main contribution to the normalization factor D is due to the $2s$–$2p$ transition.

The best illustration of a transition via an intermediate level is the $2s$–$4f$ transition (Figs. 2 and 3). The normalization again decreases the cross section, but both σ(N13) and σ(B) at $E > 7$ eV are much smaller than the K-matrix and CCC results. This effect may be sensitive to the number of levels included in the K-matrix. The cross section σ(K36)

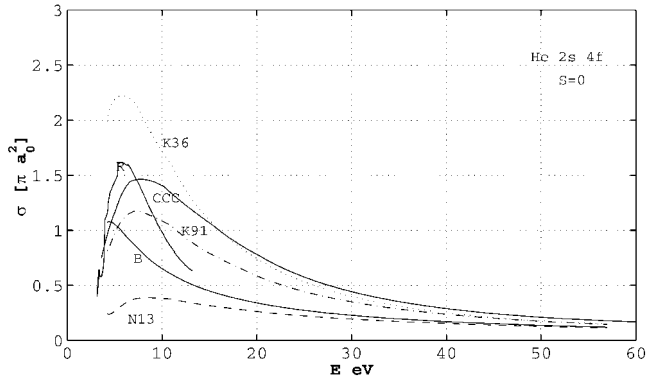

FIG. 3. Excitation cross section for the transition $1s2s\ ^1S–1s4f\ ^1F$. Designations are as in Fig. 1.

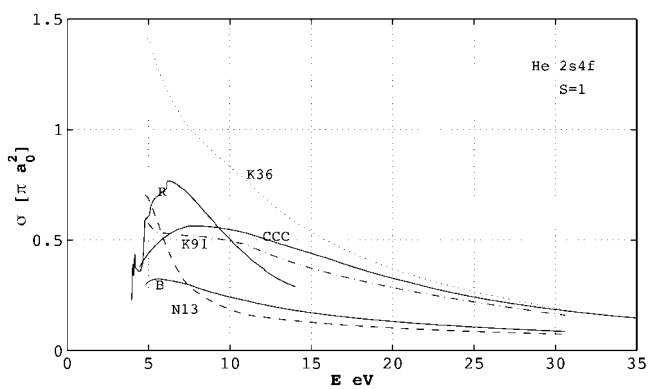

FIG. 2. Excitation cross section for the transition $1s2s\ ^3S–1s4f\ ^3F$. Designations are as in Fig. 1.

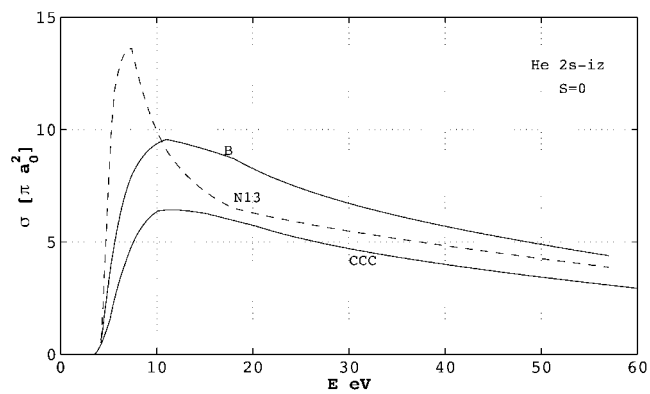

FIG. 4. Ionization cross section from the state $1s2s\ ^1S$. Designations are as in Fig. 1.

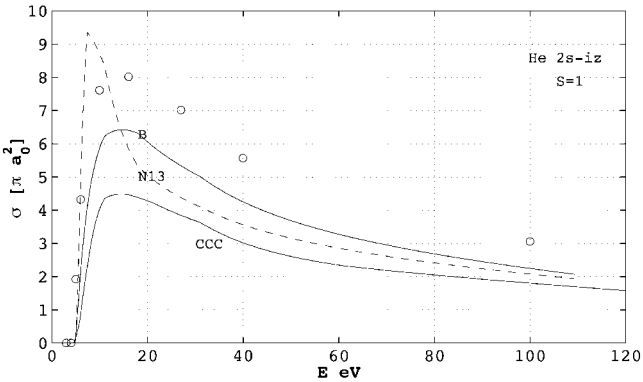

FIG. 5. Ionization cross section from the state $1s2s\ ^3S$. Designations for the theoretical results are as in Fig. 1. Experimental data [14] are represented by circles.

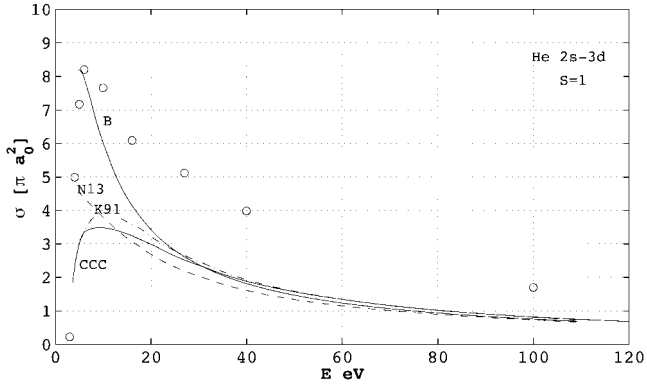

FIG. 7. Excitation cross section for the transition $1s2s\ ^3S$–$1s3d\ ^3D$. Designations for the theoretical results are as in Fig. 1. Experimental data [5, 15, 16] are represented by circles.

was obtained with the K-matrix for 36 channels (all levels within $n = 2, 3, 4$). Addition of the levels with $n = 5$ decreases the cross section, leading to the curve σ(K91); at $E < 7$ eV exchange becomes of crucial importance.

A comparison of σ(K91) with the results obtained by the CCC and R-matrix methods shows that the K-matrix method reflects the effects of the channel coupling (Figs. 1–3). It is worth noting that the influence of the channel interaction is of opposite sign for $2s$–$3d$ and $2s$–$4f$ transitions.

The cross sections for all transitions between states with $n \leq 4$ obtained by the R-matrix method are presented in [8]. They are limited to an electron impact energy interval of about 15 eV. The R-matrix cross sections for the $2s$–$3d$ and $2s$–$4f$ transitions are also given in Figs. 1–3.* The

* We thank Professor K. Berrington for providing the file with numerical R-matrix results.

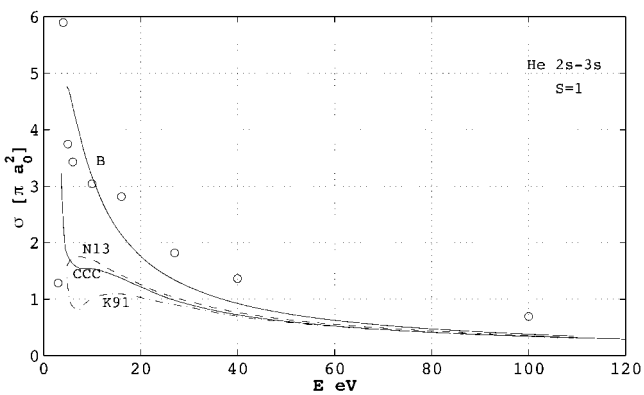

FIG. 6. Excitation cross section for the transition $1s2s\ ^3S$–$1s3s\ ^3S$. Designations for the theoretical results are as in Fig. 1. Experimental data [5, 15, 16] are represented by circles.

difference between the R-matrix and CCC results is somewhat larger than one would expect.

A comparison of the ionization cross sections from the $2s$ states obtained by B, N13, and CCC methods is shown in Figs. 4 and 5 (circles are experimental data [14]—see also below). The large N13 cross section at $E < 10$ eV is caused by exchange. Without normalization this effect is two times stronger.

A comparison of the cross sections σ obtained by the four methods B, N13, K91, and CCC for all transitions from $2s$ and $2p$ states is shown in Figure Sets I and II. Plots for the cross sections are presented for energies up to 60 eV. It was checked that at large energies $E > 100$ eV all methods including CCC give the same results.

Comparison with Experiment

In Refs. [5, 15, 16], measured cross sections for transitions from the metastable He I $1s2s\ ^3S$ state were

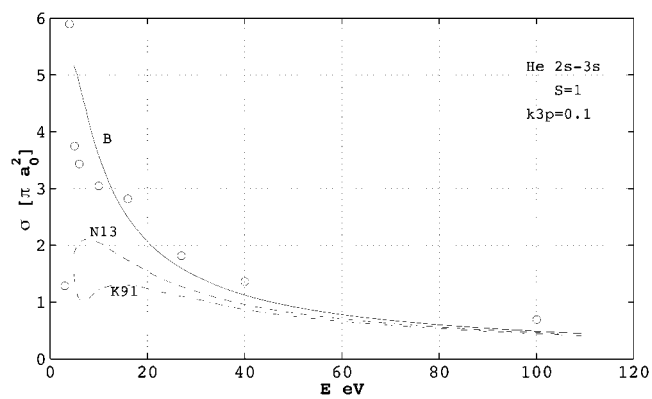

FIG. 8. Same as in Fig. 6, with addition of 10% of atoms in the state $1s2p\ ^3P$ in the calculation.

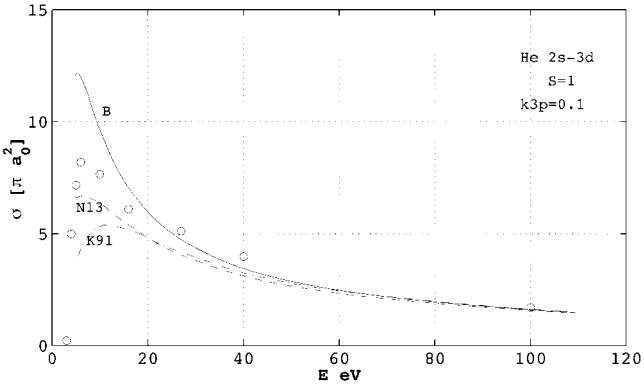

FIG. 9. Same as in Fig. 7, with addition of 10% of atoms in the state $1s2p\ ^3P$ in the calculation.

reported. In [15] charge transfer of a He^+ beam with Cs atoms was used to obtain He metastables, and thus He atoms in the ground state were excluded. This made it possible to measure excitation from the metastables at large incident electron energies (in the validity region of the Born approximation). This is very important for comparison with theory.

In Figs. 6 and 7 the experimental and calculated cross sections are compared for transitions $2s$–$3s$, $3d$, for which the most detailed experimental data have been presented. The measured cross sections are larger than the ones calculated by the CCC and K91 methods for practically all energies. Note that differences up to a factor of 2 occur even at $E > 100$ eV, where all theoretical methods give the same results. In previous experiments [17] even larger cross sections (up to an order of magnitude above theory) were obtained. The measured ionization cross section from the $2s$ state [14] also exceeds the calculated one even at high energies (Fig. 5).

One possible explanation for these observations may be the presence of a small fraction of atoms in the $1s2p\ ^3P$ state. Since excitation cross sections from $1s2p$ are larger than from $1s2s$, this would increase the apparent cross section. In Figs. 8 and 9 we show the results of three calculations with the B, N13, and K91 methods for the $1s2s\ ^3S$–$1s3s\ ^3S$ and $1s2s\ ^3S$–$1s3d\ ^3D$ transitions for a 10% admixture of the $1s2p\ ^3P$ level to the initial state. It is clearly seen that the agreement with the experimental data becomes much better.

Acknowledgments

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EXPLANATION OF TABLES

TABLE I. Electron Impact Cross Sections and Rate Coefficients for Transitions between Singlet States

TABLE II. Electron Impact Cross Sections and Rate Coefficients for Transitions between Triplet States

Cross sections, rate coefficients, parameters for fitting formulas, oscillator strengths, and transition probabilities are given in these tabulations. All calculations are in *SL*-coupling.

Each page of each Table consists of two parts:

N13: results obtained by the Normalized Born method, 13 channels
K91: results obtained by the K-matrix method, 91 channels

The two parts are similarly structured, as follows:

Line 1 gives the method and the transition $n_0 l_0\ SL_0$–$nl\ SL$ with 1*s* of the core electron omitted. Line 2 gives *nl* (as $2p$, $3s\ldots$); *iz* means ionization.

Next are two segments arrayed as follows:

First column	E eV: incident electron energies $\mathscr{E}$ in eV
	T eV: temperatures T in eV
Next columns	cross sections σ in units of $\pi a_0^2 = 0.8797 \times 10^{-16}$ cm^2 rate coefficients $\langle v\sigma\rangle$ in units of 10^{-8} cm^{3}s^{-1}

Below these segments are given the fit parameters:

A, Hi(= χ), Da(= D)	parameters for the $\langle v\sigma\rangle$ fitting formulas Eqs. (17)–(19)
RM	maximum deviation from 1 of $R(\beta) = \langle v\sigma\rangle/\langle v\sigma_{fit}\rangle$

The three lines below the N13 listings give the following for each transition:

E01(= ΔE)	transition energy, binding energy for ionization
f	absorption oscillator strength for dipole transitions
Ar	radiative transition probability in 10^8s^{-1} for dipole transitions

EXPLANATION OF FIGURE SETS

FIGURE SET I. Comparison of Electron Impact Cross Sections and Rate Coefficients for Transitions between Singlet States from Different Calculations

FIGURE SET II. Comparison of Electron Impact Cross Sections and Rate Coefficients for Transitions between Triplet States from Different Calculations

Cross sections and rate coefficients are shown for transitions from the levels $2s$ and $2p$.

The top plot on each page is the cross section in units of πa_0^2 versus incident electron energy E in eV for the transition indicated in the upper right side of each plot. The bottom plot is the rate coefficient in units of 10^{-8}cm^3/s versus electron temperature T in eV for the same transition.
Lines and labels on curves are as follows:

B Born approximation —
N13 Normalized-Born, 13 transitions ($2 \rightarrow 2$–5) - - -
K91 K-matrix, 91 channels ($n = 2$–5) - · - ·
CCC Convergent close coupling —

TABLE I. Electron Impact Cross Sections and Rate Coefficients for Transitions between Singlet States

See page 132 for Explanation of Tables

N13 He I 2s 1S - nl 1L

	2p	3s	3p	3d	4s	4p	4d	4f	iz
E eV									
4.20E+00	2.43E+02	1.73E+00	5.66E-01	4.59E+00	2.97E-01	1.15E-01	6.98E-01	2.44E-01	6.24E-01
4.40E+00	2.39E+02	1.80E+00	6.30E-01	4.88E+00	2.86E-01	9.91E-02	6.27E-01	2.39E-01	2.02E+00
4.80E+00	2.32E+02	1.93E+00	7.88E-01	5.48E+00	2.80E-01	9.59E-02	5.89E-01	2.52E-01	5.75E+00
5.60E+00	2.19E+02	2.18E+00	1.16E+00	6.46E+00	3.08E-01	1.63E-01	6.99E-01	3.07E-01	1.17E+01
7.40E+00	1.94E+02	2.51E+00	1.84E+00	7.47E+00	3.99E-01	3.52E-01	9.87E-01	3.84E-01	1.36E+01
1.10E+01	1.58E+02	2.46E+00	2.49E+00	7.18E+00	4.45E-01	5.53E-01	1.11E+00	3.75E-01	9.09E+00
1.80E+01	1.17E+02	1.94E+00	2.69E+00	5.59E+00	3.68E-01	6.46E-01	9.31E-01	2.85E-01	6.50E+00
3.10E+01	7.99E+01	1.34E+00	2.43E+00	3.77E+00	2.58E-01	6.01E-01	6.49E-01	1.90E-01	5.41E+00
5.80E+01	4.93E+01	8.09E-01	1.88E+00	2.23E+00	1.57E-01	4.70E-01	3.90E-01	1.11E-01	3.82E+00
1.10E+02	2.91E+01	4.61E-01	1.30E+00	1.24E+00	8.97E-02	3.28E-01	2.20E-01	6.11E-02	2.50E+00
2.20E+02	1.61E+01	2.41E-01	8.12E-01	6.36E-01	4.71E-02	2.06E-01	1.14E-01	3.12E-02	1.44E+00
4.40E+02	8.80E+00	1.23E-01	4.86E-01	3.22E-01	2.40E-02	1.23E-01	5.78E-02	1.57E-02	8.01E-01
T eV									
3.40E+00	2.24E+02	1.86E+00	1.37E+00	5.28E+00	3.08E-01	2.92E-01	7.77E-01	2.69E-01	6.87E+00
6.80E+00	2.47E+02	2.94E+00	3.04E+00	8.45E+00	5.16E-01	6.88E-01	1.29E+00	4.32E-01	1.12E+01
1.36E+01	2.45E+02	3.49E+00	4.80E+00	9.98E+00	6.41E-01	1.14E+00	1.61E+00	5.08E-01	1.36E+01
2.72E+01	2.24E+02	3.46E+00	6.08E+00	9.75E+00	6.52E-01	1.49E+00	1.63E+00	4.92E-01	1.45E+01
5.44E+01	1.93E+02	3.05E+00	6.64E+00	8.44E+00	5.84E-01	1.65E+00	1.45E+00	4.22E-01	1.41E+01
1.09E+02	1.60E+02	2.49E+00	6.54E+00	6.77E+00	4.81E-01	1.64E+00	1.18E+00	3.36E-01	1.28E+01
2.18E+02	1.28E+02	1.93E+00	6.01E+00	5.17E+00	3.75E-01	1.52E+00	9.15E-01	2.55E-01	1.09E+01
A	7.74E+01	1.03E+00	6.29E-01	2.99E+00	2.97E-01	1.65E-01	7.91E-01	2.94E-01	7.22E+01
Hi	6.69E-01	9.53E-01	1.97E-01	1.16E+00	8.41E-01	2.10E-01	8.75E-01	1.16E+00	2.92E+00
Da	3.60E+00	6.50E+00	9.00E+00	7.40E+00	3.50E+00	9.00E+00	3.30E+00	3.20E+00	7.00E-01
RM	4.52E-02	2.40E-02	1.34E-01	1.80E-02	2.21E-02	8.58E-02	1.58E-02	1.42E-02	3.67E-01
E01	5.62E-01	2.30E+00	2.46E+00	2.46E+00	3.06E+00	3.12E+00	3.12E+00	3.12E+00	3.97E+00
f	3.44E-01	0.00E+00	1.68E-01	0.00E+00	0.00E+00	5.32E-02	0.00E+00	0.00E+00	0.00E+00
Ar	4.72E-02	0.00E+00	4.41E-01	0.00E+00	0.00E+00	2.25E-01	0.00E+00	0.00E+00	0.00E+00

K91 He I 2s 1S - nl 1L

	2p	3s	3p	3d	4s	4p	4d	4f
E eV								
4.20E+00	2.51E+02	8.53E-01	1.29E+00	6.68E+00	4.28E-01	3.04E-01	1.74E+00	8.12E-01
4.40E+00	2.46E+02	8.78E-01	1.25E+00	6.71E+00	3.58E-01	3.22E-01	1.76E+00	8.40E-01
4.80E+00	2.37E+02	1.05E+00	1.22E+00	6.91E+00	3.00E-01	3.48E-01	1.76E+00	9.30E-01
5.60E+00	2.20E+02	1.41E+00	1.10E+00	7.44E+00	3.11E-01	3.85E-01	1.78E+00	1.07E+00
7.40E+00	1.90E+02	1.83E+00	9.62E-01	8.10E+00	3.86E-01	3.45E-01	1.87E+00	1.18E+00
1.10E+01	1.52E+02	2.03E+00	1.14E+00	7.89E+00	4.62E-01	3.35E-01	1.74E+00	1.04E+00
1.80E+01	1.12E+02	1.82E+00	1.56E+00	6.43E+00	4.22E-01	4.15E-01	1.30E+00	6.67E-01
3.10E+01	7.70E+01	1.32E+00	1.84E+00	4.40E+00	3.03E-01	4.65E-01	8.20E-01	3.36E-01
5.80E+01	4.83E+01	7.89E-01	1.72E+00	2.50E+00	1.73E-01	4.24E-01	4.51E-01	1.43E-01
1.10E+02	2.89E+01	4.46E-01	1.28E+00	1.31E+00	9.23E-02	3.19E-01	2.39E-01	6.64E-02
2.20E+02	1.61E+01	2.37E-01	8.12E-01	6.47E-01	4.73E-02	2.05E-01	1.18E-01	3.19E-02
4.40E+02	8.79E+00	1.22E-01	4.86E-01	3.22E-01	2.41E-02	1.23E-01	5.82E-02	1.58E-02
T eV								
3.40E+00	2.27E+02	1.36E+00	1.11E+00	6.54E+00	4.11E-01	2.78E-01	1.39E+00	8.00E-01
6.80E+00	2.45E+02	2.40E+00	1.98E+00	9.88E+00	6.08E-01	5.33E-01	2.09E+00	1.17E+00
1.36E+01	2.39E+02	3.10E+00	3.35E+00	1.15E+01	7.35E-01	8.74E-01	2.34E+00	1.19E+00
2.72E+01	2.18E+02	3.22E+00	4.83E+00	1.11E+01	7.36E-01	1.23E+00	2.16E+00	9.56E-01
5.44E+01	1.89E+02	2.91E+00	5.85E+00	9.41E+00	6.41E-01	1.47E+00	1.77E+00	6.79E-01
1.09E+02	1.58E+02	2.41E+00	6.14E+00	7.33E+00	5.12E-01	1.54E+00	1.36E+00	4.57E-01
2.18E+02	1.27E+02	1.89E+00	5.84E+00	5.44E+00	3.89E-01	1.47E+00	9.96E-01	3.07E-01
A	8.65E+01	6.12E-01	4.40E-01	4.02E+00	4.86E-01	1.93E-01	1.60E+00	1.59E+00
Hi	6.03E-01	7.46E-01	1.20E-01	1.36E+00	8.14E-01	1.39E-01	1.84E+00	1.37E-01
Da	2.7E+00	9.0E+00	9.0E+00	6.8E+00	1.8E+00	5.2E+00	3.8E+00	-9.0E-01
RM	4.6E-02	4.1E-02	6.0E-02	2.7E-03	2.0E-02	2.7E-02	2.4E-03	1.4E-01

TABLE I. Electron Impact Cross Sections and Rate Coefficients for Transitions between Singlet States

See page 132 for Explanation of Tables

N13 He I 2p 1P - nl 1L

	3s	3p	3d	4s	4p	4d	4f	iz
E eV								
3.64E+00	9.79E-01	5.18E+00	2.33E+01	1.01E-01	7.43E-01	2.60E+00	9.98E-01	1.97E+00
3.84E+00	1.06E+00	5.34E+00	2.46E+01	1.02E-01	8.12E-01	2.77E+00	9.59E-01	4.01E+00
4.24E+00	1.21E+00	5.56E+00	2.67E+01	1.05E-01	9.08E-01	3.03E+00	9.35E-01	7.00E+00
5.04E+00	1.43E+00	5.62E+00	2.97E+01	1.19E-01	9.71E-01	3.40E+00	9.94E-01	1.03E+01
6.84E+00	1.69E+00	5.11E+00	3.31E+01	1.61E-01	9.12E-01	4.03E+00	1.13E+00	1.30E+01
1.04E+01	1.79E+00	4.26E+00	3.36E+01	1.98E-01	7.84E-01	4.47E+00	1.11E+00	1.34E+01
1.74E+01	1.61E+00	3.18E+00	2.94E+01	1.95E-01	6.02E-01	4.13E+00	8.64E-01	1.13E+01
3.04E+01	1.28E+00	2.11E+00	2.30E+01	1.61E-01	4.08E-01	3.27E+00	5.78E-01	8.40E+00
5.74E+01	8.98E-01	1.24E+00	1.59E+01	1.14E-01	2.40E-01	2.26E+00	3.36E-01	5.24E+00
1.09E+02	5.87E-01	6.87E-01	1.01E+01	7.54E-02	1.34E-01	1.44E+00	1.84E-01	3.11E+00
2.19E+02	3.53E-01	3.53E-01	5.97E+00	4.54E-02	6.90E-02	8.43E-01	9.35E-02	1.68E+00
4.39E+02	2.06E-01	1.78E-01	3.41E+00	2.64E-02	3.49E-02	4.79E-01	4.71E-02	8.93E-01
T eV								
3.40E+00	1.33E+00	4.33E+00	2.69E+01	1.36E-01	6.99E-01	3.23E+00	9.36E-01	8.82E+00
6.80E+00	2.23E+00	5.70E+00	4.28E+01	2.48E-01	1.00E+00	5.57E+00	1.36E+00	1.56E+01
1.36E+01	2.93E+00	6.07E+00	5.41E+01	3.46E-01	1.12E+00	7.39E+00	1.55E+00	1.99E+01
2.72E+01	3.26E+00	5.63E+00	5.89E+01	4.02E-01	1.06E+00	8.24E+00	1.48E+00	2.08E+01
5.44E+01	3.26E+00	4.76E+00	5.77E+01	4.11E-01	9.12E-01	8.15E+00	1.27E+00	1.92E+01
1.09E+02	3.03E+00	3.78E+00	5.25E+01	3.85E-01	7.30E-01	7.42E+00	1.01E+00	1.63E+01
2.18E+02	2.66E+00	2.87E+00	4.54E+01	3.41E-01	5.58E-01	6.40E+00	7.64E-01	1.32E+01
A	1.29E+00	8.76E+00	3.72E+01	2.09E-01	2.03E+00	6.50E+00	2.48E+00	3.93E+02
Hi	3.60E-01	9.99E-01	3.96E-01	3.41E-01	8.96E-01	3.96E-01	1.03E+00	9.57E+00
Da	9.00E+00	3.10E+00	5.40E+00	6.60E+00	2.10E+00	4.20E+00	3.00E+00	2.90E+00
RM	5.48E-02	1.72E-02	5.13E-02	5.08E-02	1.64E-02	4.73E-02	1.13E-02	1.15E-01
E01	1.74E+00	1.89E+00	1.90E+00	2.49E+00	2.56E+00	2.56E+00	2.56E+00	3.41E+00
f	1.32E-01	0.00E+00	2.08E+00	2.37E-02	0.00E+00	3.65E-01	0.00E+00	0.00E+00
Ar	1.74E-01	0.00E+00	3.26E+00	6.43E-02	0.00E+00	1.04E+00	0.00E+00	0.00E+00

K91 He I 2p 1P - nl 1L

	3s	3p	3d	4s	4p	4d	4f
E eV							
3.64E+00	1.61E+00	3.04E+00	1.16E+01	5.74E-01	6.30E-01	1.94E+00	1.39E+00
3.84E+00	1.51E+00	3.30E+00	1.22E+01	5.97E-01	6.80E-01	2.15E+00	1.42E+00
4.24E+00	1.33E+00	3.75E+00	1.33E+01	5.92E-01	7.74E-01	2.54E+00	1.50E+00
5.04E+00	1.13E+00	4.17E+00	1.51E+01	4.63E-01	9.76E-01	3.14E+00	1.66E+00
6.84E+00	1.09E+00	4.31E+00	1.83E+01	3.26E-01	1.13E+00	3.87E+00	1.87E+00
1.04E+01	1.15E+00	4.06E+00	2.15E+01	2.41E-01	1.08E+00	4.35E+00	1.87E+00
1.74E+01	1.18E+00	3.29E+00	2.23E+01	1.85E-01	8.37E-01	4.13E+00	1.46E+00
3.04E+01	1.09E+00	2.24E+00	1.99E+01	1.46E-01	5.45E-01	3.30E+00	9.02E-01
5.74E+01	8.52E-01	1.28E+00	1.50E+01	1.08E-01	2.90E-01	2.26E+00	4.39E-01
1.09E+02	5.82E-01	6.87E-01	9.97E+00	7.43E-02	1.45E-01	1.44E+00	2.04E-01
2.19E+02	3.53E-01	3.50E-01	5.95E+00	4.55E-02	7.00E-02	8.41E-01	9.55E-02
4.39E+02	2.06E-01	1.78E-01	3.41E+00	2.65E-02	3.50E-02	4.78E-01	4.72E-02
T eV							
3.40E+00	1.27E+00	3.39E+00	1.57E+01	3.09E-01	8.19E-01	3.02E+00	1.47E+00
6.80E+00	1.79E+00	5.07E+00	2.86E+01	3.77E-01	1.27E+00	5.40E+00	2.22E+00
1.36E+01	2.36E+00	5.85E+00	4.12E+01	4.04E-01	1.46E+00	7.31E+00	2.48E+00
2.72E+01	2.81E+00	5.64E+00	4.98E+01	4.14E-01	1.36E+00	8.21E+00	2.23E+00
5.44E+01	3.00E+00	4.81E+00	5.24E+01	4.08E-01	1.11E+00	8.13E+00	1.74E+00
1.09E+02	2.90E+00	3.81E+00	4.99E+01	3.81E-01	8.37E-01	7.41E+00	1.25E+00
2.18E+02	2.61E+00	2.88E+00	4.42E+01	3.39E-01	6.09E-01	6.39E+00	8.79E-01
A	2.10E+00	4.12E+00	1.65E+01	1.12E+00	1.48E+00	5.25E+00	2.97E+00
Hi	1.97E-01	1.13E+00	2.51E-01	1.16E-01	1.89E+00	4.15E-01	2.51E+00
Da	2.8E+00	9.0E+00	9.0E+00	-4.0E-01	9.0E+00	5.7E+00	9.0E+00
RM	1.8E-02	1.7E-02	5.9E-02	1.8E-02	2.5E-02	5.0E-02	8.1E-02

TABLE I. Electron Impact Cross Sections and Rate Coefficients for Transitions between Singlet States

See page 132 for Explanation of Tables

N13 He I 3s 1S - nl 1L

	3p	3d	4s	4p	4d	4f	iz
E eV							
1.90E+00	2.23E+03	8.04E+01	1.01E+01	3.04E+00	1.75E+01	1.88E+01	1.92E+01
2.10E+00	2.21E+03	7.94E+01	1.16E+01	3.88E+00	2.03E+01	2.03E+01	4.13E+01
2.50E+00	2.15E+03	7.64E+01	1.33E+01	5.65E+00	2.44E+01	2.14E+01	5.09E+01
3.30E+00	2.04E+03	6.99E+01	1.42E+01	8.31E+00	2.84E+01	2.19E+01	3.28E+01
5.10E+00	1.79E+03	5.93E+01	1.49E+01	1.17E+01	2.93E+01	2.05E+01	3.26E+01
8.70E+00	1.40E+03	4.65E+01	1.35E+01	1.42E+01	2.50E+01	1.69E+01	3.22E+01
1.57E+01	9.70E+02	3.27E+01	1.07E+01	1.43E+01	1.77E+01	1.21E+01	2.48E+01
2.87E+01	6.22E+02	2.11E+01	7.44E+00	1.16E+01	1.09E+01	7.80E+00	1.77E+01
5.57E+01	3.62E+02	1.19E+01	4.35E+00	7.92E+00	5.89E+00	4.37E+00	1.08E+01
1.08E+02	2.06E+02	6.35E+00	2.35E+00	5.03E+00	3.11E+00	2.33E+00	6.29E+00
2.18E+02	1.11E+02	3.17E+00	1.18E+00	2.98E+00	1.55E+00	1.16E+00	3.36E+00
4.38E+02	5.95E+01	1.58E+00	5.92E-01	1.72E+00	7.73E-01	5.79E-01	1.78E+00
T eV							
3.40E+00	1.81E+03	6.12E+01	1.35E+01	1.14E+01	2.52E+01	1.86E+01	3.20E+01
6.80E+00	1.93E+03	6.50E+01	1.75E+01	1.90E+01	3.10E+01	2.20E+01	4.12E+01
1.36E+01	1.86E+03	6.26E+01	1.92E+01	2.52E+01	3.15E+01	2.23E+01	4.54E+01
2.72E+01	1.66E+03	5.52E+01	1.83E+01	2.82E+01	2.80E+01	2.00E+01	4.44E+01
5.44E+01	1.40E+03	4.52E+01	1.58E+01	2.80E+01	2.27E+01	1.65E+01	3.96E+01
1.09E+02	1.13E+03	3.50E+01	1.26E+01	2.57E+01	1.74E+01	1.28E+01	3.30E+01
2.18E+02	8.88E+02	2.61E+01	9.57E+00	2.25E+01	1.29E+01	9.57E+00	2.64E+01
A	3.90E+02	1.21E+01	3.31E+00	2.85E+00	6.96E+00	4.97E+00	2.15E+02
Hi	8.71E-01	1.11E+00	7.98E-01	2.53E-01	1.28E+00	1.25E+00	9.10E+00
Da	7.10E+00	9.00E+00	9.00E+00	9.00E+00	9.00E+00	9.00E+00	3.50E+00
RM	4.33E-02	1.71E-02	3.95E-02	1.60E-01	3.54E-02	1.14E-02	1.45E-01
E01	1.53E-01	1.54E-01	7.53E-01	8.15E-01	8.16E-01	8.16E-01	1.67E+00
f	5.67E-01	0.00E+00	0.00E+00	1.67E-01	0.00E+00	0.00E+00	0.00E+00
Ar	5.75E-03	0.00E+00	0.00E+00	4.84E-02	0.00E+00	0.00E+00	0.00E+00

K91 He I 3s 1S - nl 1L

	3p	3d	4s	4p	4d	4f
E eV						
1.90E+00	2.23E+03	3.44E+02	6.00E+00	7.68E+00	1.27E+01	4.32E+01
2.10E+00	2.22E+03	3.07E+02	6.15E+00	8.00E+00	1.44E+01	4.44E+01
2.50E+00	2.16E+03	2.51E+02	6.48E+00	8.74E+00	1.75E+01	4.54E+01
3.30E+00	2.03E+03	1.81E+02	7.92E+00	9.22E+00	2.34E+01	4.43E+01
5.10E+00	1.73E+03	1.10E+02	1.00E+01	9.01E+00	3.08E+01	3.71E+01
8.70E+00	1.32E+03	6.45E+01	1.04E+01	1.04E+01	3.10E+01	2.64E+01
1.57E+01	9.23E+02	3.87E+01	8.69E+00	1.24E+01	2.27E+01	1.61E+01
2.87E+01	6.04E+02	2.31E+01	6.53E+00	1.13E+01	1.27E+01	8.87E+00
5.57E+01	3.59E+02	1.24E+01	4.12E+00	7.93E+00	6.16E+00	4.54E+00
1.08E+02	2.05E+02	6.39E+00	2.32E+00	5.03E+00	3.13E+00	2.36E+00
2.18E+02	1.11E+02	3.17E+00	1.18E+00	2.98E+00	1.55E+00	1.16E+00
4.38E+02	5.95E+01	1.58E+00	5.92E-01	1.72E+00	7.74E-01	5.79E-01
T eV						
3.40E+00	1.75E+03	1.79E+02	9.40E+00	1.03E+01	2.68E+01	3.41E+01
6.80E+00	1.86E+03	1.31E+02	1.32E+01	1.64E+01	3.58E+01	3.51E+01
1.36E+01	1.79E+03	9.60E+01	1.56E+01	2.28E+01	3.70E+01	3.12E+01
2.72E+01	1.61E+03	7.09E+01	1.59E+01	2.68E+01	3.20E+01	2.50E+01
5.44E+01	1.37E+03	5.21E+01	1.44E+01	2.73E+01	2.50E+01	1.89E+01
1.09E+02	1.12E+03	3.78E+01	1.19E+01	2.55E+01	1.84E+01	1.39E+01
2.18E+02	8.83E+02	2.72E+01	9.28E+00	2.24E+01	1.33E+01	9.98E+00
A	4.04E+02	9.37E+01	2.25E+00	2.51E+00	7.90E+00	1.21E+01
Hi	7.91E-01	3.35E-01	5.34E-01	2.12E-01	1.33E+00	2.96E+00
Da	6.1E+00	-6.0E-01	9.0E+00	9.0E+00	9.0E+00	9.0E+00
RM	4.4E-02	9.2E-03	7.4E-02	1.5E-01	9.4E-02	1.2E-02

TABLE I. Electron Impact Cross Sections and Rate Coefficients for Transitions between Singlet States

See page 132 for Explanation of Tables

N13 He I 3p 1P - nl 1L

	3d	4s	4p	4d	4f	iz
E eV						
1.74E+00	7.90E+03	8.58E+00	1.85E+01	4.62E+01	5.65E+01	1.19E+01
1.94E+00	7.22E+03	1.02E+01	2.06E+01	5.46E+01	6.13E+01	2.23E+01
2.34E+00	6.19E+03	1.25E+01	2.43E+01	6.76E+01	6.74E+01	4.01E+01
3.14E+00	4.84E+03	1.54E+01	2.80E+01	8.47E+01	7.15E+01	4.99E+01
4.94E+00	3.30E+03	1.74E+01	2.72E+01	9.89E+01	6.69E+01	4.25E+01
8.54E+00	2.06E+03	1.75E+01	2.28E+01	1.04E+02	5.35E+01	3.95E+01
1.55E+01	1.22E+03	1.52E+01	1.68E+01	9.41E+01	3.69E+01	3.14E+01
2.85E+01	7.03E+02	1.13E+01	1.11E+01	7.12E+01	2.28E+01	2.15E+01
5.55E+01	3.79E+02	7.29E+00	6.26E+00	4.60E+01	1.24E+01	1.26E+01
1.08E+02	2.04E+02	4.48E+00	3.35E+00	2.81E+01	6.55E+00	7.13E+00
2.18E+02	1.05E+02	2.59E+00	1.68E+00	1.61E+01	3.26E+00	3.76E+00
4.38E+02	5.41E+01	1.47E+00	8.37E-01	9.11E+00	1.63E+00	1.97E+00
T eV						
3.40E+00	4.31E+03	1.63E+01	2.43E+01	9.44E+01	6.01E+01	3.93E+01
6.80E+00	3.48E+03	2.29E+01	2.95E+01	1.37E+02	6.89E+01	5.10E+01
1.36E+01	2.73E+03	2.71E+01	3.05E+01	1.66E+02	6.77E+01	5.57E+01
2.72E+01	2.10E+03	2.80E+01	2.79E+01	1.74E+02	5.93E+01	5.34E+01
5.44E+01	1.59E+03	2.64E+01	2.33E+01	1.65E+02	4.79E+01	4.66E+01
1.09E+02	1.19E+03	2.34E+01	1.83E+01	1.46E+02	3.66E+01	3.81E+01
2.18E+02	8.79E+02	1.98E+01	1.37E+01	1.24E+02	2.71E+01	2.99E+01
A	5.18E+03	1.05E+01	1.78E+01	6.34E+01	4.68E+01	1.07E+03
Hi	1.27E+00	3.93E-01	1.02E+00	3.74E-01	1.38E+00	1.50E+01
Da	1.60E+00	9.00E+00	9.00E+00	9.00E+00	9.00E+00	4.10E+00
RM	2.24E-02	6.00E-02	2.43E-02	7.80E-02	1.67E-02	7.42E-02
E01	1.12E-03	6.00E-01	6.62E-01	6.63E-01	6.64E-01	1.51E+00
f	5.52E-03	2.81E-01	0.00E+00	1.85E+00	0.00E+00	0.00E+00
Ar	2.99E-09	4.41E-02	0.00E+00	3.54E-01	0.00E+00	0.00E+00

K91 He I 3p 1P - nl 1L

	3d	4s	4p	4d	4f
E eV					
1.74E+00	8.24E+03	5.09E+00	1.18E+01	1.29E+01	5.54E+01
1.94E+00	7.50E+03	5.67E+00	1.27E+01	1.46E+01	5.90E+01
2.34E+00	6.37E+03	6.71E+00	1.50E+01	1.84E+01	6.34E+01
3.14E+00	4.93E+03	8.59E+00	1.97E+01	2.81E+01	6.85E+01
4.94E+00	3.31E+03	1.12E+01	2.49E+01	4.89E+01	6.96E+01
8.54E+00	2.04E+03	1.35E+01	2.40E+01	7.22E+01	6.01E+01
1.55E+01	1.20E+03	1.36E+01	1.74E+01	7.97E+01	4.26E+01
2.85E+01	6.95E+02	1.11E+01	1.09E+01	6.72E+01	2.53E+01
5.55E+01	3.78E+02	7.31E+00	6.12E+00	4.56E+01	1.28E+01
1.08E+02	2.04E+02	4.48E+00	3.32E+00	2.81E+01	6.58E+00
2.18E+02	1.05E+02	2.59E+00	1.67E+00	1.61E+01	3.26E+00
4.38E+02	5.41E+01	1.47E+00	8.37E-01	9.11E+00	1.63E+00
T eV					
3.40E+00	4.41E+03	1.16E+01	2.19E+01	5.49E+01	6.33E+01
6.80E+00	3.51E+03	1.84E+01	2.85E+01	9.90E+01	7.52E+01
1.36E+01	2.73E+03	2.40E+01	3.01E+01	1.38E+02	7.45E+01
2.72E+01	2.09E+03	2.64E+01	2.76E+01	1.58E+02	6.44E+01
5.44E+01	1.58E+03	2.57E+01	2.31E+01	1.57E+02	5.07E+01
1.09E+02	1.18E+03	2.31E+01	1.81E+01	1.43E+02	3.80E+01
2.18E+02	8.77E+02	1.97E+01	1.36E+01	1.22E+02	2.76E+01
A	5.56E+03	8.03E+00	1.63E+01	4.25E+01	5.14E+01
Hi	1.10E+00	2.71E-01	9.24E-01	2.10E-01	1.45E+00
Da	1.1E+00	9.0E+00	9.0E+00	9.0E+00	9.0E+00
RM	2.2E-02	1.7E-01	6.2E-02	2.9E-01	4.8E-02

TABLE I. Electron Impact Cross Sections and Rate Coefficients for Transitions between Singlet States

See page 132 for Explanation of Tables

N13 He I 3d 1D - nl 1L

	4s	4p	4d	4f	iz
E eV					
1.74E+00	1.79E+00	3.85E+00	2.11E+01	1.60E+02	8.96E+00
1.94E+00	1.87E+00	3.99E+00	2.31E+01	1.78E+02	2.14E+01
2.34E+00	1.94E+00	4.05E+00	2.56E+01	2.03E+02	3.92E+01
3.14E+00	1.88E+00	3.90E+00	2.63E+01	2.30E+02	5.19E+01
4.94E+00	1.55E+00	3.62E+00	2.43E+01	2.41E+02	5.18E+01
8.54E+00	1.10E+00	3.06E+00	1.95E+01	2.25E+02	4.36E+01
1.55E+01	6.96E-01	2.35E+00	1.37E+01	1.87E+02	3.27E+01
2.85E+01	4.11E-01	1.65E+00	8.81E+00	1.37E+02	2.20E+01
5.55E+01	2.25E-01	1.04E+00	5.01E+00	8.74E+01	1.26E+01
1.08E+02	1.19E-01	6.23E-01	2.69E+00	5.26E+01	6.97E+00
2.18E+02	5.92E-02	3.50E-01	1.35E+00	2.97E+01	3.58E+00
4.38E+02	2.95E-02	1.94E-01	6.73E-01	1.66E+01	1.83E+00
T eV					
3.40E+00	1.43E+00	3.49E+00	2.20E+01	2.25E+02	4.33E+01
6.80E+00	1.48E+00	4.14E+00	2.54E+01	2.98E+02	5.53E+01
1.36E+01	1.35E+00	4.39E+00	2.54E+01	3.39E+02	5.88E+01
2.72E+01	1.13E+00	4.25E+00	2.28E+01	3.43E+02	5.50E+01
5.44E+01	8.90E-01	3.84E+00	1.89E+01	3.17E+02	4.69E+01
1.09E+02	6.73E-01	3.29E+00	1.47E+01	2.75E+02	3.75E+01
2.18E+02	4.95E-01	2.72E+00	1.10E+01	2.30E+02	2.88E+01
A	2.39E+00	5.51E+00	2.83E+01	2.43E+02	3.64E+03
Hi	1.65E+00	5.27E-01	1.16E+00	4.90E-01	2.69E+01
Da	6.00E+00	4.50E+00	8.40E+00	9.00E+00	3.40E+00
RM	1.34E-02	4.82E-02	1.49E-02	4.24E-02	2.76E-02
E01	5.99E-01	6.61E-01	6.62E-01	6.63E-01	1.51E+00
f	0.00E+00	5.60E-02	0.00E+00	5.07E+00	0.00E+00
Ar	0.00E+00	1.07E-02	0.00E+00	9.71E-01	0.00E+00

K91 He I 3d 1D - nl 1L

	4s	4p	4d	4f
E eV				
1.74E+00	4.50E+00	1.02E+01	3.62E+01	7.18E+01
1.94E+00	3.98E+00	9.88E+00	3.64E+01	8.01E+01
2.34E+00	3.27E+00	9.19E+00	3.67E+01	9.50E+01
3.14E+00	2.47E+00	7.82E+00	3.63E+01	1.19E+02
4.94E+00	1.66E+00	5.73E+00	3.24E+01	1.50E+02
8.54E+00	1.23E+00	3.92E+00	2.40E+01	1.69E+02
1.55E+01	8.42E-01	2.72E+00	1.51E+01	1.61E+02
2.85E+01	4.77E-01	1.79E+00	8.79E+00	1.29E+02
5.55E+01	2.44E-01	1.05E+00	4.81E+00	8.58E+01
1.08E+02	1.24E-01	6.20E-01	2.61E+00	5.24E+01
2.18E+02	5.98E-02	3.50E-01	1.32E+00	2.97E+01
4.38E+02	2.95E-02	1.94E-01	6.59E-01	1.66E+01
T eV				
3.40E+00	2.24E+00	6.01E+00	3.00E+01	1.49E+02
6.80E+00	1.97E+00	5.93E+00	3.15E+01	2.27E+02
1.36E+01	1.66E+00	5.49E+00	2.89E+01	2.87E+02
2.72E+01	1.32E+00	4.84E+00	2.42E+01	3.11E+02
5.44E+01	9.98E-01	4.11E+00	1.92E+01	3.01E+02
1.09E+02	7.26E-01	3.40E+00	1.46E+01	2.68E+02
2.18E+02	5.19E-01	2.76E+00	1.09E+01	2.26E+02
A	5.69E+00	1.66E+01	5.34E+01	1.71E+02
Hi	1.76E+00	3.88E-01	1.54E+00	3.13E-01
Da	2.3E+00	4.0E-01	5.4E+00	9.0E+00
RM	1.1E-02	2.8E-02	1.7E-02	1.2E-01

TABLE II. Electron Impact Cross Sections and Rate Coefficients for Transitions between Triplet States

See page 132 for Explanation of Tables

N13 He I 2s 3S - nl 3L

	2p	3s	3p	3d	4s	4p	4d	4f	iz
E eV									
4.80E+00	1.16E+02	1.59E+00	8.23E-01	4.63E+00	3.58E-01	3.48E-01	1.37E+00	7.04E-01	8.35E-03
5.00E+00	1.15E+02	1.62E+00	7.85E-01	4.57E+00	3.47E-01	3.16E-01	1.34E+00	6.87E-01	2.80E-01
5.20E+00	1.15E+02	1.65E+00	7.56E-01	4.51E+00	3.42E-01	2.85E-01	1.31E+00	6.55E-01	8.89E-01
5.60E+00	1.13E+02	1.70E+00	7.23E-01	4.43E+00	3.40E-01	2.42E-01	1.25E+00	5.72E-01	2.67E+00
7.40E+00	1.04E+02	1.75E+00	7.16E-01	4.16E+00	3.37E-01	2.19E-01	1.07E+00	2.96E-01	9.35E+00
1.10E+01	8.84E+01	1.66E+00	6.77E-01	3.68E+00	3.08E-01	2.06E-01	8.47E-01	1.63E-01	8.35E+00
1.80E+01	6.80E+01	1.35E+00	6.60E-01	2.89E+00	2.58E-01	1.98E-01	6.66E-01	1.12E-01	5.32E+00
3.10E+01	4.83E+01	9.41E-01	6.14E-01	1.99E+00	1.83E-01	1.91E-01	4.67E-01	7.33E-02	4.10E+00
5.80E+01	3.09E+01	5.70E-01	4.89E-01	1.18E+00	1.12E-01	1.56E-01	2.82E-01	4.28E-02	2.91E+00
1.10E+02	1.87E+01	3.25E-01	3.48E-01	6.62E-01	6.39E-02	1.12E-01	1.59E-01	2.37E-02	1.93E+00
2.20E+02	1.06E+01	1.70E-01	2.21E-01	3.42E-01	3.36E-02	7.19E-02	8.27E-02	1.21E-02	1.13E+00
4.40E+02	5.85E+00	8.70E-02	1.34E-01	1.73E-01	1.72E-02	4.37E-02	4.20E-02	6.11E-03	6.31E-01
T eV									
3.40E+00	1.03E+02	1.32E+00	6.33E-01	3.23E+00	2.45E-01	1.79E-01	7.55E-01	2.41E-01	4.31E+00
6.80E+00	1.28E+02	2.06E+00	9.90E-01	4.76E+00	3.90E-01	2.95E-01	1.12E+00	2.86E-01	8.15E+00
1.36E+01	1.37E+02	2.44E+00	1.34E+00	5.40E+00	4.67E-01	4.08E-01	1.27E+00	2.63E-01	1.04E+01
2.72E+01	1.32E+02	2.42E+00	1.61E+00	5.20E+00	4.68E-01	5.04E-01	1.23E+00	2.21E-01	1.11E+01
5.44E+01	1.18E+02	2.14E+00	1.76E+00	4.50E+00	4.17E-01	5.58E-01	1.07E+00	1.76E-01	1.09E+01
1.09E+02	1.01E+02	1.75E+00	1.75E+00	3.61E+00	3.43E-01	5.62E-01	8.64E-01	1.35E-01	9.89E+00
2.18E+02	8.28E+01	1.36E+00	1.63E+00	2.77E+00	2.68E-01	5.27E-01	6.66E-01	1.01E-01	8.43E+00
A	1.43E+02	4.10E+00	2.54E+00	1.48E+01	1.39E+00	9.51E-01	4.84E+00	2.40E+00	1.95E+02
Hi	5.43E-01	8.08E-01	1.37E-01	6.25E-01	4.73E-01	1.23E-01	3.29E-01	1.14E+01	3.02E+00
Da	3.00E+00	2.40E+00	5.00E-01	5.00E-01	2.00E-01	2.00E-01	-4.0E-01	4.60E+00	5.00E-01
RM	4.73E-02	2.13E-02	2.17E-02	7.58E-03	6.16E-03	3.31E-02	2.15E-02	1.20E-01	3.28E-01
E01	1.14E+00	2.90E+00	3.19E+00	3.25E+00	3.77E+00	3.89E+00	3.92E+00	3.92E+00	4.77E+00
f	1.62E+00	0.00E+00	1.91E-01	0.00E+00	0.00E+00	7.64E-02	0.00E+00	0.00E+00	0.00E+00
Ar	9.22E-01	0.00E+00	8.43E-01	0.00E+00	0.00E+00	5.03E-01	0.00E+00	0.00E+00	0.00E+00

K91 He I 2s 3S - nl 3L

	2p	3s	3p	3d	4s	4p	4d	4f
E eV								
4.80E+00	1.09E+02	1.38E+00	1.75E+00	3.28E+00	7.05E-01	5.11E-01	1.19E+00	5.99E-01
5.00E+00	1.07E+02	1.20E+00	1.60E+00	3.13E+00	5.97E-01	5.15E-01	1.31E+00	5.74E-01
5.20E+00	1.06E+02	1.07E+00	1.50E+00	3.13E+00	5.09E-01	5.09E-01	1.37E+00	5.57E-01
5.60E+00	1.04E+02	9.17E-01	1.38E+00	3.23E+00	3.93E-01	4.88E-01	1.38E+00	5.33E-01
7.40E+00	9.53E+01	8.14E-01	1.03E+00	3.70E+00	2.01E-01	4.57E-01	1.29E+00	5.22E-01
1.10E+01	8.11E+01	1.05E+00	7.11E-01	3.93E+00	2.03E-01	2.86E-01	1.25E+00	4.79E-01
1.80E+01	6.35E+01	1.08E+00	5.57E-01	3.42E+00	2.23E-01	1.74E-01	9.80E-01	3.17E-01
3.10E+01	4.60E+01	8.43E-01	5.17E-01	2.42E+00	1.82E-01	1.53E-01	6.28E-01	1.57E-01
5.80E+01	3.01E+01	5.29E-01	4.59E-01	1.39E+00	1.14E-01	1.42E-01	3.39E-01	6.29E-02
1.10E+02	1.85E+01	3.07E-01	3.45E-01	7.25E-01	6.36E-02	1.11E-01	1.76E-01	2.71E-02
2.20E+02	1.05E+01	1.66E-01	2.21E-01	3.53E-01	3.35E-02	7.19E-02	8.62E-02	1.25E-02
4.40E+02	5.85E+00	8.64E-02	1.34E-01	1.74E-01	1.72E-02	4.37E-02	4.25E-02	6.15E-03
T eV								
3.40E+00	1.00E+02	1.84E+00	1.17E+00	3.19E+00	2.81E-01	2.76E-01	8.57E-01	3.69E-01
6.80E+00	1.21E+02	2.00E+00	1.33E+00	4.98E+00	3.70E-01	3.85E-01	1.44E+00	5.43E-01
1.36E+01	1.29E+02	2.14E+00	1.42E+00	6.01E+00	4.31E-01	4.36E-01	1.69E+00	5.51E-01
2.72E+01	1.26E+02	2.13E+00	1.56E+00	5.95E+00	4.45E-01	4.86E-01	1.60E+00	4.40E-01
5.44E+01	1.14E+02	1.94E+00	1.69E+00	5.11E+00	4.06E-01	5.32E-01	1.32E+00	3.04E-01
1.09E+02	9.87E+01	1.63E+00	1.71E+00	4.00E+00	3.39E-01	5.45E-01	1.01E+00	1.98E-01
2.18E+02	8.19E+01	1.30E+00	1.61E+00	2.97E+00	2.66E-01	5.20E-01	7.34E-01	1.29E-01
A	1.51E+02	7.38E+00	4.78E+00	1.17E+01	1.58E+00	1.53E+00	4.15E+00	2.71E+00
Hi	4.55E-01	1.97E-01	7.44E-02	1.07E+00	2.55E-01	7.32E-02	2.19E+00	2.16E-01
Da	2.2E+00	-5.0E-01	-5.0E-01	2.5E+00	-4.0E-01	-5.0E-01	3.9E+00	-9.0E-01
RM	4.3E-02	1.1E-01	1.8E-01	1.3E-02	8.5E-02	1.2E-01	9.2E-03	2.6E-02

TABLE II. Electron Impact Cross Sections and Rate Coefficients for Transitions between Triplet States

See page 132 for Explanation of Tables

N13 He I 2p 3P - nl 3L

	3s	3p	3d	4s	4p	4d	4f	iz
E eV								
3.66E+00	2.41E+00	5.25E+00	2.01E+01	2.25E-01	1.07E+00	3.53E+00	2.31E+00	1.12E-01
3.86E+00	2.59E+00	5.31E+00	2.07E+01	2.38E-01	1.07E+00	3.57E+00	1.99E+00	1.71E+00
4.06E+00	2.75E+00	5.36E+00	2.12E+01	2.48E-01	1.07E+00	3.58E+00	1.73E+00	3.49E+00
4.46E+00	3.00E+00	5.42E+00	2.21E+01	2.61E-01	1.05E+00	3.55E+00	1.39E+00	6.15E+00
6.26E+00	3.51E+00	5.09E+00	2.47E+01	3.04E-01	9.45E-01	3.68E+00	9.71E-01	1.17E+01
9.86E+00	3.49E+00	4.12E+00	2.54E+01	3.27E-01	7.87E-01	3.94E+00	8.21E-01	1.26E+01
1.69E+01	2.96E+00	2.97E+00	2.24E+01	2.93E-01	5.72E-01	3.62E+00	6.21E-01	1.09E+01
2.99E+01	2.26E+00	1.93E+00	1.75E+01	2.30E-01	3.74E-01	2.87E+00	4.11E-01	8.11E+00
5.69E+01	1.54E+00	1.12E+00	1.21E+01	1.59E-01	2.17E-01	1.99E+00	2.38E-01	5.16E+00
1.09E+02	9.88E-01	6.19E-01	7.76E+00	1.03E-01	1.21E-01	1.28E+00	1.30E-01	3.10E+00
2.19E+02	5.86E-01	3.18E-01	4.58E+00	6.10E-02	6.20E-02	7.51E-01	6.59E-02	1.69E+00
4.39E+02	3.39E-01	1.60E-01	2.63E+00	3.52E-02	3.14E-02	4.29E-01	3.32E-02	9.08E-01
T eV								
3.40E+00	2.79E+00	4.23E+00	2.11E+01	2.47E-01	7.58E-01	3.15E+00	1.08E+00	7.96E+00
6.80E+00	4.36E+00	5.41E+00	3.27E+01	4.09E-01	1.01E+00	5.09E+00	1.24E+00	1.44E+01
1.36E+01	5.40E+00	5.63E+00	4.10E+01	5.28E-01	1.07E+00	6.56E+00	1.22E+00	1.87E+01
2.72E+01	5.79E+00	5.14E+00	4.46E+01	5.81E-01	9.87E-01	7.24E+00	1.10E+00	1.99E+01
5.44E+01	5.63E+00	4.31E+00	4.38E+01	5.75E-01	8.33E-01	7.16E+00	9.13E-01	1.87E+01
1.09E+02	5.12E+00	3.41E+00	4.00E+01	5.28E-01	6.61E-01	6.55E+00	7.16E-01	1.61E+01
2.18E+02	4.45E+00	2.58E+00	3.47E+01	4.61E-01	5.03E-01	5.68E+00	5.40E-01	1.30E+01
A	1.08E+01	3.14E+01	1.19E+02	1.86E+00	8.95E+00	3.02E+01	1.36E+01	1.02E+03
Hi	4.05E-01	9.41E-01	3.58E-01	3.49E-01	6.02E-01	2.88E-01	2.55E-01	8.20E+00
Da	5.60E+00	1.90E+00	3.20E+00	2.50E+00	3.00E-01	1.30E+00	-6.0E-01	2.80E+00
RM	5.78E-02	1.69E-02	4.75E-02	4.84E-02	7.08E-03	2.83E-02	4.81E-02	1.42E-01
E01	1.75E+00	2.04E+00	2.11E+00	2.63E+00	2.74E+00	2.77E+00	2.77E+00	3.62E+00
f	6.21E-01	0.00E+00	5.50E+00	9.44E-02	0.00E+00	1.11E+00	0.00E+00	0.00E+00
Ar	8.32E-01	0.00E+00	1.07E+01	2.84E-01	0.00E+00	3.71E+00	0.00E+00	0.00E+00

K91 He I 2p 3P - nl 3L

	3s	3p	3d	4s	4p	4d	4f
E eV							
3.66E+00	2.11E+00	3.43E+00	7.15E+00	8.39E-01	8.76E-01	1.65E+00	1.22E+00
3.86E+00	2.07E+00	3.47E+00	7.49E+00	7.51E-01	8.98E-01	1.76E+00	1.21E+00
4.06E+00	2.06E+00	3.58E+00	7.94E+00	6.73E-01	9.32E-01	1.87E+00	1.19E+00
4.46E+00	1.99E+00	3.85E+00	8.68E+00	6.14E-01	9.51E-01	2.07E+00	1.12E+00
6.26E+00	1.84E+00	4.25E+00	1.13E+01	4.29E-01	1.13E+00	2.67E+00	1.24E+00
9.86E+00	2.02E+00	3.97E+00	1.46E+01	3.16E-01	1.07E+00	3.34E+00	1.32E+00
1.69E+01	2.11E+00	3.17E+00	1.60E+01	2.56E-01	8.24E-01	3.38E+00	1.07E+00
2.99E+01	1.92E+00	2.11E+00	1.47E+01	2.07E-01	5.17E-01	2.82E+00	6.84E-01
5.69E+01	1.47E+00	1.17E+00	1.13E+01	1.52E-01	2.62E-01	1.99E+00	3.39E-01
1.09E+02	9.81E-01	6.21E-01	7.58E+00	1.02E-01	1.28E-01	1.27E+00	1.53E-01
2.19E+02	5.86E-01	3.16E-01	4.56E+00	6.10E-02	6.28E-02	7.49E-01	6.90E-02
4.39E+02	3.39E-01	1.60E-01	2.63E+00	3.52E-02	3.15E-02	4.28E-01	3.34E-02
T eV							
3.40E+00	2.03E+00	3.60E+00	1.06E+01	4.25E-01	8.63E-01	2.31E+00	1.04E+00
6.80E+00	3.04E+00	5.03E+00	1.99E+01	5.05E-01	1.27E+00	4.26E+00	1.58E+00
1.36E+01	4.09E+00	5.60E+00	2.96E+01	5.47E-01	1.41E+00	5.98E+00	1.79E+00
2.72E+01	4.87E+00	5.27E+00	3.65E+01	5.68E-01	1.28E+00	6.92E+00	1.64E+00
5.44E+01	5.12E+00	4.43E+00	3.91E+01	5.60E-01	1.02E+00	7.01E+00	1.29E+00
1.09E+02	4.89E+00	3.47E+00	3.76E+01	5.19E-01	7.59E-01	6.48E+00	9.24E-01
2.18E+02	4.35E+00	2.61E+00	3.37E+01	4.57E-01	5.48E-01	5.65E+00	6.43E-01
A	8.48E+00	1.80E+01	3.59E+01	4.71E+00	5.63E+00	1.34E+01	6.84E+00
Hi	2.36E-01	1.27E+00	2.35E-01	1.24E-01	2.69E+00	3.68E-01	2.62E+00
Da	4.4E+00	5.9E+00	9.0E+00	-4.0E-01	9.0E+00	5.3E+00	9.0E+00
RM	2.2E-02	9.9E-03	5.7E-02	4.9E-02	2.3E-02	4.6E-02	8.6E-02

TABLE II. Electron Impact Cross Sections and Rate Coefficients for Transitions between Triplet States

See page 132 for Explanation of Tables

N13 He I 3s 3S - nl 3L

	3p	3d	4s	4p	4d	4f	iz
E eV							
1.90E+00	1.19E+03	8.27E+01	6.95E+00	3.72E+00	7.14E+00	2.18E+01	3.09E-01
2.10E+00	1.18E+03	8.11E+01	7.96E+00	3.56E+00	7.89E+00	2.05E+01	1.30E+01
2.30E+00	1.18E+03	7.96E+01	8.97E+00	3.49E+00	8.38E+00	1.92E+01	3.07E+01
2.70E+00	1.17E+03	7.66E+01	1.04E+01	3.58E+00	9.16E+00	1.77E+01	4.54E+01
4.50E+00	1.06E+03	6.39E+01	1.16E+01	4.26E+00	1.15E+01	1.54E+01	2.58E+01
8.10E+00	8.88E+02	4.80E+01	1.08E+01	4.57E+00	1.02E+01	1.23E+01	2.57E+01
1.51E+01	6.49E+02	3.30E+01	8.49E+00	4.27E+00	7.36E+00	8.67E+00	2.10E+01
2.81E+01	4.30E+02	2.10E+01	5.93E+00	3.40E+00	4.55E+00	5.55E+00	1.49E+01
5.51E+01	2.56E+02	1.19E+01	3.51E+00	2.29E+00	2.45E+00	3.12E+00	9.11E+00
1.07E+02	1.48E+02	6.34E+00	1.91E+00	1.44E+00	1.29E+00	1.66E+00	5.26E+00
2.17E+02	8.04E+01	3.17E+00	9.60E-01	8.34E-01	6.44E-01	8.28E-01	2.79E+00
4.37E+02	4.36E+01	1.58E+00	4.80E-01	4.75E-01	3.21E-01	4.12E-01	1.47E+00
T eV							
3.40E+00	1.04E+03	6.25E+01	1.04E+01	4.43E+00	9.79E+00	1.48E+01	2.59E+01
6.80E+00	1.17E+03	6.53E+01	1.36E+01	6.27E+00	1.23E+01	1.63E+01	3.36E+01
1.36E+01	1.19E+03	6.22E+01	1.50E+01	7.70E+00	1.26E+01	1.59E+01	3.73E+01
2.72E+01	1.10E+03	5.46E+01	1.45E+01	8.31E+00	1.14E+01	1.42E+01	3.67E+01
5.44E+01	9.57E+02	4.47E+01	1.25E+01	8.09E+00	9.29E+00	1.17E+01	3.28E+01
1.09E+02	7.92E+02	3.47E+01	1.01E+01	7.33E+00	7.16E+00	9.08E+00	2.74E+01
2.18E+02	6.35E+02	2.59E+01	7.69E+00	6.31E+00	5.32E+00	6.78E+00	2.17E+01
A	6.65E+02	5.10E+01	8.00E+00	3.17E+00	8.75E+00	2.12E+01	5.92E+02
Hi	7.17E-01	1.10E+00	8.05E-01	3.74E-01	1.31E+00	1.02E+00	9.42E+00
Da	7.50E+00	6.00E+00	9.00E+00	9.00E+00	9.00E+00	3.10E+00	3.20E+00
RM	4.52E-02	1.23E-02	2.59E-02	4.35E-02	2.28E-02	7.36E-03	1.57E-01
E01	2.89E-01	3.55E-01	8.75E-01	9.89E-01	1.02E+00	1.02E+00	1.87E+00
f	2.67E+00	0.00E+00	0.00E+00	1.50E-01	0.00E+00	0.00E+00	0.00E+00
Ar	9.69E-02	0.00E+00	0.00E+00	6.38E-02	0.00E+00	0.00E+00	0.00E+00

K91 He I 3s 3S - nl 3L

	3p	3d	4s	4p	4d	4f
E eV						
1.90E+00	8.66E+02	2.95E+02	5.66E+00	5.90E+00	9.40E+00	3.40E+01
2.10E+00	9.02E+02	2.70E+02	5.12E+00	6.12E+00	8.89E+00	3.38E+01
2.30E+00	9.27E+02	2.50E+02	4.83E+00	6.45E+00	8.36E+00	3.42E+01
2.70E+00	9.55E+02	2.17E+02	4.44E+00	7.65E+00	7.46E+00	3.42E+01
4.50E+00	9.42E+02	1.31E+02	5.17E+00	9.20E+00	9.79E+00	3.11E+01
8.10E+00	8.05E+02	7.25E+01	6.13E+00	7.28E+00	1.29E+01	2.20E+01
1.51E+01	6.05E+02	4.07E+01	5.59E+00	5.14E+00	1.09E+01	1.28E+01
2.81E+01	4.14E+02	2.34E+01	4.72E+00	3.53E+00	6.22E+00	6.76E+00
5.51E+01	2.53E+02	1.24E+01	3.25E+00	2.32E+00	2.79E+00	3.32E+00
1.07E+02	1.47E+02	6.42E+00	1.86E+00	1.45E+00	1.33E+00	1.69E+00
2.17E+02	8.04E+01	3.17E+00	9.54E-01	8.35E-01	6.47E-01	8.31E-01
4.37E+02	4.36E+01	1.58E+00	4.79E-01	4.75E-01	3.21E-01	4.12E-01
T eV						
3.40E+00	8.72E+02	1.53E+02	6.06E+00	7.57E+00	1.11E+01	2.67E+01
6.80E+00	1.04E+03	1.21E+02	8.40E+00	9.14E+00	1.54E+01	2.74E+01
1.36E+01	1.10E+03	9.30E+01	1.04E+01	9.62E+00	1.65E+01	2.39E+01
2.72E+01	1.05E+03	6.99E+01	1.14E+01	9.35E+00	1.45E+01	1.89E+01
5.44E+01	9.29E+02	5.17E+01	1.08E+01	8.59E+00	1.11E+01	1.40E+01
1.09E+02	7.79E+02	3.76E+01	9.26E+00	7.54E+00	8.06E+00	1.01E+01
2.18E+02	6.29E+02	2.71E+01	7.34E+00	6.39E+00	5.71E+00	7.19E+00
A	4.97E+02	2.57E+02	4.33E+00	1.03E+01	1.08E+01	3.56E+01
Hi	6.25E-01	7.74E-01	4.21E-01	4.26E-01	1.36E+00	3.98E+00
Da	9.0E+00	0.0E+00	9.0E+00	2.4E+00	9.0E+00	9.0E+00
RM	3.9E-02	4.1E-03	3.9E-02	5.5E-02	1.0E-01	2.0E-02

TABLE II. Electron Impact Cross Sections and Rate Coefficients for Transitions between Triplet States

See page 132 for Explanation of Tables

N13 He I 3p 3P - nl 3L

	3d	4s	4p	4d	4f	iz
E eV						
1.61E+00	2.25E+03	2.03E+01	1.97E+01	2.52E+01	4.87E+01	1.13E+00
1.81E+00	2.13E+03	2.36E+01	2.13E+01	3.02E+01	5.30E+01	1.06E+01
2.01E+00	2.04E+03	2.60E+01	2.26E+01	3.51E+01	5.63E+01	1.96E+01
2.41E+00	1.91E+03	3.01E+01	2.49E+01	4.26E+01	6.01E+01	3.54E+01
4.21E+00	1.43E+03	3.50E+01	2.69E+01	5.95E+01	6.03E+01	4.61E+01
7.81E+00	9.74E+02	3.30E+01	2.20E+01	6.60E+01	4.88E+01	3.67E+01
1.48E+01	6.13E+02	2.73E+01	1.59E+01	6.16E+01	3.35E+01	3.02E+01
2.78E+01	3.71E+02	1.98E+01	1.04E+01	4.75E+01	2.06E+01	2.10E+01
5.48E+01	2.08E+02	1.25E+01	5.85E+00	3.10E+01	1.11E+01	1.25E+01
1.07E+02	1.15E+02	7.60E+00	3.12E+00	1.90E+01	5.83E+00	7.07E+00
2.17E+02	6.09E+01	4.34E+00	1.56E+00	1.09E+01	2.90E+00	3.74E+00
4.37E+02	3.22E+01	2.45E+00	7.78E-01	6.21E+00	1.44E+00	1.98E+00
T eV						
3.40E+00	1.44E+03	3.23E+01	2.34E+01	5.96E+01	5.26E+01	3.66E+01
6.80E+00	1.35E+03	4.27E+01	2.77E+01	8.77E+01	6.03E+01	4.78E+01
1.36E+01	1.20E+03	4.85E+01	2.83E+01	1.08E+02	5.93E+01	5.27E+01
2.72E+01	1.01E+03	4.89E+01	2.58E+01	1.15E+02	5.21E+01	5.11E+01
5.44E+01	8.14E+02	4.54E+01	2.15E+01	1.10E+02	4.22E+01	4.51E+01
1.09E+02	6.40E+02	3.96E+01	1.69E+01	9.78E+01	3.23E+01	3.72E+01
2.18E+02	4.93E+02	3.33E+01	1.27E+01	8.34E+01	2.39E+01	2.93E+01
A	3.91E+03	6.09E+01	5.20E+01	1.22E+02	1.26E+02	2.62E+03
Hi	9.78E-01	4.69E-01	1.09E+00	3.54E-01	1.41E+00	1.32E+01
Da	3.50E+00	9.00E+00	9.00E+00	9.00E+00	9.00E+00	4.40E+00
RM	3.71E-02	4.64E-02	1.42E-02	7.61E-02	1.26E-02	1.04E-01
E01	6.66E-02	5.87E-01	7.01E-01	7.29E-01	7.30E-01	1.58E+00
f	1.01E+00	1.31E+00	0.00E+00	4.29E+00	0.00E+00	0.00E+00
Ar	1.95E-03	1.96E-01	0.00E+00	9.93E-01	0.00E+00	0.00E+00

K91 He I 3p 3P - nl 3L

	3d	4s	4p	4d	4f
E eV					
1.61E+00	2.59E+03	7.04E+00	1.44E+01	1.09E+01	5.06E+01
1.81E+00	2.43E+03	8.20E+00	1.48E+01	1.14E+01	5.39E+01
2.01E+00	2.29E+03	9.07E+00	1.50E+01	1.16E+01	5.67E+01
2.41E+00	2.06E+03	1.10E+01	1.63E+01	1.24E+01	6.00E+01
4.21E+00	1.44E+03	1.82E+01	2.31E+01	2.22E+01	6.44E+01
7.81E+00	9.44E+02	2.41E+01	2.31E+01	3.95E+01	5.73E+01
1.48E+01	5.92E+02	2.44E+01	1.65E+01	4.90E+01	4.04E+01
2.78E+01	3.62E+02	1.92E+01	1.03E+01	4.33E+01	2.36E+01
5.48E+01	2.06E+02	1.25E+01	5.79E+00	3.02E+01	1.18E+01
1.07E+02	1.15E+02	7.60E+00	3.10E+00	1.89E+01	5.91E+00
2.17E+02	6.09E+01	4.34E+00	1.56E+00	1.09E+01	2.90E+00
4.37E+02	3.22E+01	2.45E+00	7.77E-01	6.21E+00	1.44E+00
T eV					
3.40E+00	1.50E+03	2.03E+01	2.13E+01	3.23E+01	5.85E+01
6.80E+00	1.36E+03	3.25E+01	2.70E+01	5.96E+01	6.91E+01
1.36E+01	1.19E+03	4.18E+01	2.82E+01	8.59E+01	6.82E+01
2.72E+01	9.93E+02	4.54E+01	2.58E+01	1.01E+02	5.86E+01
5.44E+01	8.04E+02	4.37E+01	2.15E+01	1.03E+02	4.59E+01
1.09E+02	6.35E+02	3.90E+01	1.68E+01	9.47E+01	3.41E+01
2.18E+02	4.91E+02	3.31E+01	1.26E+01	8.21E+01	2.47E+01
A	4.61E+03	4.24E+01	4.82E+01	7.76E+01	1.49E+02
Hi	8.45E-01	2.88E-01	9.91E-01	1.83E-01	1.57E+00
Da	2.3E+00	9.0E+00	9.0E+00	9.0E+00	9.0E+00
RM	3.6E-02	1.8E-01	4.4E-02	3.1E-01	4.3E-02

TABLE II. Electron Impact Cross Sections and Rate Coefficients for Transitions between Triplet States

See page 132 for Explanation of Tables

N13 He I 3d 3D - nl 3L

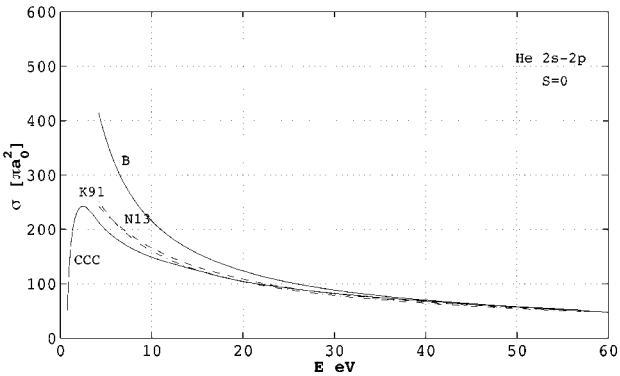
	4s	4p	4d	4f	iz
E eV					
1.55E+00	6.51E+00	6.48E+00	2.19E+01	1.33E+02	2.80E-01
1.75E+00	6.33E+00	6.97E+00	2.40E+01	1.53E+02	9.67E+00
1.95E+00	6.08E+00	7.18E+00	2.57E+01	1.70E+02	2.20E+01
2.35E+00	5.54E+00	7.14E+00	2.77E+01	1.94E+02	3.85E+01
4.15E+00	3.96E+00	6.18E+00	2.63E+01	2.33E+02	5.49E+01
7.75E+00	2.46E+00	5.26E+00	2.06E+01	2.26E+02	4.47E+01
1.47E+01	1.46E+00	4.09E+00	1.42E+01	1.91E+02	3.33E+01
2.77E+01	8.38E-01	2.90E+00	9.01E+00	1.39E+02	2.24E+01
5.47E+01	4.44E-01	1.83E+00	5.07E+00	8.82E+01	1.28E+01
1.07E+02	2.33E-01	1.11E+00	2.71E+00	5.29E+01	7.02E+00
2.17E+02	1.15E-01	6.32E-01	1.35E+00	2.98E+01	3.59E+00
4.37E+02	5.73E-02	3.55E-01	6.74E-01	1.66E+01	1.83E+00
T eV					
3.40E+00	3.62E+00	5.86E+00	2.30E+01	2.20E+02	4.32E+01
6.80E+00	3.37E+00	6.98E+00	2.59E+01	2.94E+02	5.49E+01
1.36E+01	2.88E+00	7.47E+00	2.56E+01	3.36E+02	5.84E+01
2.72E+01	2.31E+00	7.32E+00	2.29E+01	3.41E+02	5.48E+01
5.44E+01	1.78E+00	6.69E+00	1.89E+01	3.16E+02	4.68E+01
1.09E+02	1.33E+00	5.81E+00	1.47E+01	2.75E+02	3.75E+01
2.18E+02	9.67E-01	4.86E+00	1.10E+01	2.29E+02	2.86E+01
A	2.40E+01	2.74E+01	9.94E+01	7.15E+02	1.16E+04
Hi	1.62E+00	4.75E-01	1.14E+00	4.79E-01	2.92E+01
Da	3.00E+00	4.40E+00	6.90E+00	9.00E+00	3.50E+00
RM	9.45E-03	5.06E-02	1.39E-02	4.07E-02	2.82E-02
E01	5.20E-01	6.34E-01	6.62E-01	6.63E-01	1.51E+00
f	0.00E+00	3.33E-01	0.00E+00	1.52E+01	0.00E+00
Ar	0.00E+00	5.82E-02	0.00E+00	2.91E+00	0.00E+00

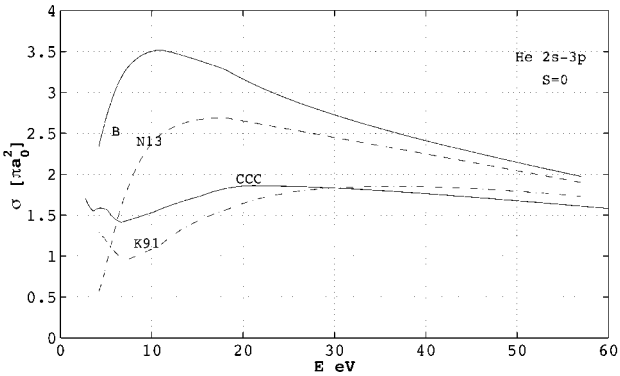
K91 He I 3d 3D - nl 3L

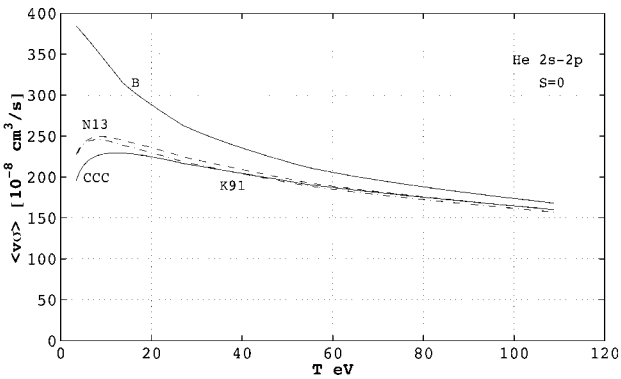
	4s	4p	4d	4f
E eV				
1.55E+00	6.91E+00	1.43E+01	2.70E+01	5.84E+01
1.75E+00	6.32E+00	1.31E+01	2.93E+01	6.66E+01
1.95E+00	5.67E+00	1.22E+01	3.06E+01	7.48E+01
2.35E+00	4.76E+00	1.10E+01	3.18E+01	8.94E+01
4.15E+00	3.25E+00	7.75E+00	3.18E+01	1.35E+02
7.75E+00	2.31E+00	5.89E+00	2.48E+01	1.63E+02
1.47E+01	1.57E+00	4.61E+00	1.54E+01	1.59E+02
2.77E+01	9.11E-01	3.09E+00	9.02E+00	1.28E+02
5.47E+01	4.66E-01	1.86E+00	4.95E+00	8.56E+01
1.07E+02	2.37E-01	1.11E+00	2.64E+00	5.24E+01
2.17E+02	1.16E-01	6.33E-01	1.32E+00	2.97E+01
4.37E+02	5.73E-02	3.55E-01	6.60E-01	1.66E+01
T eV				
3.40E+00	3.38E+00	8.21E+00	2.71E+01	1.44E+02
6.80E+00	3.25E+00	8.57E+00	2.97E+01	2.20E+02
1.36E+01	2.89E+00	8.50E+00	2.79E+01	2.80E+02
2.72E+01	2.38E+00	7.91E+00	2.39E+01	3.06E+02
5.44E+01	1.84E+00	6.99E+00	1.91E+01	2.97E+02
1.09E+02	1.36E+00	5.94E+00	1.46E+01	2.66E+02
2.18E+02	9.85E-01	4.92E+00	1.09E+01	2.25E+02
A	1.80E+01	5.53E+01	1.23E+02	4.95E+02
Hi	1.86E+00	4.36E-01	1.50E+00	3.02E-01
Da	5.3E+00	1.5E+00	7.2E+00	9.0E+00
RM	3.4E-03	4.2E-02	1.8E-02	1.3E-01

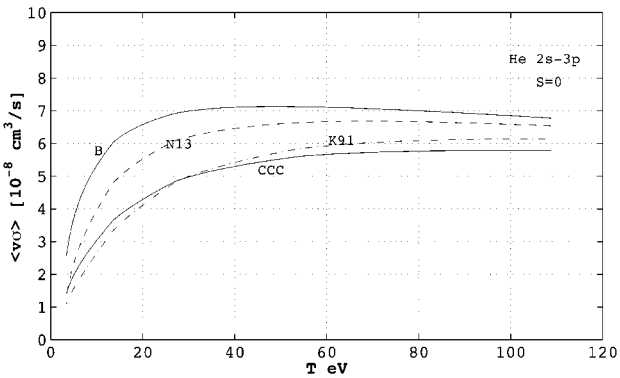
FIGURE SET I. Comparison of Electron Impact Cross Sections and Rate Coefficients for Transitions between Singlet States from Different Calculations

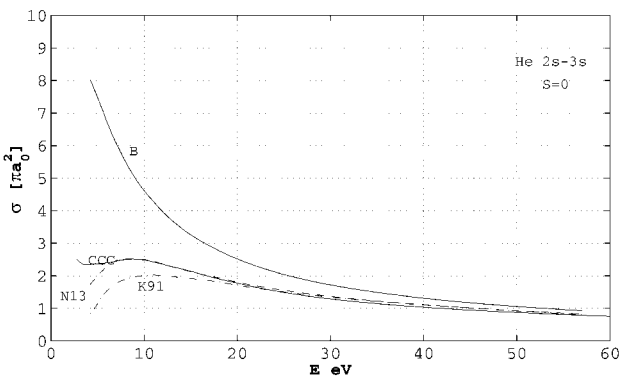
See page 133 for Explanation of Figure Sets

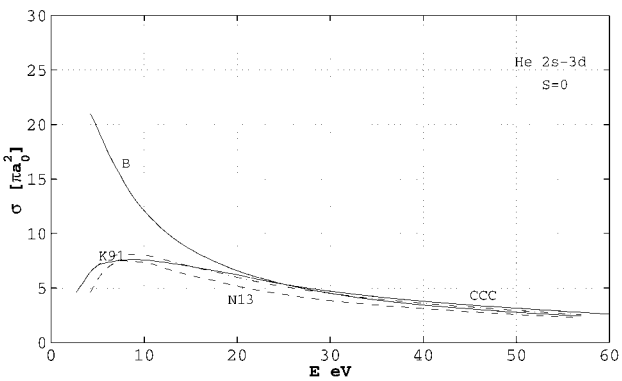


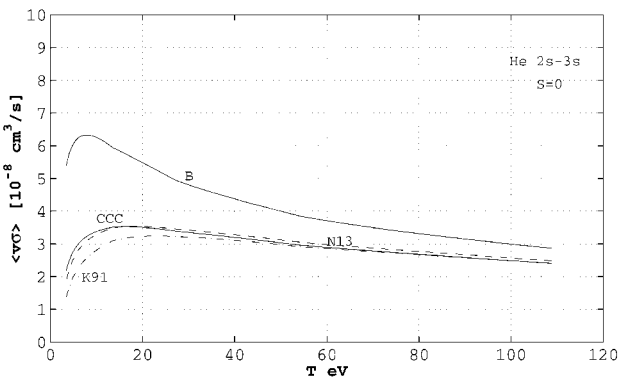












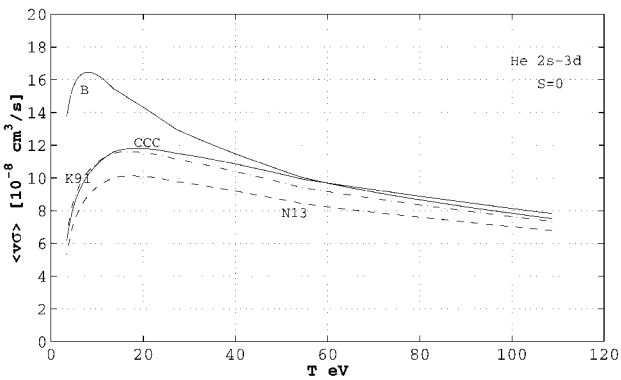
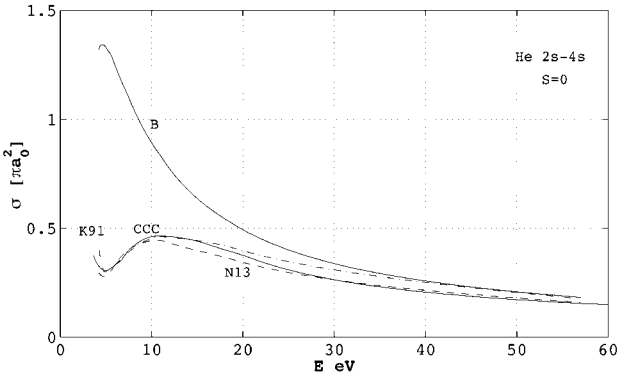
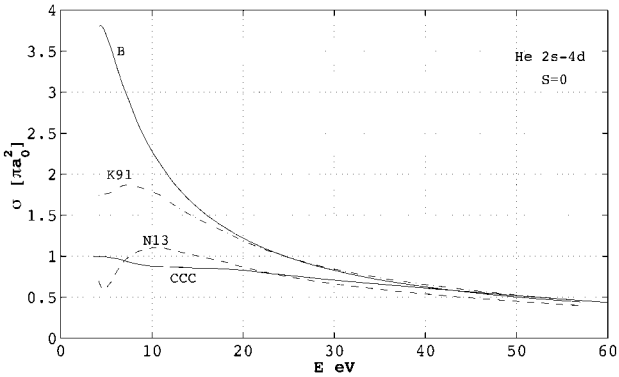
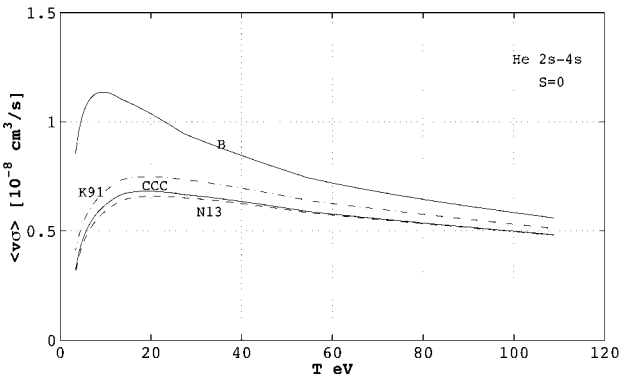


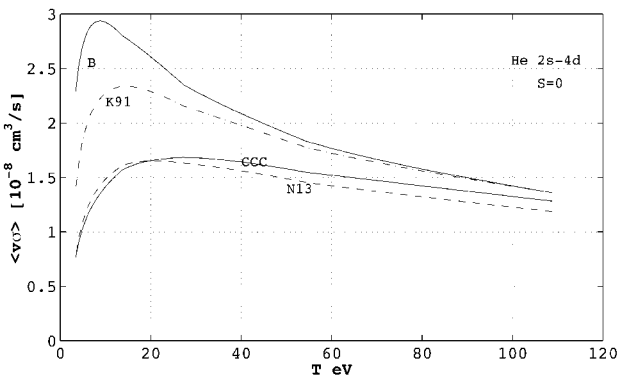
FIGURE SET I. Comparison of Electron Impact Cross Sections and Rate Coefficients for Transitions between Singlet States from Different Calculations

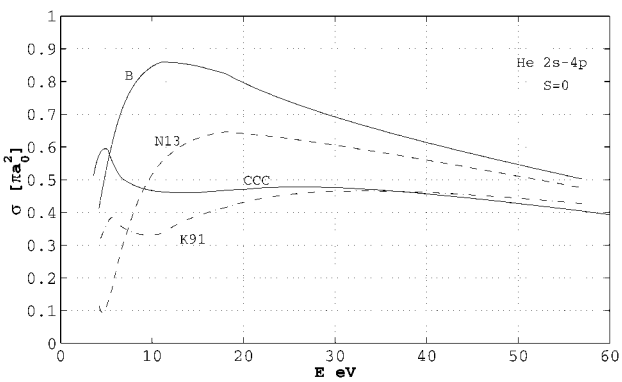
See page 133 for Explanation of Figure Sets

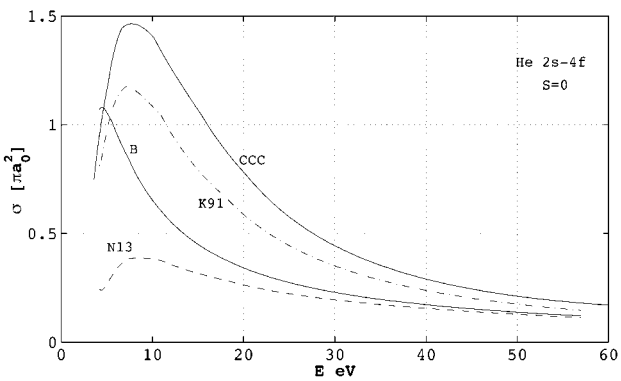


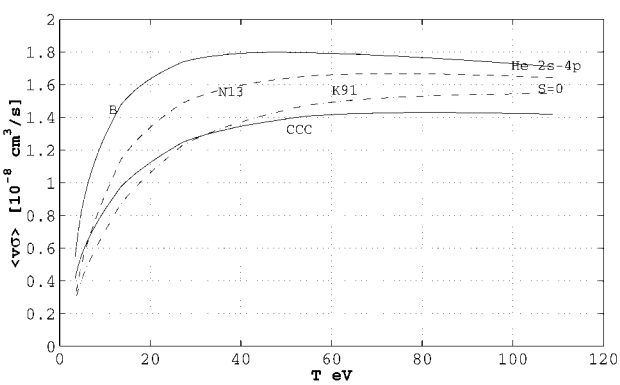












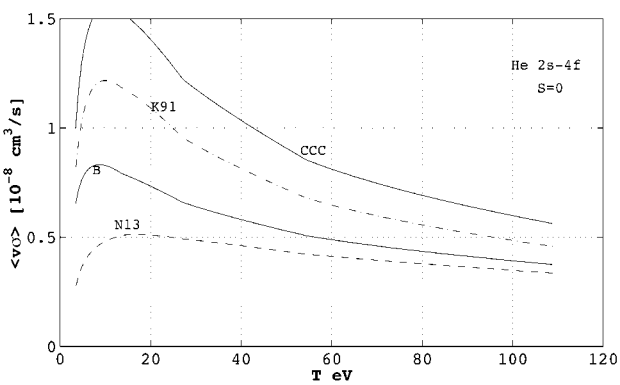
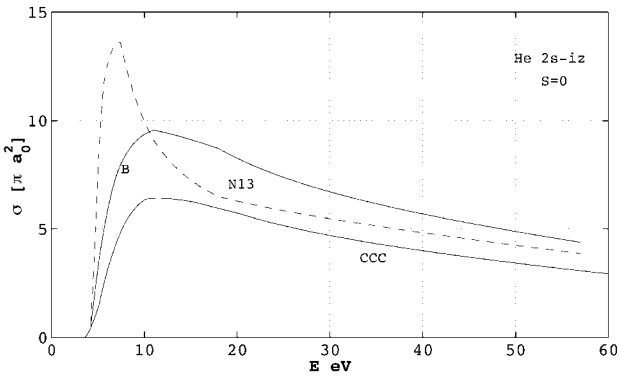
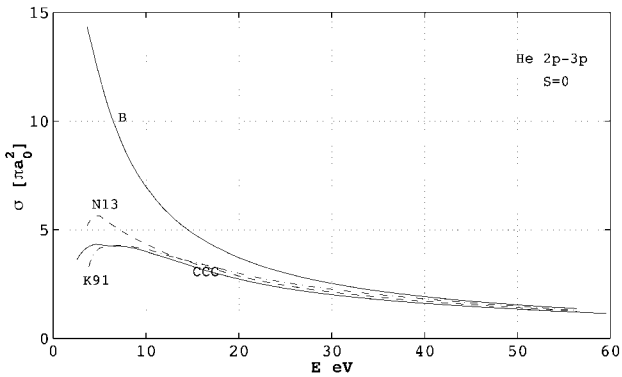
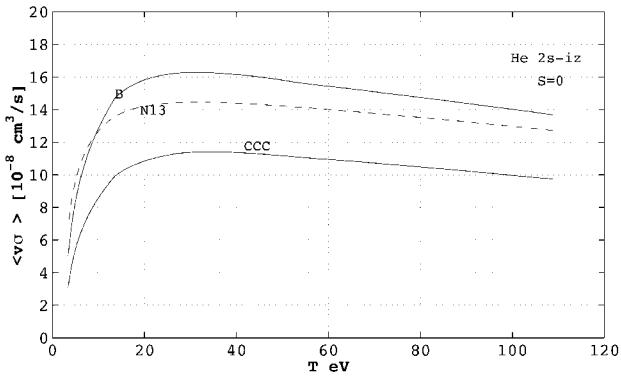


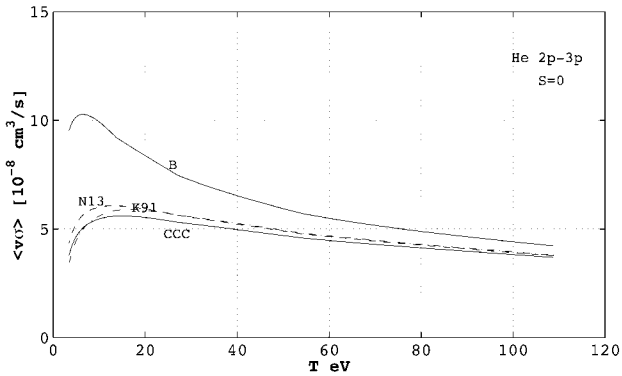
FIGURE SET I. Comparison of Electron Impact Cross Sections and Rate Coefficients for Transitions between Singlet States from Different Calculations

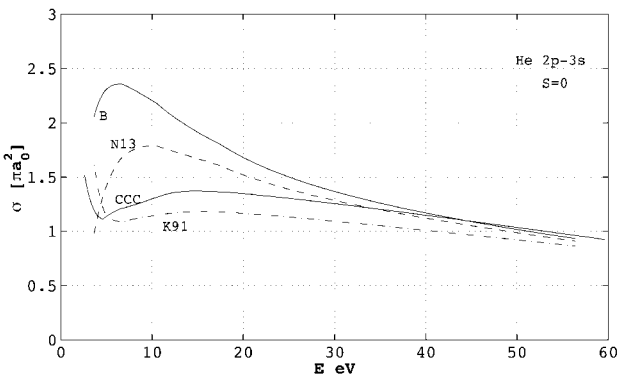
See page 133 for Explanation of Figure Sets

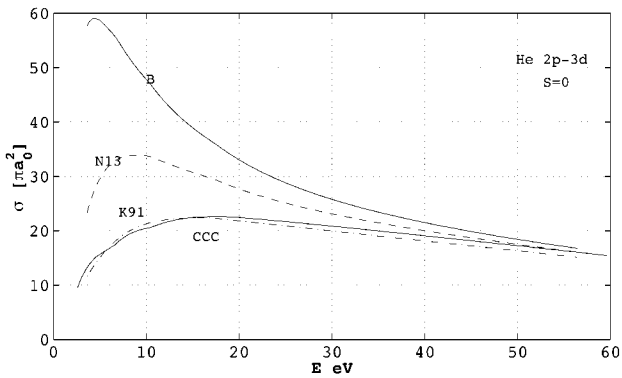


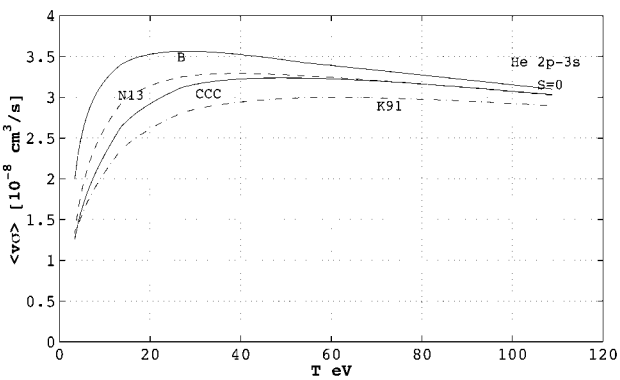












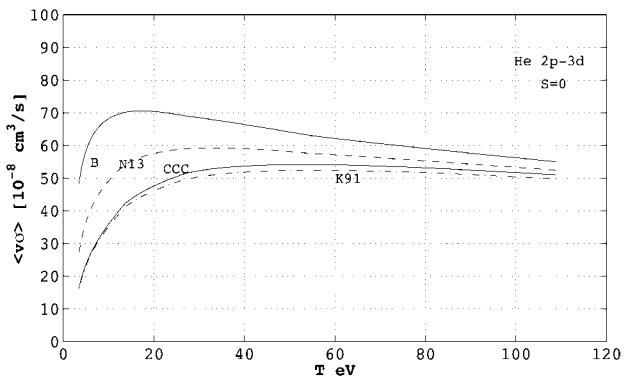
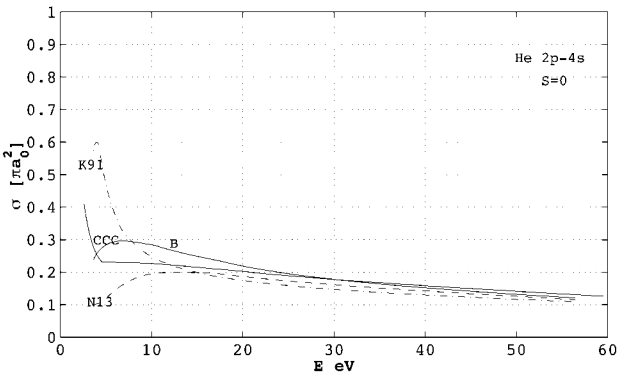
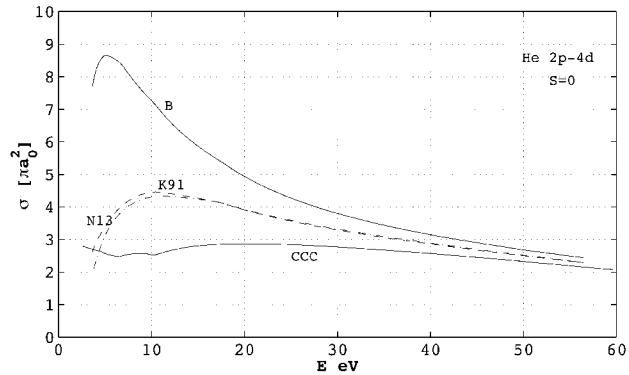
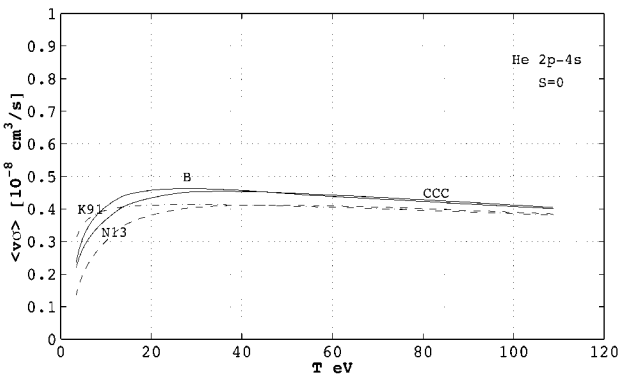


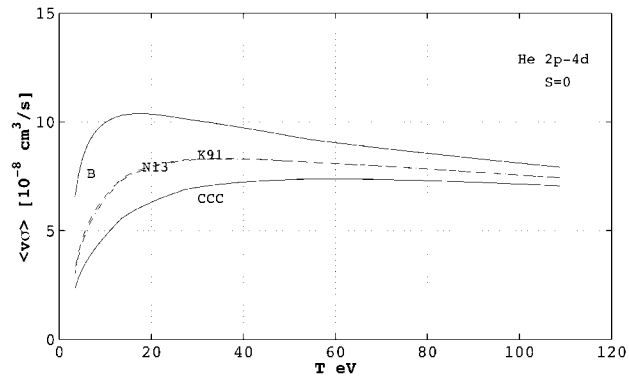
FIGURE SET I. Comparison of Electron Impact Cross Sections and Rate Coefficients for Transitions between Singlet States from Different Calculations

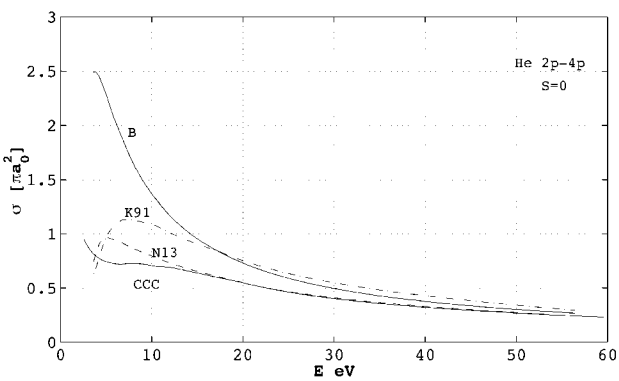
See page 133 for Explanation of Figure Sets

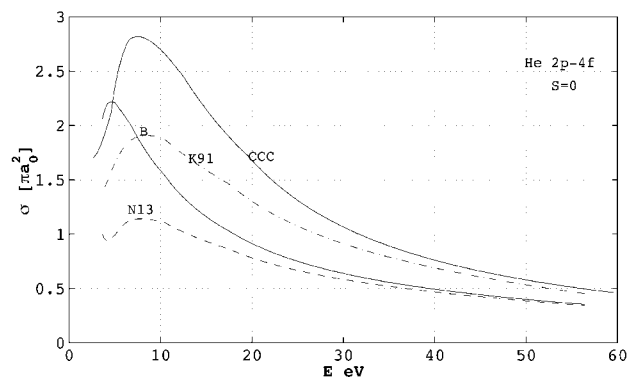


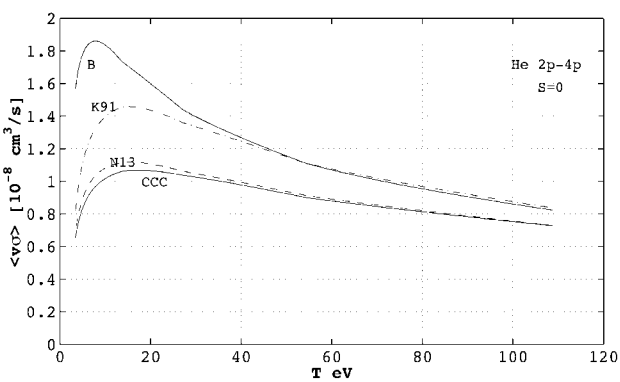












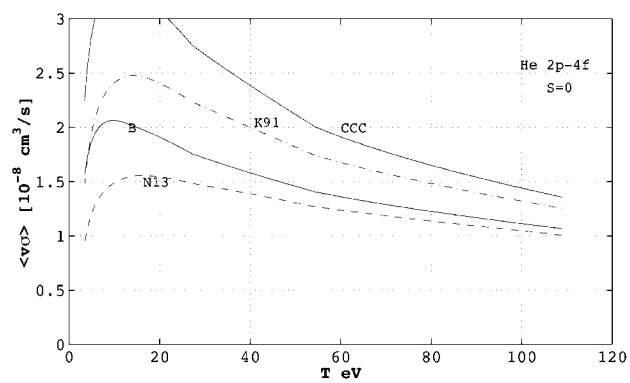
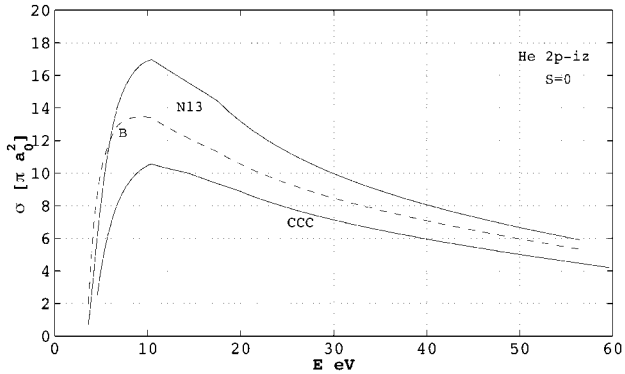


FIGURE SET I. Comparison of Electron Impact Cross Sections and Rate Coefficients for Transitions between Singlet States from Different Calculations

See page 133 for Explanation of Figure Sets



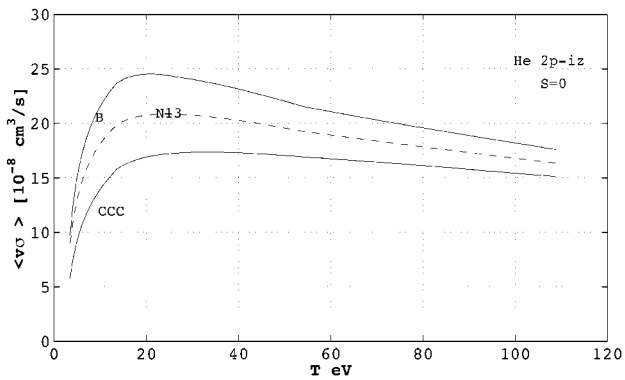
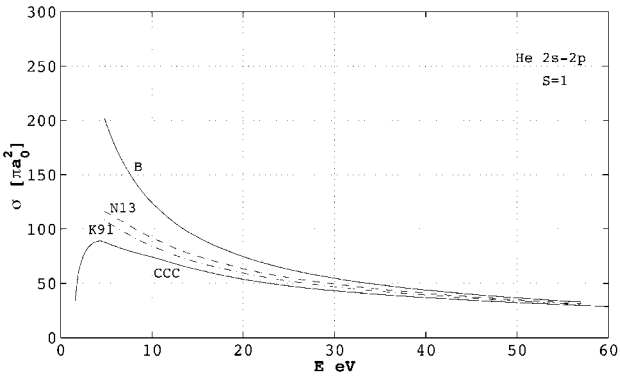
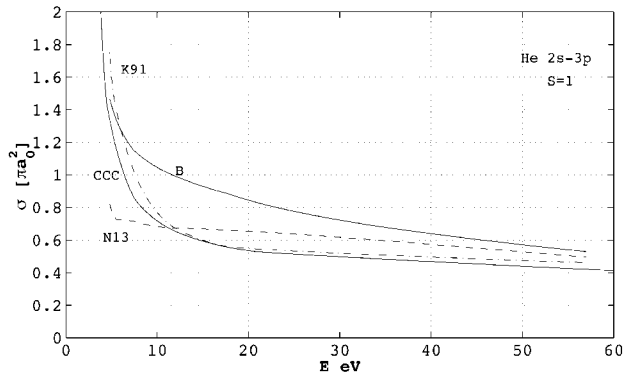
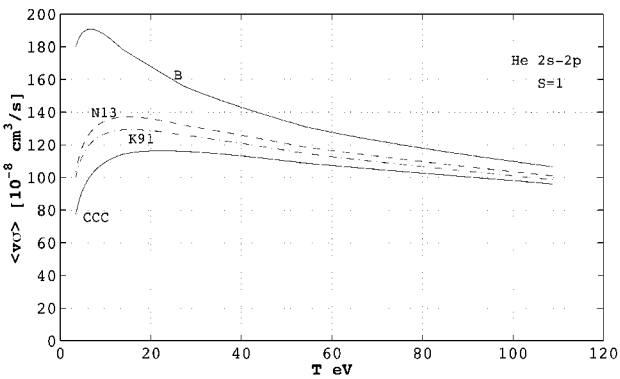


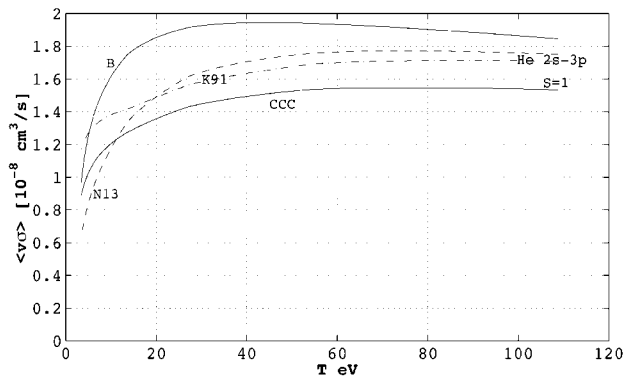
FIGURE SET II. Comparison of Electron Impact Cross Sections and Rate Coefficients for Transitions between Triplet States from Different Calculations

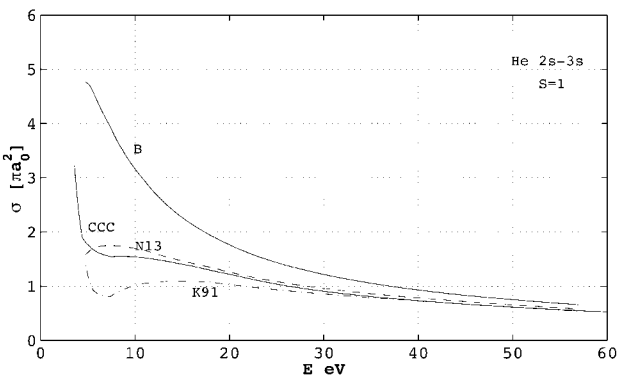
See page 133 for Explanation of Figure Sets

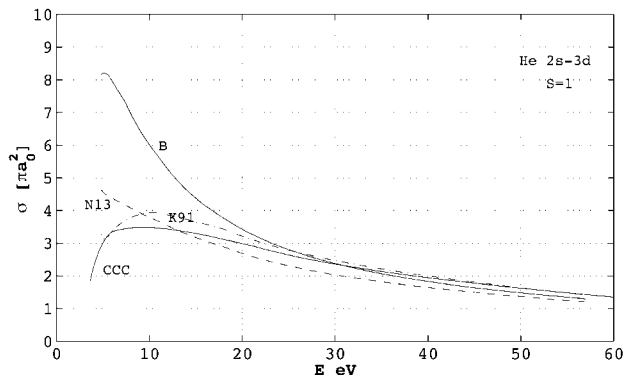


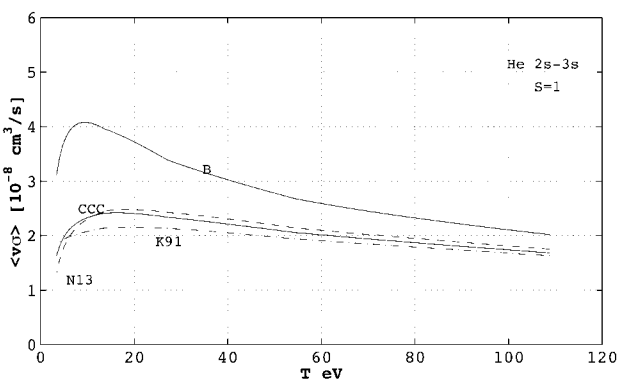












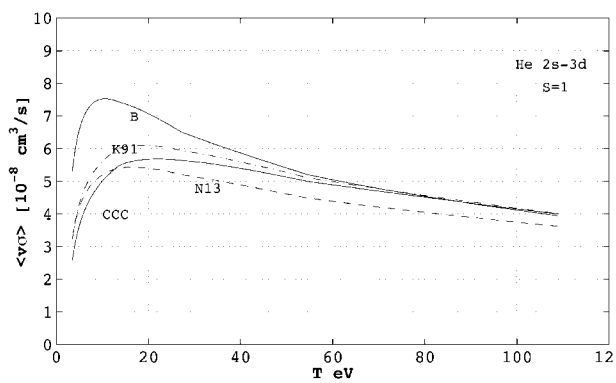
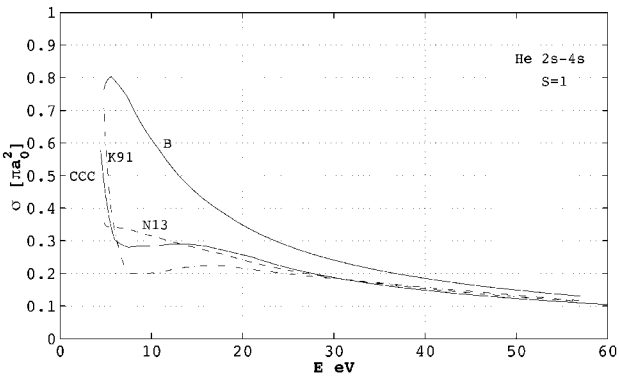
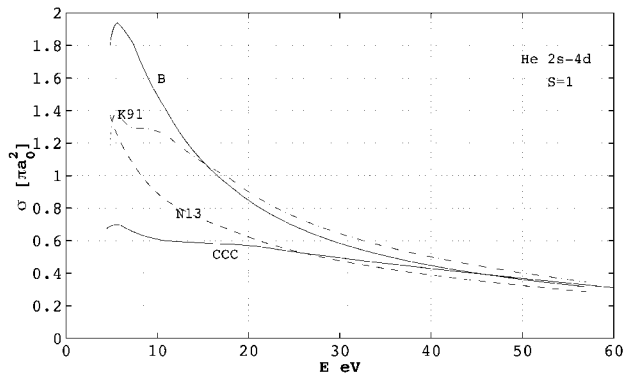
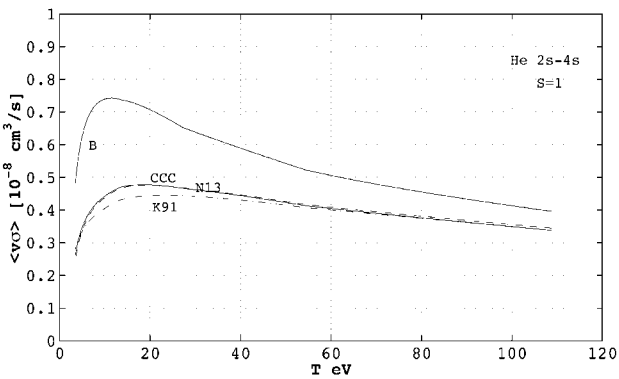


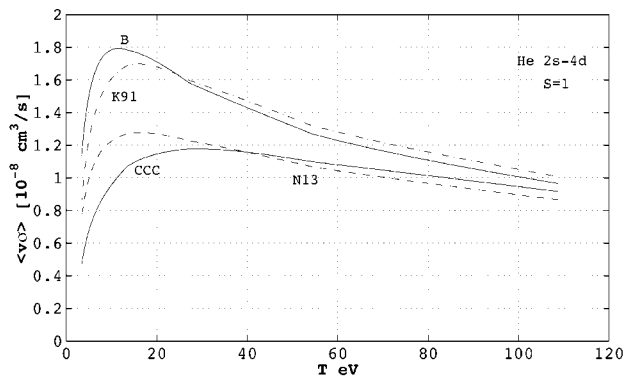
FIGURE SET II. Comparison of Electron Impact Cross Sections and Rate Coefficients for Transitions between Triplet States from Different Calculations

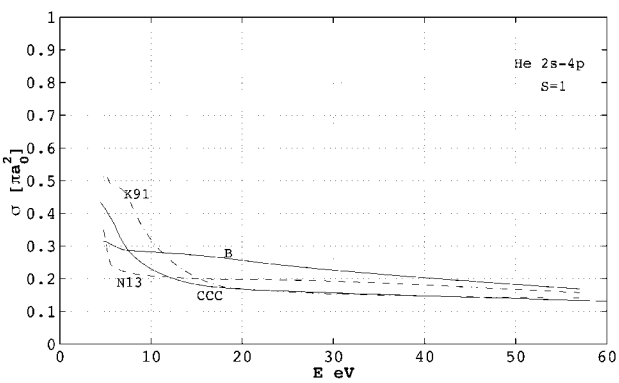
See page 133 for Explanation of Figure Sets

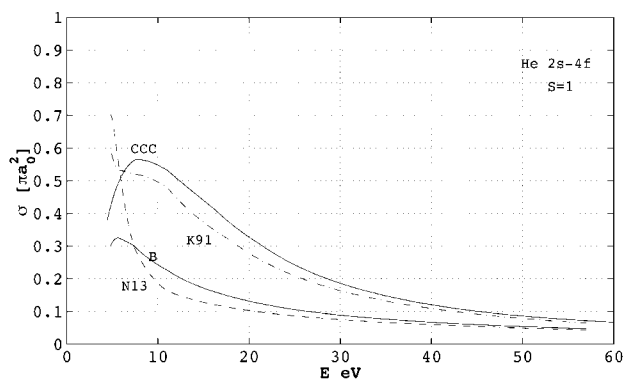


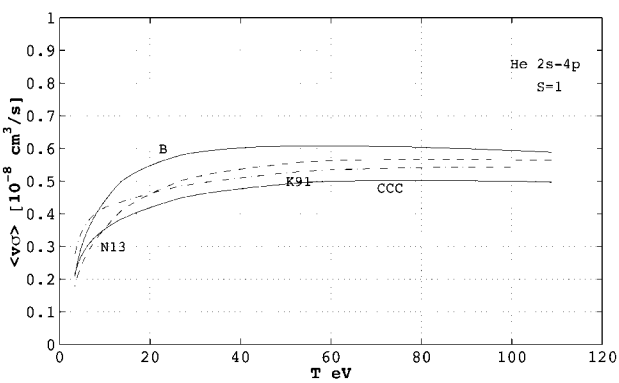












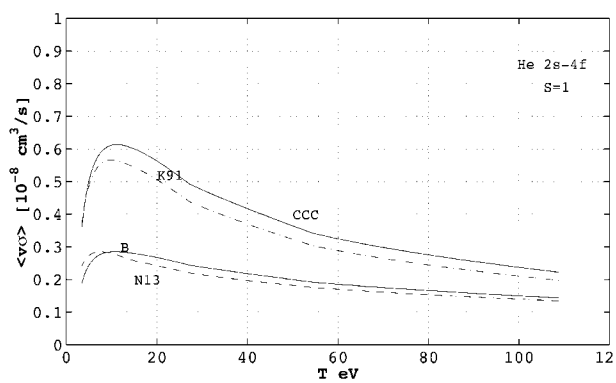
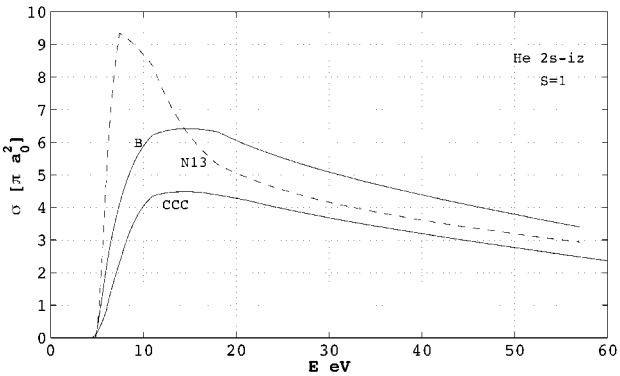
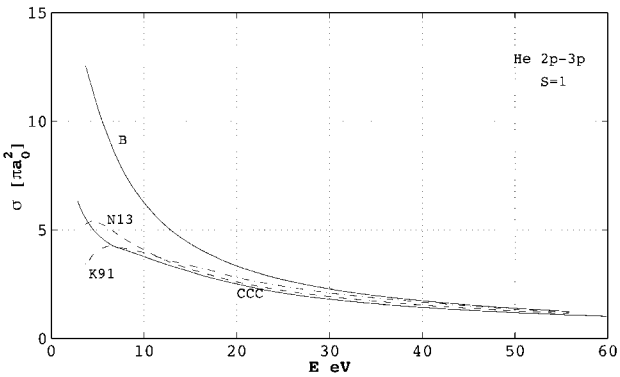
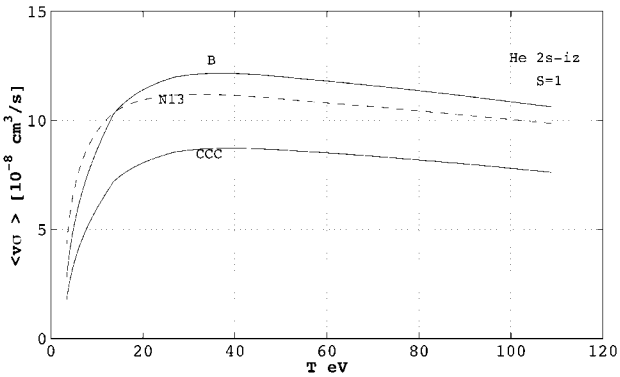


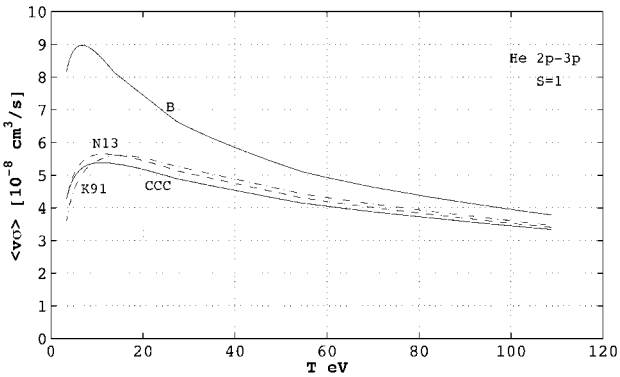
FIGURE SET II. Comparison of Electron Impact Cross Sections and Rate Coefficients for Transitions between Triplet States from Different Calculations

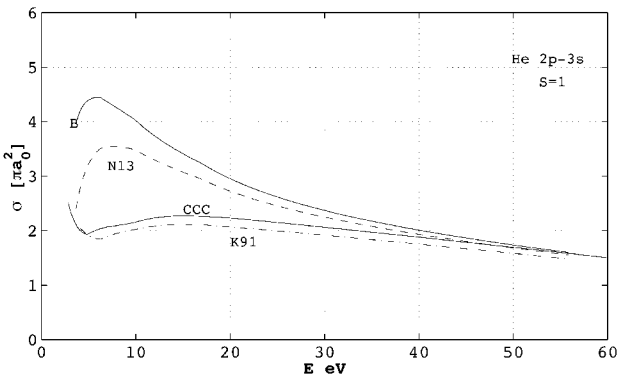
See page 133 for Explanation of Figure Sets

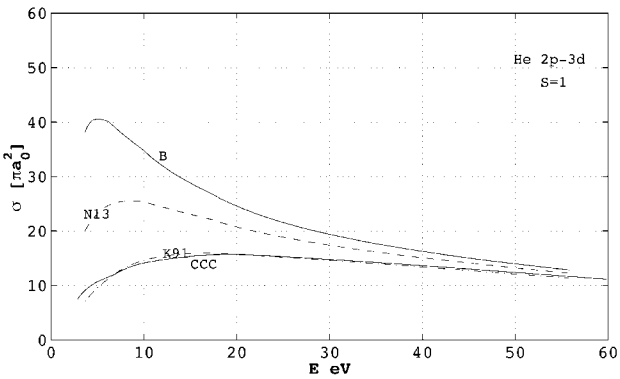


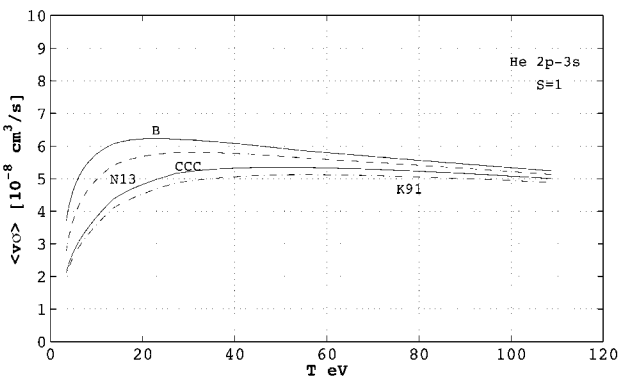












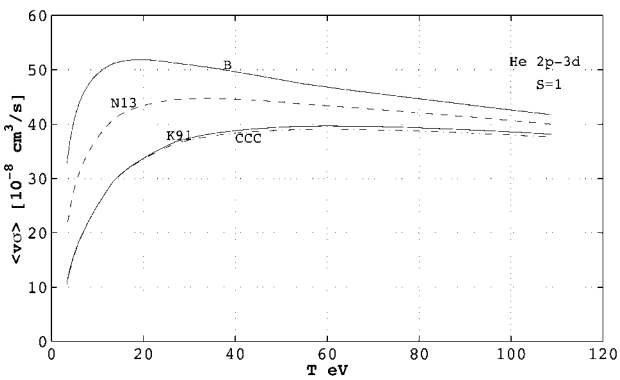
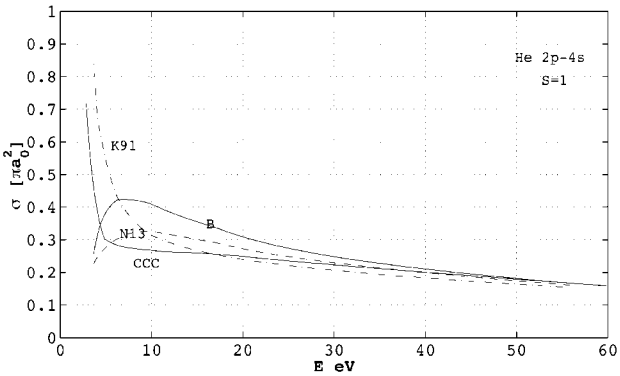
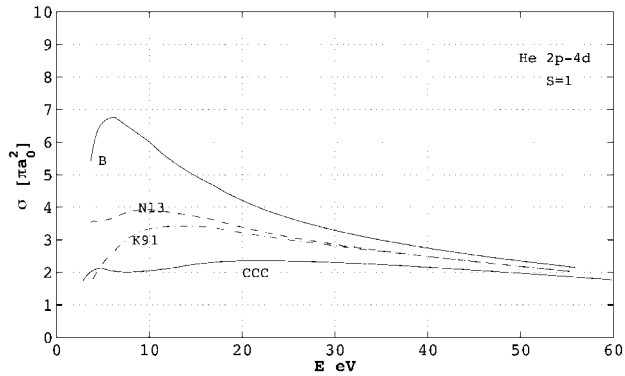
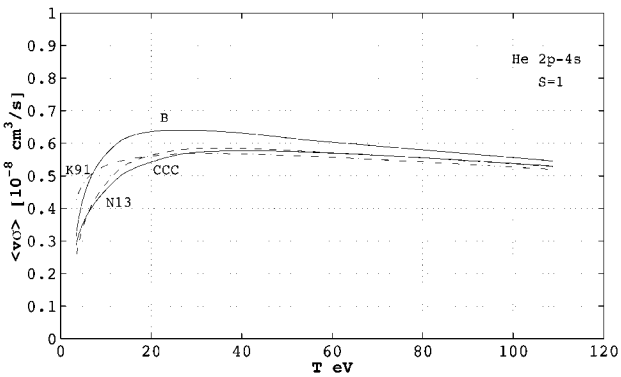


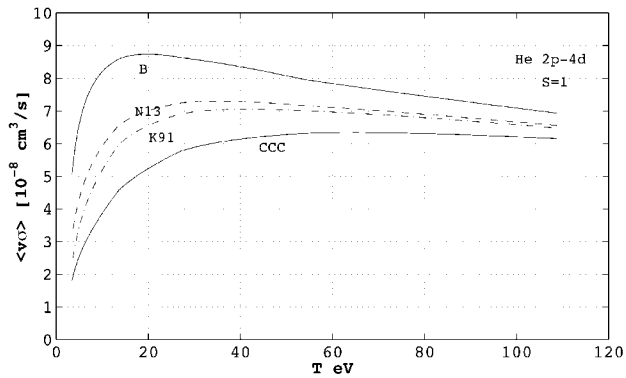
FIGURE SET II. Comparison of Electron Impact Cross Sections and Rate Coefficients for Transitions between Triplet States from Different Calculations

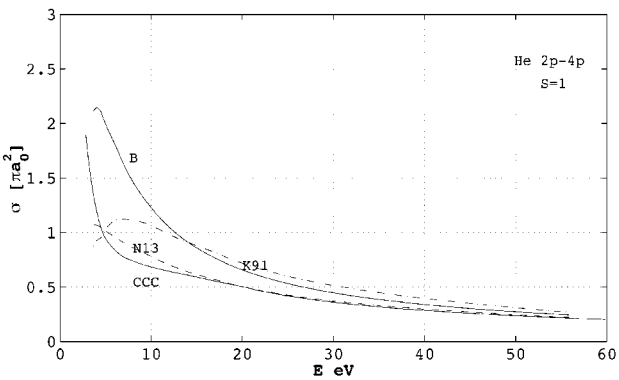
See page 133 for Explanation of Figure Sets

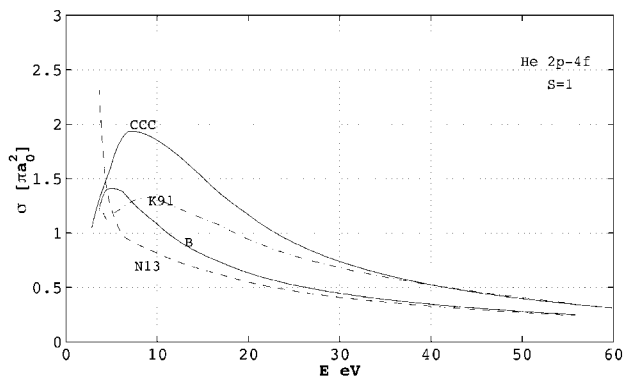


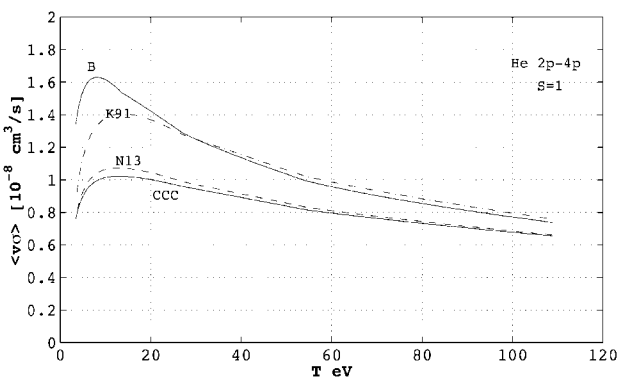












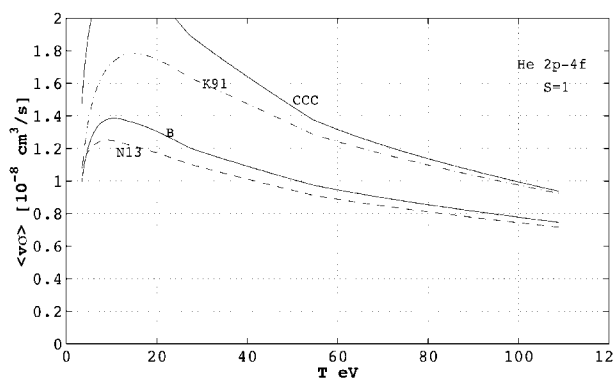


FIGURE SET II. Comparison of Electron Impact Cross Sections and Rate Coefficients for Transitions between Triplet States from Different Calculations

See page 133 for Explanation of Figure Sets