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Electric Charge State Changing Collisions of Hydrogen and Helium with Low-Z Impurity Particles Part I. Charge Exchange Processes

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Electric Charge State Changing Collisions of Hydrogen and Helium with Low-Z Impurity Particles

Part I. Charge Exchange Processes

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Contents

1. Introduction 2
2. Theoretical approaches and methods of calculations 4
3. Approximating Formula 8
4. Sample Program 9
References 12
$H^+ + Li^{k+} \rightarrow H^0 + Li^{(k+1)+}$, k = 0, 1, 2 13
$H^0 + Li^{k+} \rightarrow H^+ + Li^{(k-1)+}$, k = 1, 2, 3 15
$He^+ + Li^{k+} \rightarrow He^0 + Li^{(k+1)+}$, k = 0, 1, 2 17
$He^{2+} + Li^{k+} \rightarrow He^+ + Li^{(k+1)+}$, k = 0, 1, 2 19
$He^0 + Li^{k+} \rightarrow He^+ + Li^{(k-1)+}$, k = 1, 2, 3 21
$He^+ + Li^{k+} \rightarrow He^{2+} + Li^{(k-1)+}$, k = 1, 2, 3 23
$H^+ + Be^{k+} \rightarrow H^0 + Be^{(k+1)+}$, k = 0, 1, 2, 3 25
$H^0 + Be^{k+} \rightarrow H^+ + Be^{(k-1)+}$, k = 1, 2, 3, 4 28
$He^+ + Be^{k+} \rightarrow He^0 + Be^{(k+1)+}$, k = 0, 1, 2, 3 31
$He^{2+} + Be^{k+} \rightarrow He^+ + Be^{(k+1)+}$, k = 0, 1, 2, 3 34
$He^0 + Be^{k+} \rightarrow He^+ + Be^{(k-1)+}$, k = 1, 2, 3, 4 37
$He^+ + Be^{k+} \rightarrow He^{2+} + Be^{(k-1)+}$, k = 1, 2, 3, 4 40
$H^+ + B^{k+} \rightarrow H^0 + B^{(k+1)+}$, k = 0, 1, 2, 3, 4 43
$H^0 + B^{k+} \rightarrow H^+ + B^{(k-1)+}$, k = 1, 2, 3, 4, 5 47
$He^+ + B^{k+} \rightarrow He^0 + B^{(k+1)+}$, k = 0, 1, 2, 3, 4 51
$He^{2+} + B^{k+} \rightarrow He^+ + B^{(k+1)+}$, k = 0, 1, 2, 3, 4 55
$He^0 + B^{k+} \rightarrow He^+ + B^{(k-1)+}$, k = 1, 2, 3, 4, 5 59
$He^+ + B^{k+} \rightarrow He^{2+} + B^{(k-1)+}$, k = 1, 2, 3, 4, 5 63
$H^+ + C^{k+} \rightarrow H^0 + C^{(k+1)+}$, k = 0, 1, 2, 3, 4, 5 67
$H^0 + C^{k+} \rightarrow H^+ + C^{(k-1)+}$, k = 1, 2, 3, 4, 5, 6 71
$He^+ + C^{k+} \rightarrow He^0 + C^{(k+1)+}$, k = 0, 1, 2, 3, 4, 5 75
$He^{2+} + C^{k+} \rightarrow He^+ + C^{(k+1)+}$, k = 0, 1, 2, 3, 4, 5 79
$He^0 + C^{k+} \rightarrow He^+ + C^{(k-1)+}$, k = 1, 2, 3, 4, 5, 6 83
$He^+ + C^{k+} \rightarrow He^{2+} + C^{(k-1)+}$, k = 1, 2, 3, 4, 5, 6 87
$H^+ + Ne^{k+} \rightarrow H^0 + Ne^{(k+1)+}$, k = 0, …, 7 91
$H^0 + Ne^{k+} \rightarrow H^+ + Ne^{(k-1)+}$, k = 1, …, 10 96
$He^+ + Ne^{k+} \rightarrow He^0 + Ne^{(k+1)+}$, k = 0, …, 9 103
$He^{2+} + Ne^{k+} \rightarrow He^+ + Ne^{(k+1)+}$, k = 0, …, 9 110
$He^0 + Ne^{k+} \rightarrow He^+ + Ne^{(k-1)+}$, k = 1, …, 10 117
$He^+ + Ne^{k+} \rightarrow He^{2+} + Ne^{(k-1)+}$, k = 1, …, 10 124

Electric Charge State Changing Collisions of Hydrogen and Helium with Low-Z Impurity Particles

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Abstract

This report contains a collection of practical approximating formulas for one-electron loss and one-electron capture cross-sections of ion-atom and ion-ion collisions of H^0, H^+, He^0, He^+ and He^{2+} particles with Li, Be, B, C and Ne neutral atoms and all of their positive ions. The report consists of two parts treating charge exchange and ion impact ionization collisions respectively. The results are mainly based on theoretical calculations by CAPTURE, CDW, and ARSENY numerical codes. Independent experimental and theoretical results were taken into account where available. The primary objective of this work is to provide the necessary background concerning atomic processes essential for localized fusion plasma diagnostics based on light impurity pellet injection. As for passive line-integral diagnostics of energetic proton and α-particle energy distributions, impurities contribute to both the source function and the attenuation rate of neutral atom fluxes escaping from the plasma. Impurities also play a significant role in the high energy neutral atom heating beam stopping in the plasma. The analytic cross-section fits for a wide energy range presented here may be useful in the numerical modeling and in the experimental data analysis.

Keywords: charge exchange cross-sections, fusion plasma diagnostics, neutral particle analysis, pellet charge exchange method, neutral beam injection

1. Introduction

In controlled nuclear fusion research cross-section data are required for atomic collisions that lead to a change of electric charge state of Hydrogen and Helium particles in pure plasmas and in the presence of impurities. In particular, the knowledge of cross-sections as functions of energy is needed for the quantitative analysis of (a) magnetically confined plasma heating by high energy neutral particle beam injection and (b) passive and impurity pellet-based active diagnostics of plasma ion distribution by escaping neutral particle flux measurements. The required cross-section data for processes involving impurities are often not available in the existing literature. This explains the motivation and determines the scope of the present report.

In passive diagnostic methods naturally occurring neutral particle fluxes are measured. The local source function for neutral atoms of energy E within the plasma

$$g(E,\rho) = n_i(\rho) f_i(E,\rho) \sum_l n^{(l)}(\rho) \left\langle \sigma \mathrm{v} \right\rangle^{(l)} \tag{1}$$

is expressed via the local plasma ion distribution $n_i(\rho) f_i(E,\rho)$ and the sum of electron capture frequencies over all targets. Radial profiles of target densities $n^{(l)}(\rho)$ and the knowledge of electron capture rate coefficients $\left\langle \sigma \mathrm{v} \right\rangle^{(l)}$ are required for the processes $H^+ \rightarrow H^0$ in case when the proton distribution is studied, or $He^{2+} \rightarrow He^+$, $He^+ \rightarrow He^0$ and $He^{2+} \rightarrow He^0$ in case of α-particle distribution studies.

In the local active diagnostic method, referred to as Pellet Charge eXchange (PCX), an ablating solid impurity pellet is used as a dense target for electron capture by fast ions of a fusion plasma. Consider a monoenergetic flux $\Gamma_1(x,E)\big|_{x=0}$ [$cm^{-2}s^{-1}$] of fast protons H^+ of energy E entering the cold dense cloud surrounding an ablating solid pellet; x is the transversal distance across the cloud. The total hydrogen flux within the cloud will consist of H^0 and H^+ fractions

$$\Gamma_i(x,E) = F_i(x,E)\Gamma_1(0,E), \; i = 0, \; 1 \tag{2}$$

due to the charge changing collisions with cloud particles. The conservation of the total number of hydrogen particles requires that the dimensionless non-negative functions $F_i(x,E), \; i = 0, \; 1$ satisfy the condition $F_0(x,E) + F_1(x,E) = 1$. For the neutral fraction the boundary condition is $F_0(x,E)\big|_{x=0} = 0$. Densities $n_l(x)$ of the pellet cloud atomic and ionic species are expressed via the cloud density function $n_{\mathrm{cl}}(x)$ as $n_l(x) = \kappa_l n_{\mathrm{cl}}(x)$. The dimensionless non-negative proportionality

coefficients κ_l obviously satisfy the condition $\sum_l \kappa_l = 1$. The electron density $n_e(x) = \kappa_e n_{\rm cl}(x)$ is obtained from the cloud plasma quasineutrality condition. Denote $\sigma_{1\to 0}(E) = \sum_l \kappa_l \sigma_l^{1\to 0}(E)$ the total effective cross-section of electron capture by H^+ and $\sigma_{0\to 1}(E) = \sum_l \kappa_l \sigma_l^{0\to 1}(E)$ the total effective cross-section of electron loss by H^0. The sums run over all possible electron capture and electron loss processes, respectively, and κ_l are the proportions of the corresponding target particles of the cloud. Let Ξ [cm^{-2}] be the line integral pellet ablation cloud density representing the number of target particles per cm^2 along the hydrogen path within the cloud:

$$\Xi(x) = \int_0^x n_{\rm cl}(\tilde{x}) d\tilde{x}. \tag{3}$$

The rate equations

$$\frac{dF_0}{d\Xi} = \sigma_{1\to 0} F_1 - \sigma_{0\to 1} F_0 \text{ and } \frac{dF_1}{d\Xi} = \sigma_{0\to 1} F_0 - \sigma_{1\to 0} F_1 \tag{4}$$

were solved in a general form in [1]. The neutral fraction is

$$F_0(x,E) = F_0^{\infty}(E)\left(1 - e^{-(\sigma_{0\to 1}(E)+\sigma_{1\to 0}(E))\Xi(x)}\right) \xrightarrow{\Xi(x)\to\infty} F_0^{\infty}(E), \tag{5}$$

where

$$F_0^{\infty}(E) = \sigma_{1\to 0}(E) \big/ \left(\sigma_{0\to 1}(E) + \sigma_{1\to 0}(E)\right) \tag{6}$$

is the equilibrium value attained after a sufficient number of collisions. Thus, the proportions κ_l of cloud species and the cross-sections of relevant charge changing collision processes are needed to calculate the neutral hydrogen fraction. Neutral helium fraction can be calculated in an analogous way by solving the corresponding rate equations as shown in [1].

The neutral flux attenuation in the plasma column enters multiplicatively in the form of Poisson exponent determined by $\lambda_{\rm mfp}(E, \rho)$, i.e. the local mean free path of a neutral atom with respect to all electron loss reactions $H^0 \to H^+$ or $He^0 \to He^+$, $He^0 \to He^{2+}$. From the practical viewpoint it can be calculated as

$$\lambda_{mfp}^{-1}(E, \rho) = n_e(\rho)\sigma_s(E, \rho) \tag{7}$$

using a suitable approximating formula for the total neutral hydrogen or helium stopping cross section $\sigma_s(E, \rho)$ in magnetically confined plasma in the presence of certain impurity species. Practical formulas for hydrogen total stopping cross-section were developed in [2].

The knowledge of cross-sections of the charge changing atomic collision processes is required in a wide energy range. This report consists of two parts covering charge exchange and ion impact ionization. One-electron processes are considered.

2. Theoretical approaches and methods of calculations

The wide range of collision energies (1 keV/a.m.u. – 1 MeV/a.m.u.) makes it impossible to use a general method for the calculation of the capture cross sections: the ratio of the velocity of the outer (active) electron to the collisional velocity divides this range into two regions – adiabatic region (where this ratio is larger than unity) and Born region (the opposite case).

For the calculations of the capture cross sections of low energy ion-atom collisions the advanced adiabatic approach developed by E.A. Solov'ev [3-5] has been used (code ARSENY). The collisions of the intermediate and high energy were treated in Born approach: normalized Brinkman-Kramers (BK) approximation in the impact parameter representation [6] (code CAPTURE) and Coulomb Distorted Wave (CDW) approximation [7] (codes CDW and CDW2) were used.

The following is a brief description of the numerical codes used in the calculations.

2.1. Code ARSENY

Code ARSENY is based on the method of hidden crossings. In the adiabatic approximation inelastic transitions occur in the regions of the closest approach of potential curves and are decomposed into a sequence of individual two-level transitions via hidden crossings. Hidden crossings arise when the full-dimensional classical trajectory of the electron collapses into an unstable periodic orbit. They are invisible on the plot of the adiabatic potential curves at the real value of the adiabatic parameter R (inter-nuclear separation), and require the direct calculation in the complex R-plane. Code ARSENY (having as an input the charges of the nuclei or the effective charges, the nl quantum numbers of the initial state of the active electron, the list of the energies of the colliding particles and the basis size) calculates adiabatic potential curves of two Coulomb center problem in complex R-plane. Then it searches all branch points and calculates the corresponding Stueckelberg parameter

$$\Delta_{pq} = \left| \operatorname{Im} \int_{\operatorname{Re} R_c}^{R_c} \left[E_p(R) - E_q(R)\right] \frac{dR}{V(R,b)} \right| , \qquad (8)$$

where p and q is the set of quantum numbers of the final and initial atomic states, R_c is a complex branch point, E_p and E_q are energies of the final and initial atomic states, respectively, $V(R,b)$ is the radial internuclear velocity and b is the impact parameter. The probability as a function of L (nuclear angular momentum) for the entire set of nonadiabatic transitions is calculated as

$$P_{pq} = e^{-2\Delta_{pq}} \quad . \tag{9}$$

Then the S-matrix is calculated as a product of elementary S-matrices for the individual transitions induced by the separated branch points. Finally, the cross sections are calculated as a sum over L:

$$\sigma_{qq} = \frac{\pi}{K_q^2} \sum_{L=0}^{\infty} (2L+1) \left| 1 - S_{qq}^{(L)} \right|^2 , \tag{10}$$

for elastic scattering and

$$\sigma_{pq} = \frac{\pi}{K_q^2} \sum_{L=0}^{\infty} (2L+1) \left| S_{pq}^{(L)} \right|^2 , \tag{11}$$

for inelastic transition, where $S_{pq}^{(L)}$ are the S-matrix elements and

$$K_q = \sqrt{2M(\varepsilon - E_q(\infty))} , \tag{12}$$

M is the reduced mass of nuclei, $E_q(\infty)$ are the energy levels of separated atoms and ε is the energy of the system in the center of masses. This yields simultaneously all partial cross sections for arbitrary initial and final states in a given molecular-orbital basis set.

The range of impact energies in which the adiabatic approximation is valid depends strongly on the actual process being considered. In the case of slow atomic collisions we can extrapolate adiabatic approximation up to the values of impact velocity v at which the transition probability P_{pq} becomes comparable with unity, i.e., up to the maximum of the cross section for a given channel.

2.2. Code CAPTURE

The CAPTURE code is aimed at calculating the probabilities $P(b,\mathrm{v})$ and cross sections $\sigma(\mathrm{v})$ for single-electron capture in ion-atom and ion-ion collisions. It was created on the basis of normalized Brinkman-Kramers (BK) approximation in the impact parameter representation. The

total cross section is given by the sum of the partial cross sections σ_n for all the possible states with the principal quantum numbers n as a function of collision velocity v:

$$\sigma_{tot}(\mathrm{v}) = \sum_{\gamma}\sum_{n_0}^{n_{cut}} \sigma_{\gamma n}(\mathrm{v}), \qquad \sigma_{\gamma n}(\mathrm{v}) = 2\pi\int_0^{\infty} P_{\gamma n}^{(N)}(b,\mathrm{v})bdb,$$
$$P_{\gamma n}^{(N)}(b,\mathrm{v}) = \frac{P_{\gamma n}(b,\mathrm{v})}{1+\sum_{n'=n_0}^{n_{\max}} P_{\gamma n'}(b,\mathrm{v})}, \tag{13}$$

where $P_{\gamma n}(b,\mathrm{v})$ denotes the electron capture probability from the target shell γ into the n-state of the resulting ion, including the ground state n_0, at the impact parameter (b) and the collision velocity (v) in the BK approximation, n_{max} is the maximum principal quantum number accounted for probability. The summation is also made over all shells of the target γ. Here N refers to the normalized probability and n_{cut} is a parameter depending on the target density: for low-dense targets it is infinity while in a dense target it is strongly reduced due to the so-called target-density effects.

In the CAPTURE code, the hydrogenic wave functions P_{nl}^{H} are used to get wave functions for particle with a charge q:

$$P_{nl}^{q}(r) = Z_{scr}^{1/2}\, P_{nl}^{H}(Z_{scr}r), \quad Z_{scr} = n\sqrt{2I_{nl}(q)}\,, \tag{14}$$

where Z_{scr} is the effective charge accounting for the screening effects for the nl shell and I_{nl} denotes the binding energy of the target atom (ion), or the resulting ion $X^{(q-1)+}$. The hydrogenic wave functions here are used because of the following three main reasons: at relatively low energies, the role of excited hydrogenic states is very large; at high energies, the inner-shell target electrons close to nucleus are mainly captured and, therefore, can be described by the hydrogenic functions; it is possible to get the capture probabilities in a closed analytical form expressed over the McDonald functions $K_n(x)$ and to include excited states with n_{max} up to very high n ~1000.

2.3. Codes CDW and CDW2

Codes CDW and CDW2 are based on the CDW method proposed by Cheshire [8]. An extensive discussion of this method and its generalization to complex system has been given in [9]. The main feature of this theory is a ‘single’ electron approximation: during the collision the active electron experiences transition while all other electrons are ‘spectators’ (their orbitals are frozen

during the collision). Initial and final orbitals of the active electron are described in terms of a combination of Slater orbitals.

The total cross section for the capture of the electron from the initial orbital *i* to the final orbital *f* in CDW approximation is given by:

$$Q_{if}(a_0^2) = \frac{1}{2\pi v^2} \int_0^\infty \eta \, d\eta \, \left| T_{if}(\eta) \right|^2 , \tag{15}$$

$$T_{if}(\eta) = - N(v) \, \mathbf{I}_x \cdot \mathbf{I}_s \ , \tag{16}$$

where

$$N(v) = \Gamma(1 - \mathrm{i}v_\mathrm{A}) \Gamma(1 - \mathrm{i}v_\mathrm{B}) \exp\{(\pi/2)(v_\mathrm{A} + v_\mathrm{B}\} \tag{17}$$

and *v* is the relative velocity. Here Γ designates the gamma function. One has:

$$v_\mathrm{A,B} = \xi_\mathrm{A,B} / v, \quad \xi_\mathrm{A} = (-2n_f^2 \, \varepsilon_f)^{1/2}, \quad \xi_\mathrm{B} = (-2n_i^2 \, \varepsilon_i)^{1/2}, \tag{18}$$

n_i ε_i and n_f ε_f are the principal quantum number and orbital energy of the initial and final states, correspondingly, and $\xi_\mathrm{A,B}$ correspond to effective charges as discussed in [9].

The integrals $\mathbf{I}_\mathrm{x}$ and $\mathbf{I}_\mathrm{s}$ take the form:

$$\mathbf{I}_x = \int dx \, e^{\mathrm{i}\mathbf{p}\cdot\mathbf{x}} \left[\nabla_x \phi_i(x) \right]_1 F_1(\mathrm{i}v_\mathrm{B}, 1, \mathrm{i}\,\mathbf{v}\cdot\mathbf{x} + \mathrm{i}vx), \tag{19}$$

$$\mathbf{I}_s = \int ds \, e^{\mathrm{i}\mathbf{q}\cdot\mathbf{s}} \, \phi_f^*(s) \nabla_{s\ 1} F_1(\mathrm{i}v_\mathrm{A}, 1, \mathrm{i}\,\mathbf{v}\cdot\mathbf{s} + \mathrm{i}vs), \tag{20}$$

$$\mathbf{p} = -\boldsymbol{\eta} - \beta_1 \hat{\mathbf{v}}, \quad \mathbf{q} = -\boldsymbol{\eta} - \beta_2 \hat{\mathbf{v}}, \quad \hat{\boldsymbol{\eta}} \cdot \hat{\mathbf{v}} = 0, \tag{21}$$

$$\beta_1 = \alpha + v/2, \quad \beta_2 = \alpha - v/2, \quad \alpha = (\varepsilon_i - \varepsilon_f)/v. \tag{22}$$

The initial (ϕ_i) and final (ϕ_f) orbitals of the active electron are supposed to be of the form:

$$\phi_{i,f}(r) = \sum_{\gamma} C_{\gamma}^{i,f}\ r^{n_\gamma - 1} e^{-\lambda_\gamma r} Y_{l_{i,f}, m_{i,f}}(\hat{\mathbf{r}}), \tag{23}$$

with

$$C_{\gamma}^{i,f} = b_{\gamma}^{i,f} \left[(2n_\gamma)!\right]^{-1/2} (2n_\gamma)^{n_\gamma + 1/2}. \tag{24}$$

In our calculations the initial orbitals of active electron were described by the wave functions given by Clementi and Roetti [10] and the charge (or effective charge) of the projectile was used in the definition of the final hydrogenic orbitals (code CDW2). In case of the capture from H or He^+ targets hydrogenic wave functions were used to describe initial and final orbitals of the active electron (code CDW).

3. Approximating Formula

Cross-section σ, [cm^2] as a function of specific energy $\mathcal{E} = E/m$ [keV/a.m.u.] is expressed for all reactions by the following formula

$$\sigma(\mathcal{E}) = \exp\left(\sum_{i=0}^{15} A_i T_i(\xi) \right), \tag{25}$$

where

$$\xi = 2\left(\frac{\ln \mathcal{E} - \ln \mathcal{E}_{\min}}{\ln \mathcal{E}_{\max} - \ln \mathcal{E}_{\min}} \right)^{\gamma} - 1 \tag{26}$$

and $T_i(\xi)$ is the *i*th degree Chebyshev polynomial of the first kind. The 19 parameters required to calculate the cross-section for each reaction are given in this report. The order of the parameters is as follows.

$\mathcal{E}_{min}$	lower limit of the approximating formula applicability range
$\mathcal{E}_{max}$	upper limit of the approximating formula applicability range
γ	index of power in the nonlinear variable change formula
A_0	coefficient of $T_0(\xi)$
A_1	coefficient of $T_1(\xi)$
.	
.	
.	
A_{15}	coefficient of $T_{15}(\xi)$

For those reactions, where independent data are available, it is shown on the plots together with the calculation results and the approximating curve. Bibliographic sources are listed directly on each plot.

4. Sample Program

Cross-section calculation is a straightforward implementation of (25) and (26). Below is a sample program that calculates $H^+ + C^0 \rightarrow H^0 + C^+$ charge exchange cross-section at `N` energy values equidistant in logarithmic scale in the range between `Eleft` and `Erght`. Similar source codes are given in C++ and in Fortran.

```
/*  Sample program in C++  ------------------------------------------*/

#include <numeric>
#include <vector>
#include <cmath>
#include <fstream>
#include <iomanip>
using namespace std;

// dimension of Chebyshev polynomial basis
const int M = 16;

// below are the 19 parameters required to calculate the cross-section:
// Emin  - lower limit of the approximating formula applicability range, [keV]
// Emax  - upper limit of the approximating formula applicability range, [keV]
// gamma - index of power in the nonlinear variable change formula
// A[]   - coefficients of Chebyshev polynomials

const double Emin =    0.5308400000000000E-002,
             Emax =    0.1000000000000000E+005,
             gamma =   0.1051320000000000E+001,
             A[M] = { -0.4280088217508590E+002,
                      -0.3847174500369429E+001,
                      -0.8303841248235285E+001,
                      -0.1272784281507118E+000,
                       0.3202821077083545E+000,
                       0.2479805580143766E-001,
                       0.1575381966666113E+000,
                      -0.8901874130104495E-001,
                      -0.1433392134922326E+000,
                       0.1522664257717566E-001,
                       0.2112895403629301E-001,
                      -0.3165101585110966E-001,
                       0.6976153339471197E-001,
                       0.3426096112612832E-001,
                      -0.3845256025471072E-001,
                      -0.1855130938720516E-002  };

double ChebyshevTPolynomial(int k, double x)
{
  double T;
  T = cos(((double) k)*acos(x));
  return T;
}
```

```
const double nought = 0.0000000000000000E+000,
             one =    0.1000000000000000E+001,
             two =    0.2000000000000000E+001;

double CrossSection(double E)
{
 int j;
 double sigma;
 vector <double> v;
 sigma = log(Emin);
 sigma = two*pow((log(E) - sigma)/(log(Emax) - sigma), gamma) - one;
 for (j = (int) 0; j != M; j++) v.push_back(A[j]*ChebyshevTPolynomial(j,
sigma));
 sigma = exp(accumulate(v.begin(), v.end(), nought));
 return sigma;
}

// output cross-section file name
const char* CSFName = "cs.txt";

// energy grid dimension for the test calculation
const int N = 100;

// energy range for the test calculation
const double Eleft = 0.1000000000000000E+001,
             Erght = 0.1000000000000000E+004;

int main(void)
{
 int i;
 double p, q;
 vector <double> Egrid;
 ofstream CSFile;
 p = log(Eleft);
 q = (log(Erght) - p)/((double) N - one);
 for (i = (int) 0; i != N; i++) Egrid.push_back(exp(p + q*((double) i)));
 CSFile.open(CSFName);
 CSFile.precision(3);
 for (i = (int) 0; i != N; i++) CSFile << scientific <<
 Egrid[i] << "  " << CrossSection(Egrid[i]) << endl;
 CSFile.close();
}

/*-------------------------------------------------------------------*/
```

```
! Sample program in Fortran  ---------------------------------------

program CSCalcTest
implicit none
intrinsic :: dlog, dexp, dble

!dimension of Chebyshev polynomial basis
integer*8, parameter :: M = 16

! below are the 19 parameters required to calculate the cross-section:
! Emin  - lower limit of the approximating formula applicability range, [keV]
! Emax  - upper limit of the approximating formula applicability range, [keV]
! gamma - index of power in the nonlinear variable change formula
! A()   - coefficients of Chebyshev polynomials

real*8, parameter :: Emin =               0.5308400000000000E-002, &
                     Emax =               0.1000000000000000E+005, &
                     gamma =              0.1051320000000000E+001
```

```
real*8, dimension(M), parameter :: A = (/ -0.4280088217508590E+002, &
                                          -0.3847174500369429E+001, &
                                          -0.8303841248235285E+001, &
                                          -0.1272784281507118E+000, &
                                           0.3202821077083545E+000, &
                                           0.2479805580143766E-001, &
                                           0.1575381966666113E+000, &
                                          -0.8901874130104495E-001, &
                                          -0.1433392134922326E+000, &
                                           0.1522664257717566E-001, &
                                           0.2112895403629301E-001, &
                                          -0.3165101585110966E-001, &
                                           0.6976153339471197E-001, &
                                           0.3426096112612832E-001, &
                                          -0.3845256025471072E-001, &
                                          -0.1855130938720516E-002  /)

! energy range for the test calculation
real*8, parameter :: Eleft  = 0.1000000000000000E+001, &
                     Erght  = 0.1000000000000000E+004

! energy grid dimension for the test calculation
integer*8, parameter :: N = 100

! output cross-section file name
character*6, parameter :: CSFName = "cs.txt"

real*8, parameter :: one = 0.1000000000000000E+001, &
                     two = 0.2000000000000000E+001

integer*8 :: i
real*8 :: p, q
real*8, dimension(N) :: Egrid
p = dlog(Eleft)
q = (dlog(Erght) - p)/(dble(N) - one)
forall (i = 1_8:N) Egrid(i) = dexp(p + q*dble(i - 1_8))
open(unit = 16, file = CSFName, status = 'new')
write(16, '(2E11.3E3)') (Egrid(i), CrossSection(Egrid(i)), i = 1_8,N)
close(unit = 16)
stop

contains

real*8 pure function CrossSection(E) result(sigma)
implicit none
intrinsic :: dlog, dexp, sum
real*8, intent(in) :: E
integer*8 :: j
real*8, dimension(M) :: v
sigma = dlog(Emin)
sigma = two*((dlog(E) - sigma)/(dlog(Emax) - sigma))**gamma - one
forall (j = 1_8:M) v(j) = A(j)*ChebyshevTPolynomial((j - 1_8), sigma)
sigma = dexp(sum(v(1_8:M)))
return
end function CrossSection

real*8 pure function ChebyshevTPolynomial(k, x) result(T)
implicit none
intrinsic :: dcos, dacos, dble
integer*8, intent(in) :: k
real*8, intent(in) :: x
T = dcos(dble(k)*dacos(x))
return
end function ChebyshevTPolynomial

end program CSCalcTest

! ------------------------------------------------------------------
```

Acknowledgements

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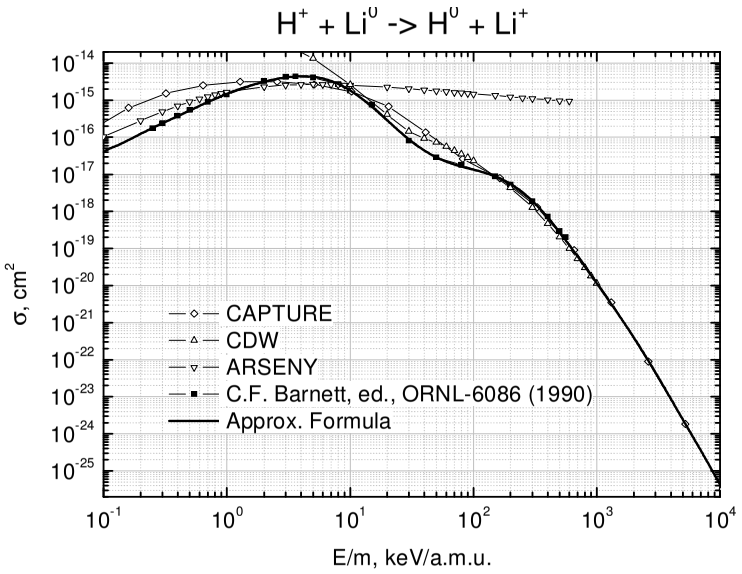
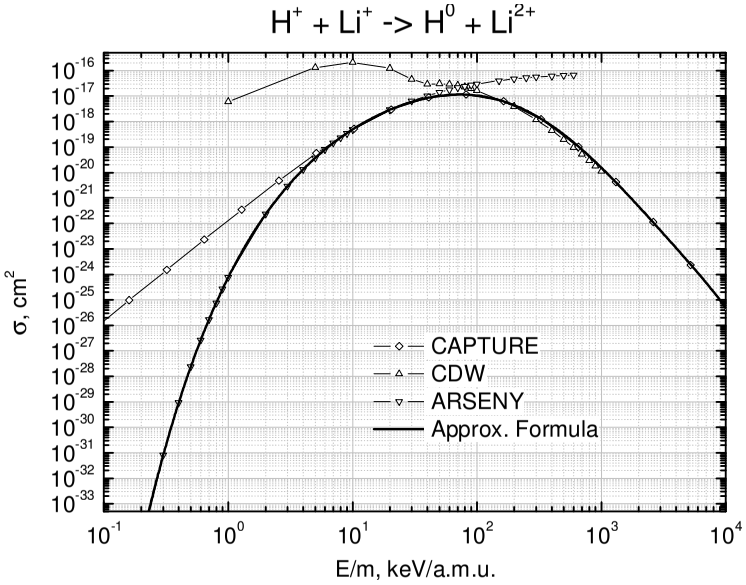
Table 1. Parameters for $H^+ + Li^{k+} \rightarrow H^0 + Li^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2.

Parameter	k = 0	k = 1	k = 2
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1000000000000000E+005	0.1000000000000000E+005	0.1000000000000000E+005
γ	0.9452300000000000E+000	0.1000000000000000E+001	0.1000000000000000E+001
A_0	-0.4182342156421720E+002	-0.5713949182606741E+002	-0.6718965348401890E+002
A_1	-0.9887272472218500E+001	0.1481148502137208E+002	0.3077972987305863E+002
A_2	-0.6358441219262746E+001	-0.1908813025910652E+002	-0.2673286776692624E+002
A_3	-0.3249006753569580E+000	0.4030361457648254E+001	0.7247237763997375E+001
A_4	-0.1397669480845314E+000	-0.1563025467905683E+001	-0.2922505825437859E+001
A_5	-0.2554680723382781E+000	0.9155419836075021E+000	0.1229661962498742E+001
A_6	0.4005953281424045E+000	-0.8388702007548088E-001	-0.6520154842349948E-001
A_7	0.2346479720778586E+000	-0.8706787003171444E-001	-0.2470659480176915E-001
A_8	-0.2670931818431087E+000	-0.6310853340710061E-001	-0.1191014681433515E+000
A_9	-0.1873626502962491E+000	0.0000000000000000E+000	0.3242762389641251E-001
A_{10}	0.1516534246746708E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{11}	0.1424190961443129E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{12}	-0.6028491685666779E-001	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	-0.9496952748350694E-001	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	-0.8416956627812822E-003	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.4011627511154481E-001	0.0000000000000000E+000	0.0000000000000000E+000





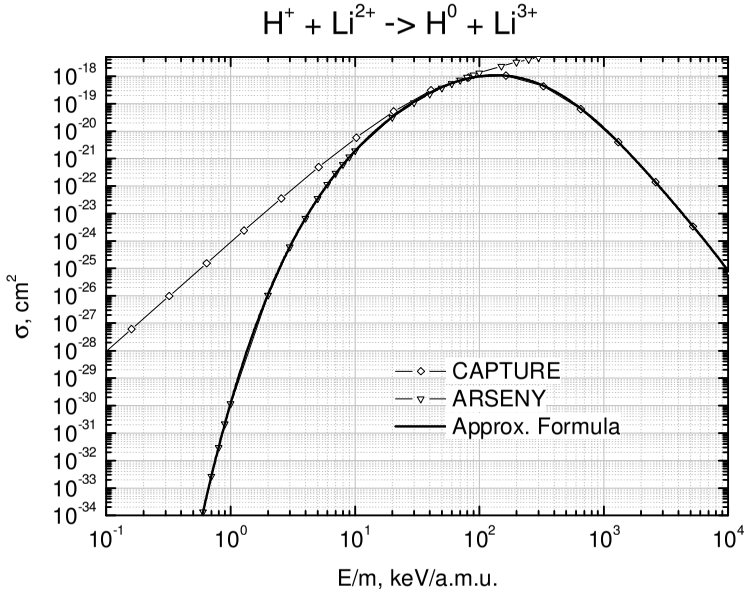
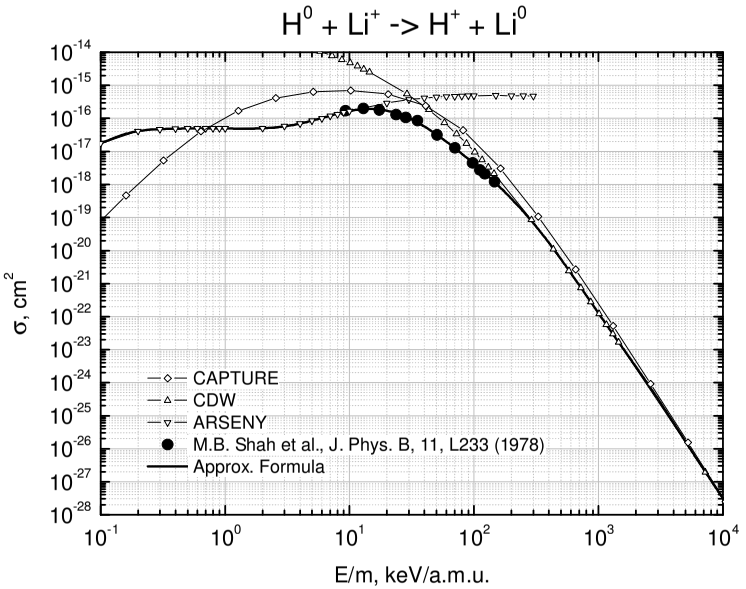
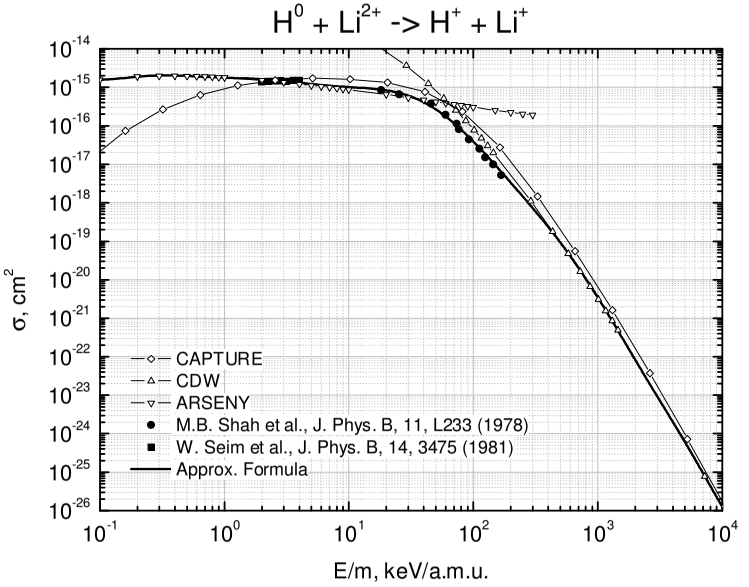


Fig. 1. $H^+ + Li^{k+} \rightarrow H^0 + Li^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2.

Table 2. Parameters for $H^0 + Li^{k+} \rightarrow H^+ + Li^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3.

Parameter	k = 1	k = 2	k = 3
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1449300000000000E+005	0.1449300000000000E+005	0.1449300000000000E+005
γ	0.1107200000000000E+001	0.1085200000000000E+001	0.1000000000000000E+001
A_0	-0.4607355451386458E+002	-0.4274079506702556E+002	-0.4261175003530091E+002
A_1	-0.1349221470464097E+002	-0.1355317741193778E+002	-0.1085373739173865E+002
A_2	-0.6550660603912418E+001	-0.5661571499798193E+001	-0.6811168728400347E+001
A_3	-0.1566209475285624E+000	-0.3956384544527256E+000	-0.6675444632840207E+000
A_4	0.9500844956413386E+000	0.6471118346787281E+000	0.8923169762646490E+000
A_5	0.5435828867559505E-001	0.1469739771253679E+000	0.1250268062768708E+000
A_6	-0.3865668245987723E+000	-0.2131663743584732E+000	-0.2916778453498353E+000
A_7	0.1914450514130218E+000	0.6919651346539499E-002	0.1184004472594763E-001
A_8	0.9441302867253667E-002	0.7320701599035226E-001	0.6694619621760987E-001
A_9	-0.8147199301190033E-001	-0.5672211905110256E-001	0.2765194171916859E-001
A_{10}	0.5082781522414298E-001	-0.5474291364032248E-001	-0.5529582111415766E-001
A_{11}	0.5717147573438126E-001	0.3939100202606777E-001	-0.5286597321913625E-001
A_{12}	-0.7421041402906497E-001	0.5873646038753159E-001	0.6695919987699651E-001
A_{13}	-0.3306181608460303E-001	-0.3574014712690650E-001	0.2140898457108905E-001
A_{14}	0.4131063633678556E-001	-0.3977668755852706E-001	-0.4736912555959212E-002
A_{15}	0.1182768587478187E-001	0.0000000000000000E+000	0.2352183343903240E-002





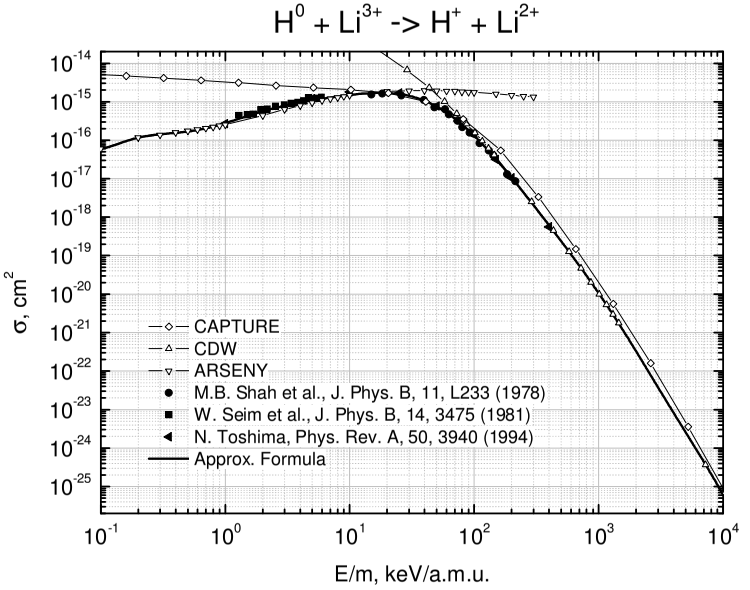
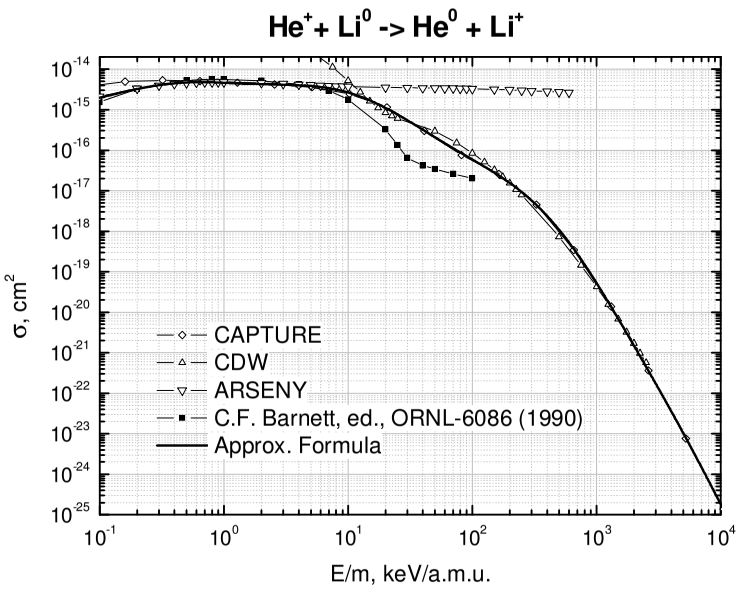
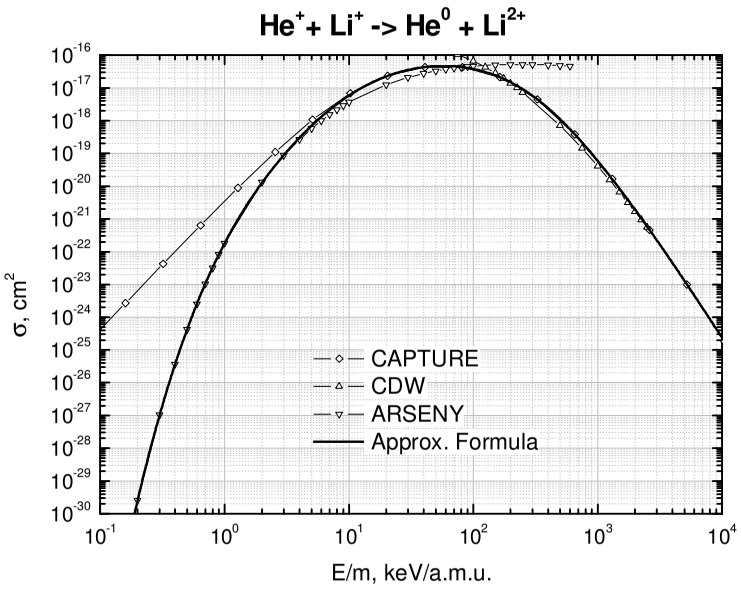


Fig. 2. $H^0 + Li^{k+} \rightarrow H^+ + Li^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3.

Table 3. Parameters for $He^{+} + Li^{k+} \rightarrow He^{0} + Li^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2.

Parameter	k = 0	k = 1	k = 2
E_{min}	0.1000000000000000E-001	0.5000000000000000E-001	0.5000000000000000E-001
E_{max}	0.4194000000000000E+005	0.4194000000000000E+005	0.4194000000000000E+005
γ	0.1253900000000000E+001	0.1000000000000000E+001	0.1000000000000000E+001
A_0	-0.4373149634429708E+002	-0.5840389488245226E+002	-0.6802438516931704E+002
A_1	-0.1487608532554121E+002	0.1114847503219201E+002	0.2722373045421488E+002
A_2	-0.7323848096802837E+001	-0.2243188819835455E+002	-0.3100579101890623E+002
A_3	-0.4675559184766546E-001	0.5423461000758816E+001	0.9343061574623359E+001
A_4	0.1988582056341126E+000	-0.1928850911586272E+001	-0.3763765085245117E+001
A_5	0.3811917933728185E+000	0.1367087032832001E+001	0.1942365356565973E+001
A_6	-0.1843910698157920E-001	-0.3409869569780031E+000	-0.3338009698317208E+000
A_7	-0.2596716196994589E-001	-0.8902598599189654E-001	-0.9630284811497454E-001
A_8	-0.1375966311798555E+000	0.4934922411508661E-003	-0.7468364700032769E-001
A_9	0.2514879574614639E-001	0.7782622230841099E-002	0.6450805183852809E-001
A_{10}	0.9706168147683777E-001	0.5296645831173455E-001	0.3773901590179575E-001
A_{11}	0.3782274771838581E-001	-0.9316041049767565E-003	-0.1345746212358675E-001
A_{12}	-0.9087835560814876E-001	0.1683560284353387E-001	-0.7305881277469672E-003
A_{13}	-0.3760861929212641E-002	-0.3329730188502685E-001	0.1267884219975461E-001
A_{14}	0.6952185201011811E-001	0.4541748434133469E-001	0.8858341664288344E-002
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000





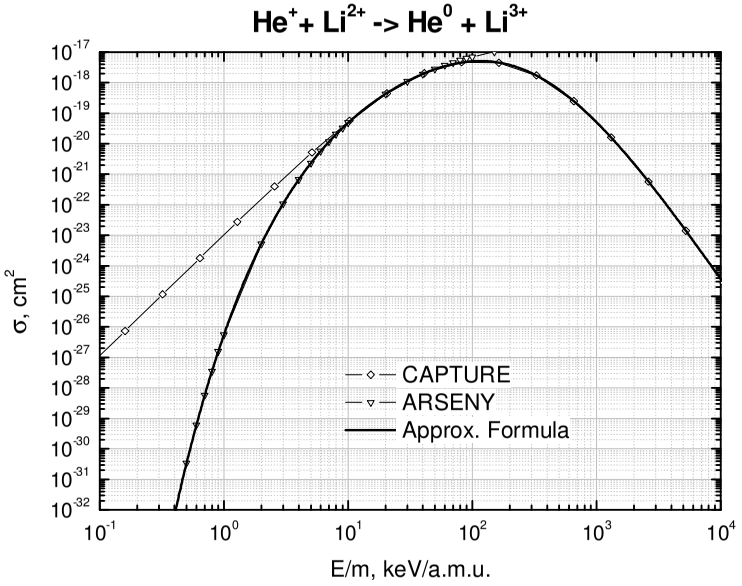
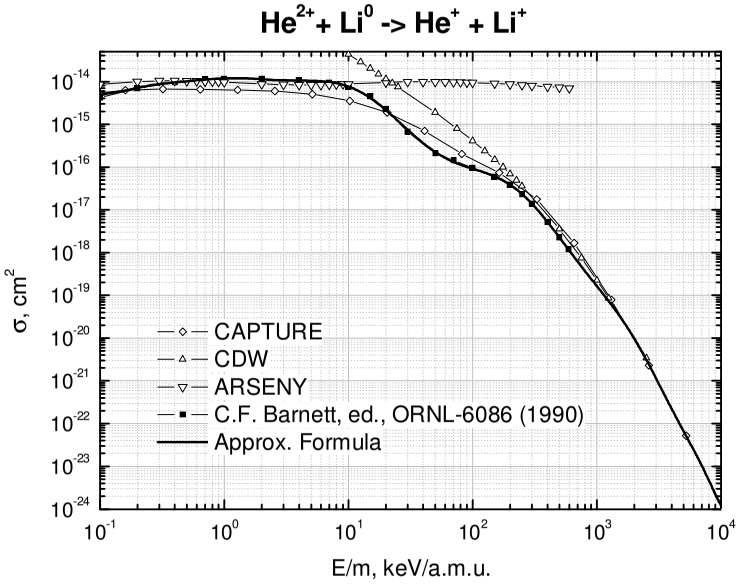
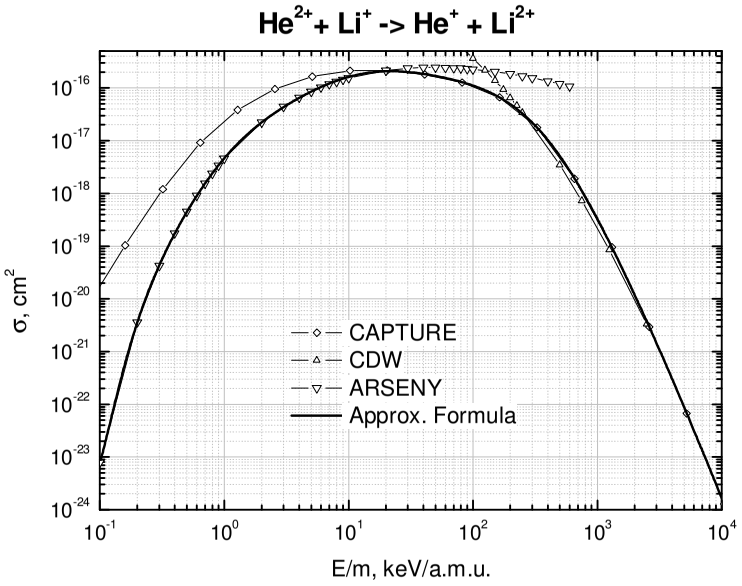


Fig. 3. $He^+ + Li^{k+} \rightarrow He^0 + Li^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2.

Table 4. Parameters for $He^{2+} + Li^{k+} \rightarrow He^{+} + Li^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2.

Parameter	k = 0	k = 1	k = 2
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1049000000000000E+005	0.4194000000000000E+005	0.4194000000000000E+005
γ	0.1031240000000000E+001	0.1000000000000000E+001	0.1000000000000000E+001
A_0	-0.3931636458521852E+002	-0.4690059275489907E+002	-0.5403624418990072E+002
A_1	-0.1062389561068768E+002	-0.6302436084269138E+001	0.5828320330736095E+001
A_2	-0.4783031334517010E+001	-0.1089316331929228E+002	-0.1717254176261076E+002
A_3	-0.5688248823643605E+000	0.6269194552625704E+000	0.3099201570682691E+001
A_4	-0.1694919177953212E+000	-0.3366964248107464E+000	-0.1133979253709510E+001
A_5	-0.6432733637361310E-001	0.7549239096406000E+000	0.9720950771417737E+000
A_6	0.1842715895094236E+000	-0.1077130945239304E+000	-0.2064417670429720E+000
A_7	0.1275672946503406E+000	-0.8519564022234102E-001	-0.4858405926223157E-001
A_8	-0.1283046142653682E+000	-0.7587400353297837E-001	0.1555068566976548E-002
A_9	-0.8946796564508584E-001	0.3688920926532273E-001	-0.4160381576493728E-001
A_{10}	0.1429664680172713E+000	0.8386443867759032E-001	0.4115643478344877E-001
A_{11}	0.7595334874420867E-001	-0.6890334563540864E-002	0.1642655993351043E-001
A_{12}	-0.1218710630341212E+000	-0.1943576687052576E-002	0.3853024899997348E-002
A_{13}	-0.8664063823802264E-001	-0.1587739350308899E-001	-0.4716753516168592E-001
A_{14}	0.7032466034640972E-001	0.4855123741960250E-001	0.3508620223218446E-001
A_{15}	0.7404004058117487E-001	0.0000000000000000E+000	0.0000000000000000E+000





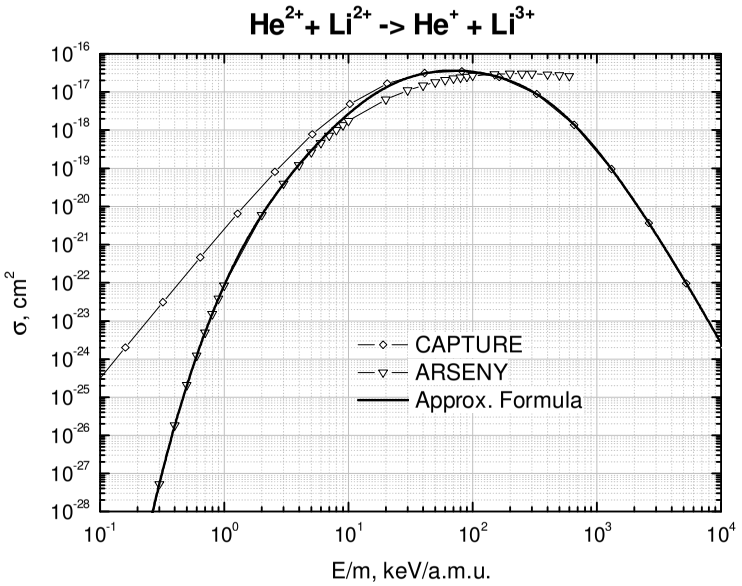
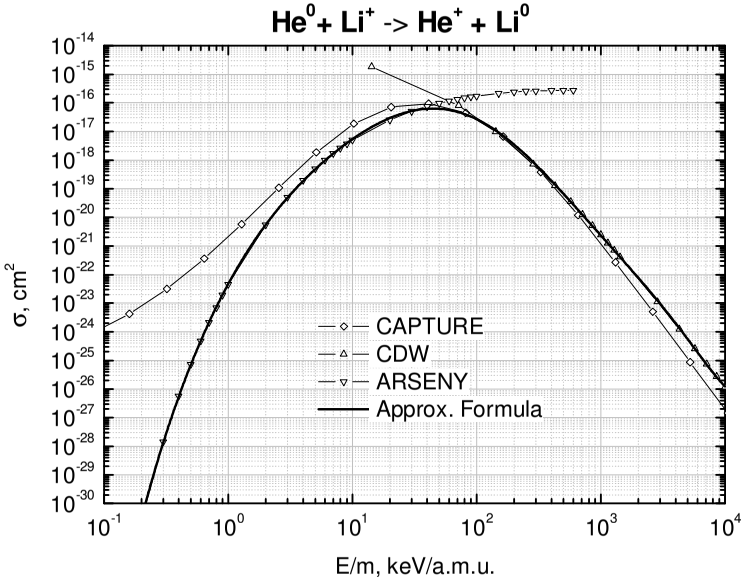
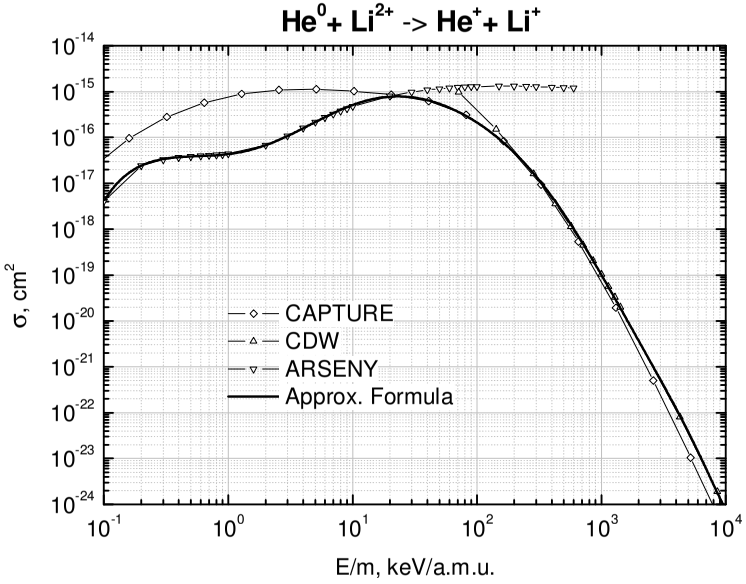


Fig. 4. $He^{2+} + Li^{k+} \rightarrow He^{+} + Li^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2.

Table 5. Parameters for $He^0 + Li^{k+} \rightarrow He^+ + Li^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3.

Parameter	k = 1	k = 2	k = 3
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1000000000000000E+005	0.1142900000000000E+005	0.1000000000000000E+005
γ	0.1000000000000000E+001	0.1025000000000000E+001	0.1020000000000000E+001
A_0	-0.5433225606660470E+002	-0.4202807613311255E+002	-0.4238033289779197E+002
A_1	0.8492647073447870E+001	-0.7518903866079643E+001	-0.5681878244806459E+001
A_2	-0.1692034101031407E+002	-0.6277960076910134E+001	-0.5456649899077270E+001
A_3	0.3120152836505021E+001	-0.1118432175249272E+001	-0.1091405492933090E+001
A_4	-0.4687787506883306E+000	0.5370864971308572E+000	-0.6149805082033363E+000
A_5	0.7544391857258413E+000	0.4379900354996213E+000	0.9528937146487871E+000
A_6	-0.3774065565700531E+000	-0.3625188121377751E+000	-0.5202417279628838E-001
A_7	-0.1147421000531143E+000	0.9914982326360940E-001	0.3076211565024345E-001
A_8	0.5463453220726157E-001	-0.3155621717677179E-001	-0.2749168251252164E+000
A_9	0.1261509302218641E+000	-0.3021429083154326E-001	0.5484135384456247E-001
A_{10}	0.0000000000000000E+000	0.4243632508570949E-001	0.8977770152795149E-001
A_{11}	0.0000000000000000E+000	0.5139699215379152E-001	0.7878539599265737E-001
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000	-0.4076491667160621E-001
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000	-0.5735744950350741E-001
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	-0.2954620781915067E-001
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.5452982197677377E-001





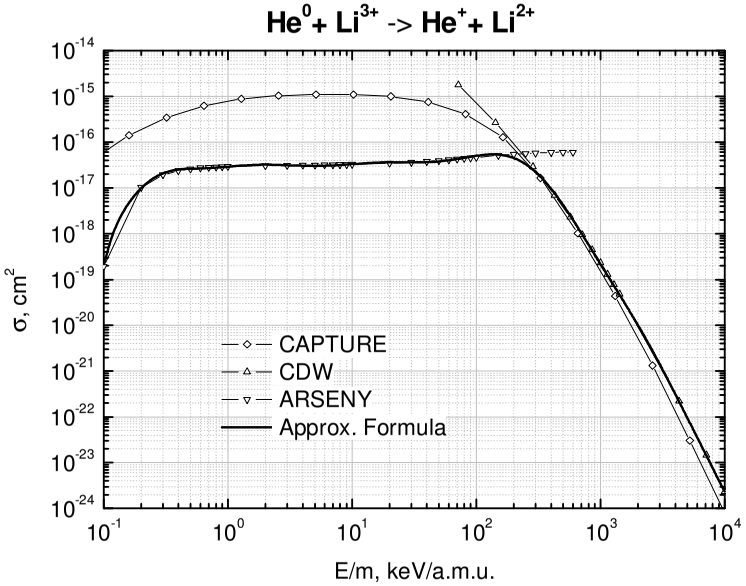
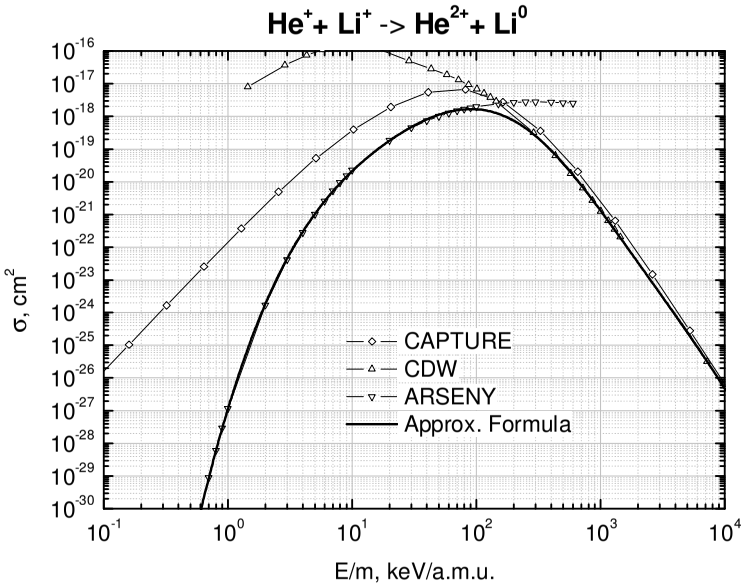
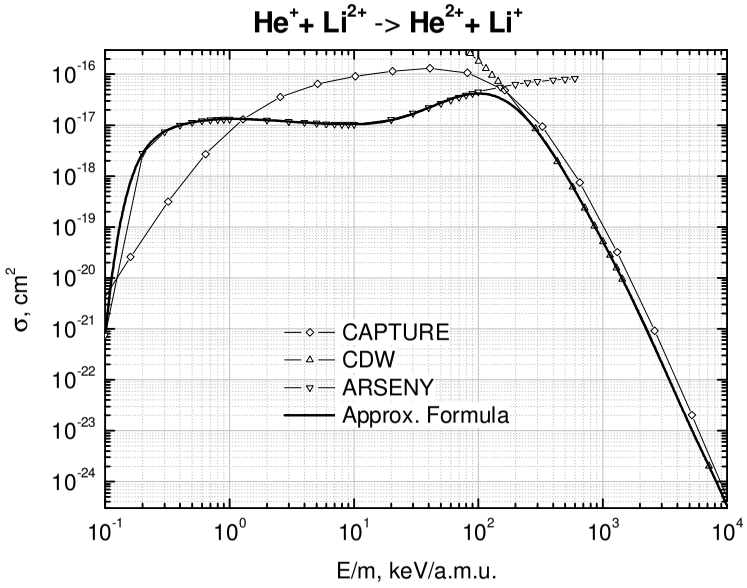


Fig. 5. $He^0 + Li^{k+} \rightarrow He^+ + Li^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3.

Table 6. Parameters for $He^{+} + Li^{k+} \rightarrow He^{2+} + Li^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3.

Parameter	k = 1	k = 2	k = 3
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1440900000000000E+005	0.1440900000000000E+005	0.1440900000000000E+005
γ	0.8417200000000000E+000	0.1018300000000000E+001	0.1005800000000000E+001
A_0	-0.6602238194236669E+002	-0.4460227545754307E+002	-0.4575320400512224E+002
A_1	0.2402618331242249E+002	-0.6455642317346425E+001	-0.1703957855228975E+001
A_2	-0.2384252086603417E+002	-0.7042588291174100E+001	-0.1054137532918602E+002
A_3	0.3103449463948035E+001	-0.5108039203191845E+000	0.2284452107210795E+001
A_4	-0.3116314085799498E+000	-0.8675330462857233E+000	-0.3201887217994166E+001
A_5	0.1083429455699629E+000	0.1657938737779560E+001	0.3593508098117209E+001
A_6	0.6938043946559379E+000	-0.5451834020304452E+000	-0.2214290592068669E+001
A_7	-0.4129965500849060E+000	0.9382913097674828E-001	0.1236462299368220E+001
A_8	-0.2689206711247753E-001	-0.3830507927756304E+000	-0.1077318129665687E+001
A_9	-0.1359036761857495E+000	0.3074524296317829E+000	0.8630223802288908E+000
A_{10}	0.1713560340902084E+000	-0.5069035544610593E-001	-0.4588786456461512E+000
A_{11}	0.0000000000000000E+000	-0.1512527664738306E-001	0.2196198488737073E+000
A_{12}	0.0000000000000000E+000	-0.8041115180437161E-001	-0.1591376865953587E+000
A_{13}	0.0000000000000000E+000	0.2897007835437201E-001	0.8322605101670252E-001
A_{14}	0.0000000000000000E+000	0.3580380472798909E-001	0.9285494378302747E-002
A_{15}	0.0000000000000000E+000	0.9165077914092054E-002	0.0000000000000000E+000





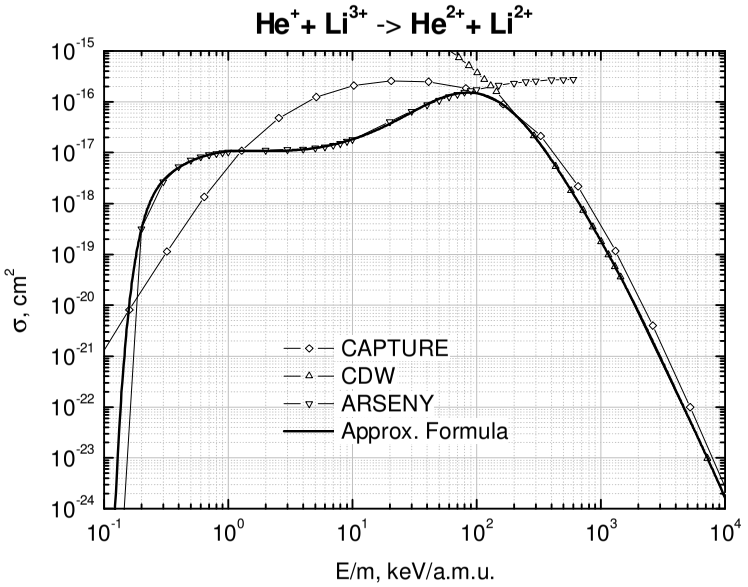


Fig. 6. $He^{+} + Li^{k+} \rightarrow He^{2+} + Li^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3.

Table 7. Parameters for $H^{+} + Be^{k+} \rightarrow H^{0} + Be^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3.

Parameter	k = 0	k = 1	k = 2
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1000000000000000E+005	0.1000000000000000E+005	0.1000000000000000E+005
γ	0.1172500000000000E+001	0.1125000000000000E+001	0.9989000000000000E+000
A_0	-0.4212433445420990E+002	-0.4270729699248206E+002	-0.7203870555989188E+002
A_1	-0.9553767888275177E+001	-0.8152540943627873E+001	0.3988796922905487E+002
A_2	-0.4701448077829596E+001	-0.5906860087686455E+001	-0.3102124592104839E+002
A_3	-0.2717320657402618E+000	0.4625353650752230E+000	0.9169631492958926E+001
A_4	0.5660774937947607E+000	-0.1426193936222674E+000	-0.3763621008421449E+001
A_5	-0.3047966557325060E+000	0.8234385165207929E-001	0.1406319757126856E+001
A_6	-0.1490723850211431E+000	-0.1155518183744285E+000	0.5425391159983158E-001
A_7	0.3495306513996061E+000	0.1608235303441917E+000	0.4784882532628979E-001
A_8	-0.2218153238882280E-001	0.3133732250778254E-001	-0.1289124850415276E+000
A_9	-0.2096654535019086E+000	-0.5981485855369920E-001	-0.7197816007411890E-001
A_{10}	0.4397202207532912E-001	-0.5626245235160311E-001	0.6405724969216506E-001
A_{11}	0.1052679772247601E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{12}	-0.1279053671952580E-001	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	-0.5769477740994094E-001	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

Table 7. Parameters for $H^+ + Be^{k+} \rightarrow H^0 + Be^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3 (continued).

Parameter	k = 3
E_{min}	0.1000000000000000E+000
E_{max}	0.1049000000000000E+005
γ	0.1012500000000000E+001
A_0	-0.8226431891097003E+002
A_1	0.5572924535182351E+002
A_2	-0.3967410836924639E+002
A_3	0.1319836880841784E+002
A_4	-0.5326937376770078E+001
A_5	0.1849551467070560E+001
A_6	-0.2744462819952003E+000
A_7	0.1510562934513171E+000
A_8	-0.1065691740054586E+000
A_9	-0.5414084301429264E-001
A_{10}	0.5384151780947039E-001
A_{11}	0.0000000000000000E+000
A_{12}	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000

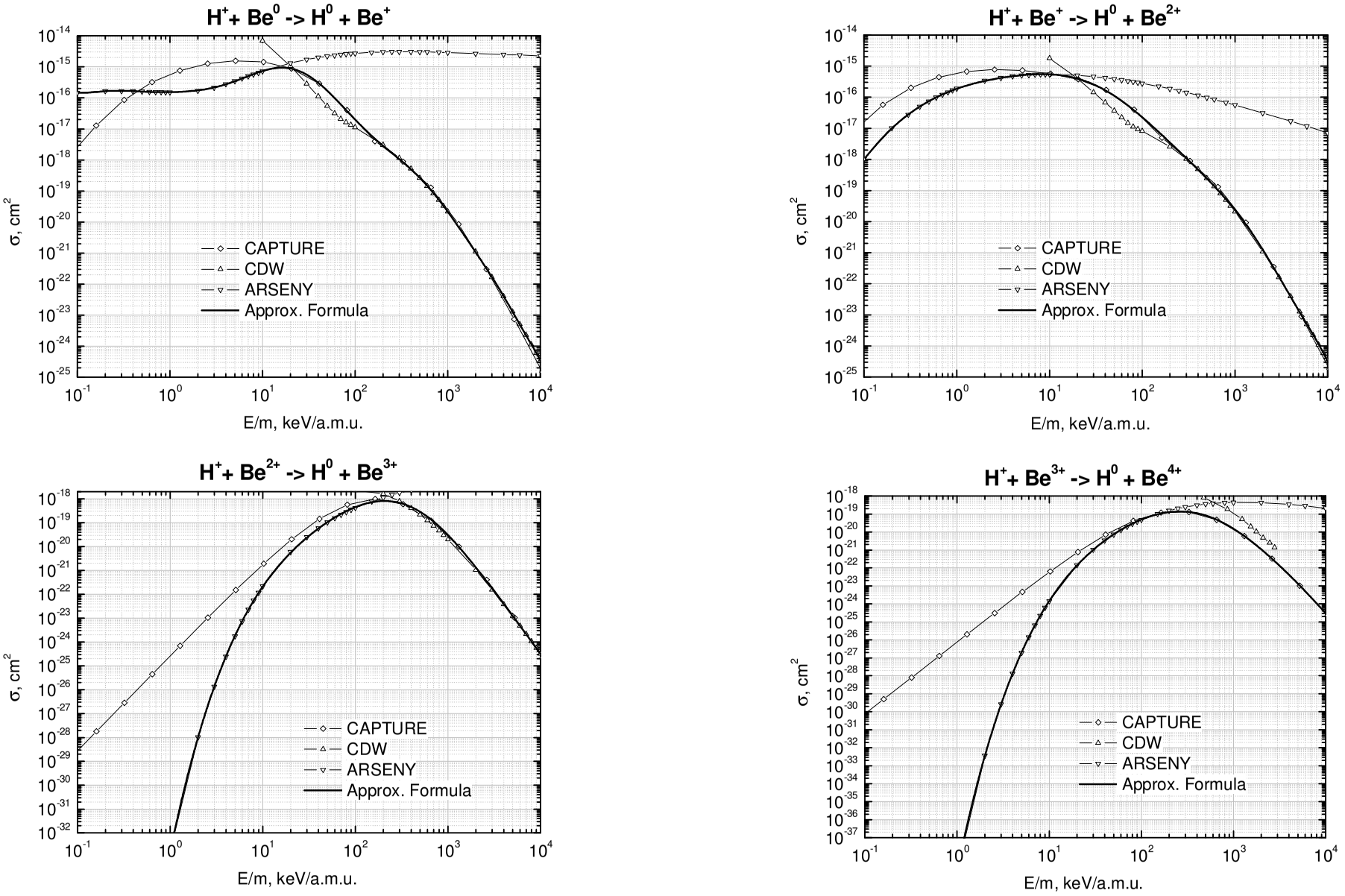


Fig. 7. $H^+ + Be^{k+} \rightarrow H^0 + Be^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2, 3.

Table 8. Parameters for $H^0 + Be^{k+} \rightarrow H^+ + Be^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4.

Parameter	k = 1	k = 2	k = 3
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1111100000000000E+005	0.1111100000000000E+005	0.1111100000000000E+005
γ	0.1274350000000000E+001	0.1035600000000000E+001	0.1223740000000000E+001
A_0	-0.4606612141489906E+002	-0.4331532184355046E+002	-0.4235172083437505E+002
A_1	-0.1164718387195960E+002	-0.1146388564230638E+002	-0.1060979373997864E+002
A_2	-0.7205080334675554E+001	-0.7041317677946706E+001	-0.6095319920201759E+001
A_3	0.1425390643652167E+001	-0.3862537995921760E+000	0.5290166180490423E+000
A_4	0.2851765246565109E+000	0.8764246303099233E+000	0.5240824704346154E+000
A_5	0.1911705677323198E+000	0.2296184569776943E+000	-0.5355889881246625E-001
A_6	-0.4814702382474167E+000	-0.2091049421557384E+000	-0.1981832653282699E+000
A_7	0.1869772196641412E+000	-0.1497917788626883E+000	0.1465602604993044E-001
A_8	0.4286020148536501E-001	0.9461857871863671E-001	0.5209835710863521E-001
A_9	-0.2167799435825509E-001	0.8459155014851440E-001	0.7484700746656668E-001
A_{10}	-0.1102220020224462E+000	-0.8987459324550816E-001	-0.1589366500165704E+000
A_{11}	0.9167299169650346E-001	-0.8438621788680749E-001	0.3676234241849021E-001
A_{12}	0.2414071652965098E-001	0.0000000000000000E+000	0.5801939460104657E-001
A_{13}	-0.1460978567259867E-001	0.0000000000000000E+000	0.3499495008148912E-001
A_{14}	-0.3408271865561767E-001	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.6668311049282380E-001	0.0000000000000000E+000	0.0000000000000000E+000

Table 8. Parameters for $H^0 + Be^{k+} \rightarrow H^+ + Be^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4 (continued).

Parameter	k = 4
E_{min}	0.1000000000000000E+000
E_{max}	0.1111100000000000E+005
γ	0.9975400000000000E+000
A_0	-0.4045682296397271E+002
A_1	-0.1116403809203255E+002
A_2	-0.5721466772661200E+001
A_3	-0.7550301114464346E+000
A_4	0.5699354618741240E+000
A_5	0.2949738972913812E+000
A_6	-0.2085533660133321E+000
A_7	-0.1648223335510841E+000
A_8	0.4616992622734843E-001
A_9	0.8900181411232160E-001
A_{10}	-0.3353640586191968E-002
A_{11}	-0.5886940455115351E-001
A_{12}	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000

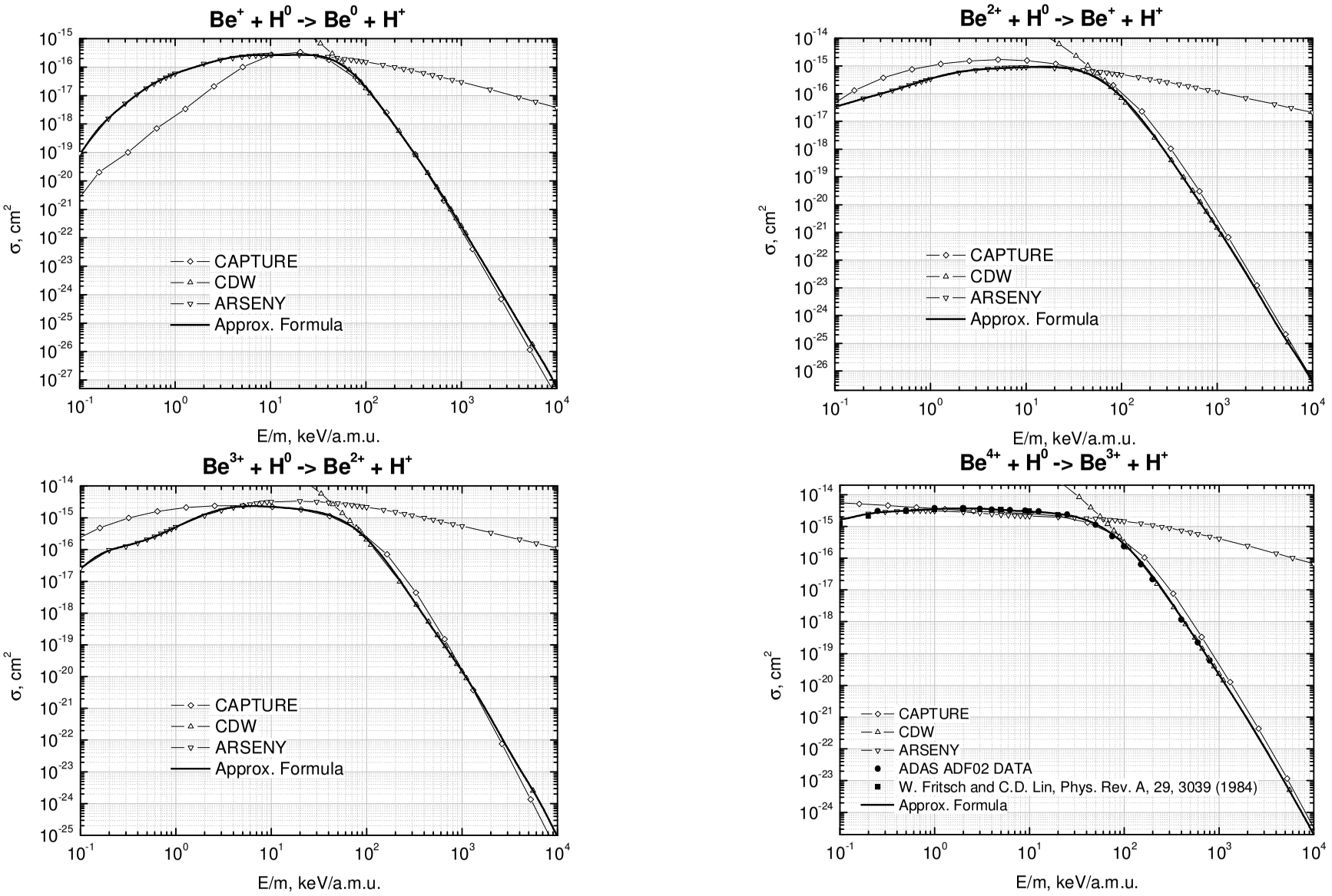


Fig. 8. $H^0 + Be^{k+} \rightarrow H^+ + Be^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3, 4.

Table 9. Parameters for $He^{+} + Be^{k+} \rightarrow He^{0} + Be^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3.

Parameter	k = 0	k = 1	k = 2
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1250000000000000E+005	0.1250000000000000E+005	0.1250000000000000E+005
γ	0.9528600000000000E+000	0.9789000000000000E+000	0.9877000000000000E+000
A_0	-0.4149265560793095E+002	-0.4255386055181815E+002	-0.6558628492210451E+002
A_1	-0.9067948688567888E+001	-0.8149232818415653E+001	0.2937284935430280E+002
A_2	-0.5777970659865960E+001	-0.5067985819353882E+001	-0.2577504581006039E+002
A_3	-0.8514499356514634E+000	-0.1582929308950171E+001	0.6816317661695869E+001
A_4	0.6221736177429269E+000	0.3827018248137014E+000	-0.2656348416417708E+001
A_5	-0.2190174307602344E+000	0.4149941716349749E+000	0.1159308793474209E+001
A_6	-0.1371419906596033E+000	-0.2620156688588741E+000	0.3787037866156685E-001
A_7	0.3097877017317840E+000	-0.1085997784446114E+000	-0.8383275897495666E-001
A_8	0.8686002872869546E-001	0.2172793890614963E+000	-0.7598984463012182E-001
A_9	-0.1190287106046539E+000	0.5308003638417659E-001	0.1380524599695203E-001
A_{10}	-0.4553739057198650E-001	-0.1602549935260556E+000	0.5693707048571112E-001
A_{11}	0.9915226168038891E-002	-0.4939204656651809E-001	0.7052472455602111E-002
A_{12}	0.3939555574520634E-001	0.1118528589522780E+000	0.0000000000000000E+000
A_{13}	-0.1323678296205872E-002	0.7879133239562391E-001	0.0000000000000000E+000
A_{14}	-0.2218813859729542E-001	-0.7690915006179881E-001	0.0000000000000000E+000
A_{15}	-0.1055240083252873E-001	-0.8040019215783351E-001	0.0000000000000000E+000

Table 9. Parameters for $He^{+} + Be^{k+} \rightarrow He^{0} + Be^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3 (continued).

Parameter	k = 3
E_{min}	0.1000000000000000E+000
E_{max}	0.1049000000000000E+005
γ	0.9975000000000001E+000
A_0	-0.7539566888667403E+002
A_1	0.4554228539556203E+002
A_2	-0.3323066721592593E+002
A_3	0.1013627172259365E+002
A_4	-0.4170256366143424E+001
A_5	0.1348081108163766E+001
A_6	-0.2938434066015498E-001
A_7	0.5827464935006543E-001
A_8	-0.1034111001058424E+000
A_9	-0.9277965020392243E-002
A_{10}	0.3149060653608098E-001
A_{11}	0.2790036323270236E-001
A_{12}	-0.1229818746795225E-001
A_{13}	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000

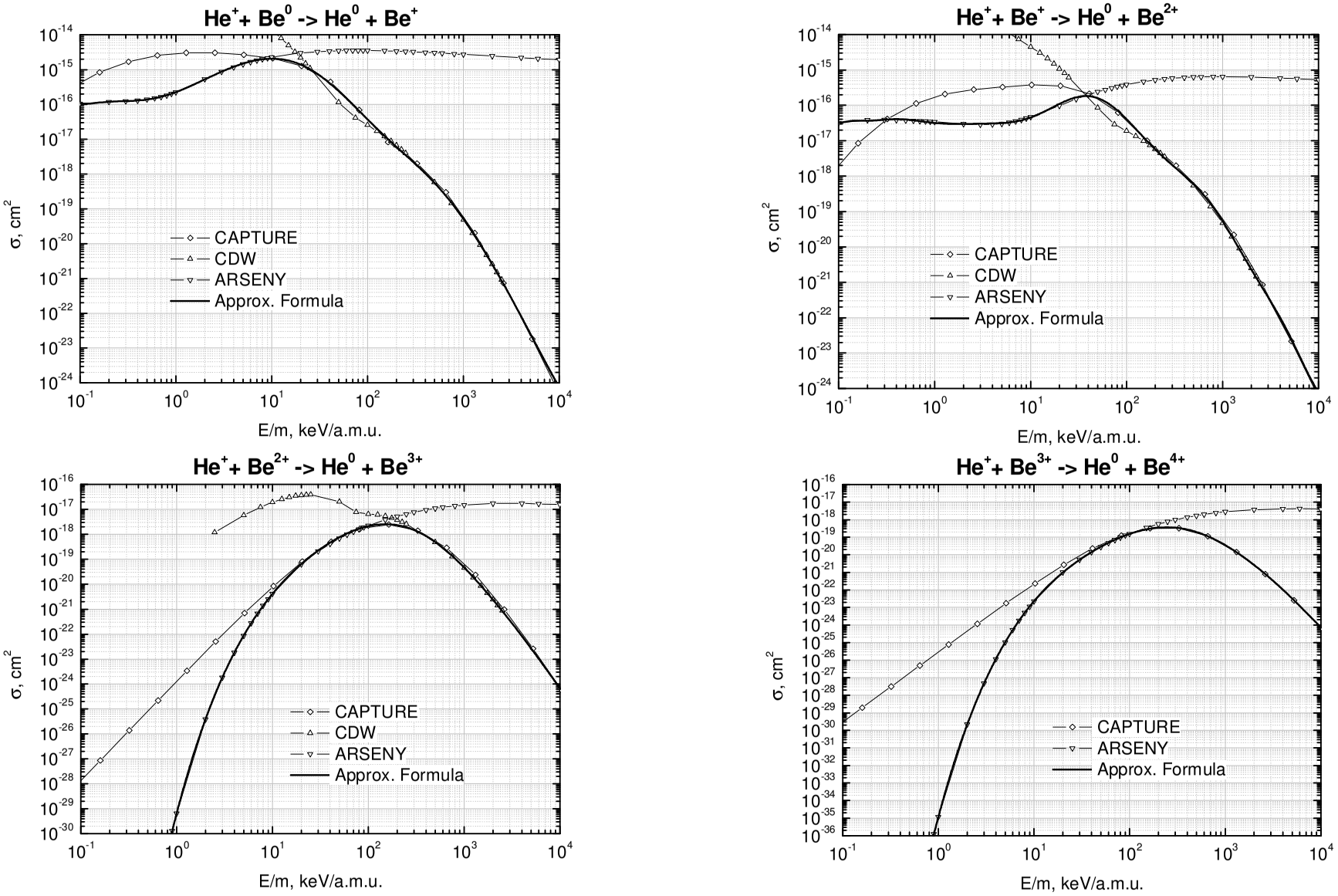


Fig. 9. $He^+ + Be^{k+} \rightarrow He^0 + Be^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2, 3.

Table 10. Parameters for $He^{2+} + Be^{k+} \rightarrow He^{+} + Be^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3.

Parameter	k = 0	k = 1	k = 2
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1250000000000000E+005	0.1250000000000000E+005	0.1250000000000000E+005
γ	0.9989400000000001E+000	0.1012330000000000E+001	0.1000000000000000E+001
A_0	-0.3940625115530527E+002	-0.4147316775826017E+002	-0.5578916107931577E+002
A_1	-0.9437998888925980E+001	-0.6617875211201517E+001	0.1681823819940999E+002
A_2	-0.4799308469014517E+001	-0.5500236664962554E+001	-0.1844496519449786E+002
A_3	-0.7351773739683405E+000	-0.1337339086332967E+001	0.4091955570446856E+001
A_4	-0.2566329685630778E-001	0.4978422383634178E+000	-0.1922230993321400E+001
A_5	0.9627069430013972E-001	0.1870441049471863E+000	0.9499573012307901E+000
A_6	0.5114906982269671E-001	-0.1797161266710038E+000	0.3953420679678941E-001
A_7	0.7805384875071085E-001	0.1822693075555416E+000	-0.4628501505857423E-001
A_8	0.4666898018377715E-001	0.7978040998182677E-001	-0.8787071150972907E-001
A_9	-0.7500685448982210E-001	-0.6683419909633465E-001	0.4815240978968563E-002
A_{10}	-0.4855253231187216E-001	-0.1020494418958371E-001	0.8553420171905231E-001
A_{11}	0.5769532360281462E-001	0.2211942457606496E-001	0.2963849210498703E-001
A_{12}	0.3692838037884647E-001	0.3878242679958218E-001	0.9648798030627439E-003
A_{13}	-0.3431759690601511E-001	-0.1588326280817851E-001	-0.3250802705846239E-001
A_{14}	-0.4396532965129744E-001	-0.5431392161399280E-001	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	-0.2137905357300583E-001	0.0000000000000000E+000

Table 10. Parameters for $He^{2+} + Be^{k+} \rightarrow He^{+} + Be^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3 (continued).

Parameter	k = 3
E_{min}	0.1000000000000000E+000
E_{max}	0.1049000000000000E+005
γ	0.8913600000000000E+000
A_0	-0.6550430766792955E+002
A_1	0.3254722085228143E+002
A_2	-0.2368116276721015E+002
A_3	0.4665800849005303E+001
A_4	-0.1762634948433466E+001
A_5	-0.9805088608266417E-001
A_6	0.5491658148104707E+000
A_7	-0.5183672346021868E-001
A_8	0.9276510911463577E-001
A_9	-0.1428427585151311E+000
A_{10}	0.2796892115475630E-002
A_{11}	0.1251901940997507E-001
A_{12}	0.5511910824106806E-001
A_{13}	0.2614764170741718E-001
A_{14}	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000

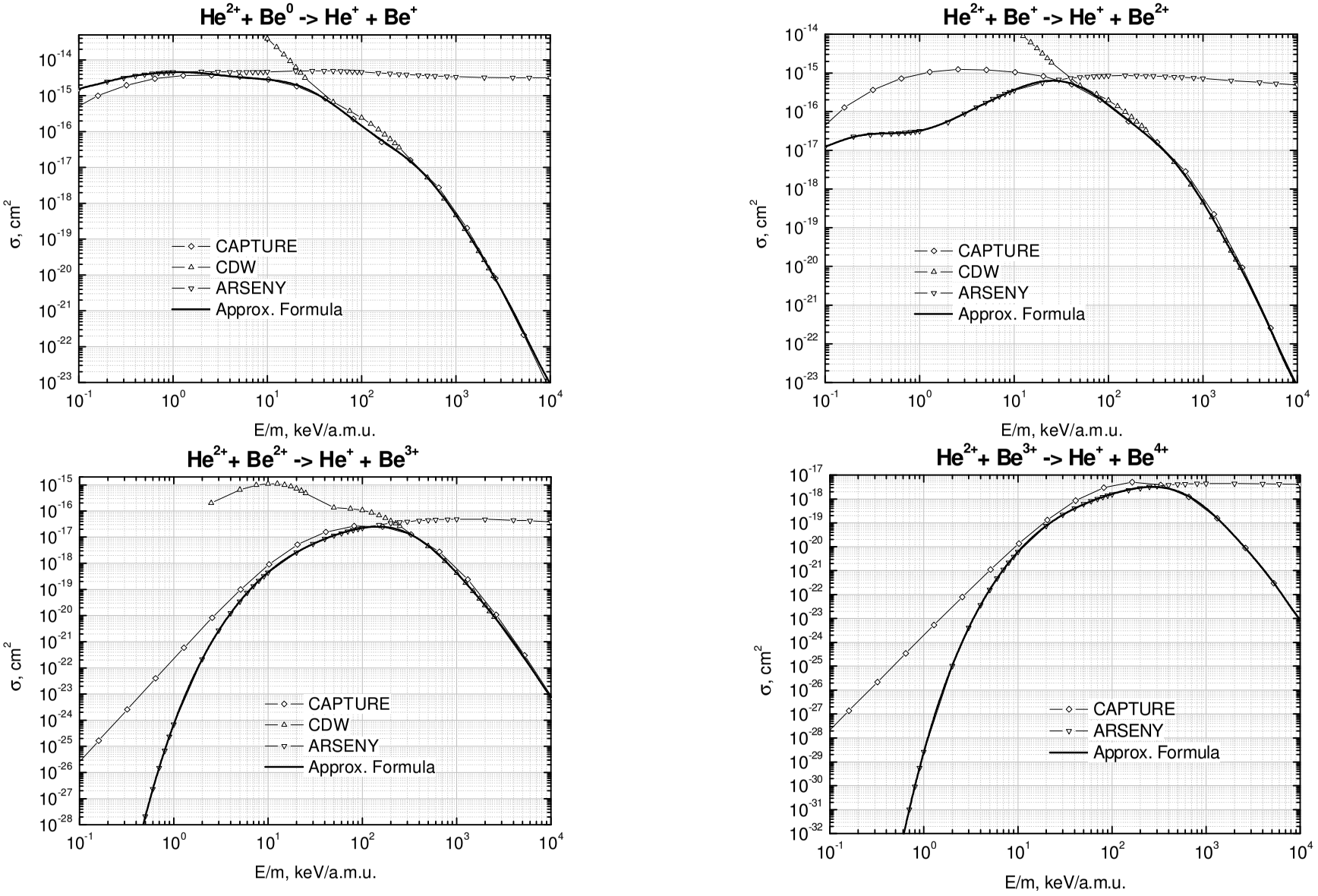


Fig. 10. $He^{2+} + Be^{k+} \rightarrow He^{+} + Be^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2, 3.

Table 11. Parameters for $He^0 + Be^{k+} \rightarrow He^+ + Be^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4.

Parameter	k = 1	k = 2	k = 3
E_{min}	0.1000000000000000E+000	0.1220000000000000E+000	0.1220000000000000E+000
E_{max}	0.1109900000000000E+005	0.1109900000000000E+005	0.1109900000000000E+005
γ	0.1000000000000000E+001	0.1000000000000000E+001	0.9987500000000000E+000
A_0	-0.4250922650736090E+002	-0.4492100665389432E+002	-0.4017523241436658E+002
A_1	-0.9407390948315197E+001	-0.3734824225775262E+001	-0.9384549595689432E+001
A_2	-0.6165916794495291E+001	-0.7452891742559123E+001	-0.4617641750129699E+001
A_3	-0.1077403373404750E+001	-0.7594239563550518E+000	-0.1200499693956250E+001
A_4	0.6433464602517375E+000	0.1029159423916105E+001	0.2090398701044830E+000
A_5	0.3308585042148651E+000	0.9107042710601217E-001	0.2310214331824287E+000
A_6	-0.1165676232440049E+000	-0.5090279633482214E+000	0.1518422480865493E-002
A_7	-0.1364762857790253E+000	0.3303034580806712E-001	0.2436702828050369E-001
A_8	-0.2065330610114795E-001	0.0000000000000000E+000	0.9854916263859393E-002
A_9	0.8928050161743004E-001	0.0000000000000000E+000	0.0000000000000000E+000
A_{10}	-0.1897453486946428E-001	0.0000000000000000E+000	0.0000000000000000E+000
A_{11}	-0.7538659486818108E-001	0.0000000000000000E+000	0.0000000000000000E+000
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

Table 11. Parameters for $He^0 + Be^{k+} \rightarrow He^+ + Be^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4 (continued).

Parameter	k = 4
E_{min}	0.1000000000000000E+000
E_{max}	0.1109900000000000E+005
γ	0.9831200000000000E+000
A_0	-0.4023829567796407E+002
A_1	-0.7327437421664829E+001
A_2	-0.5364017212745789E+001
A_3	-0.1330440924674953E+001
A_4	0.3257266039704320E+000
A_5	0.2655239209486419E+000
A_6	0.2248033623303256E-001
A_7	-0.1026482497819029E+000
A_8	-0.4733387398087405E-001
A_9	0.0000000000000000E+000
A_{10}	0.0000000000000000E+000
A_{11}	0.0000000000000000E+000
A_{12}	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000

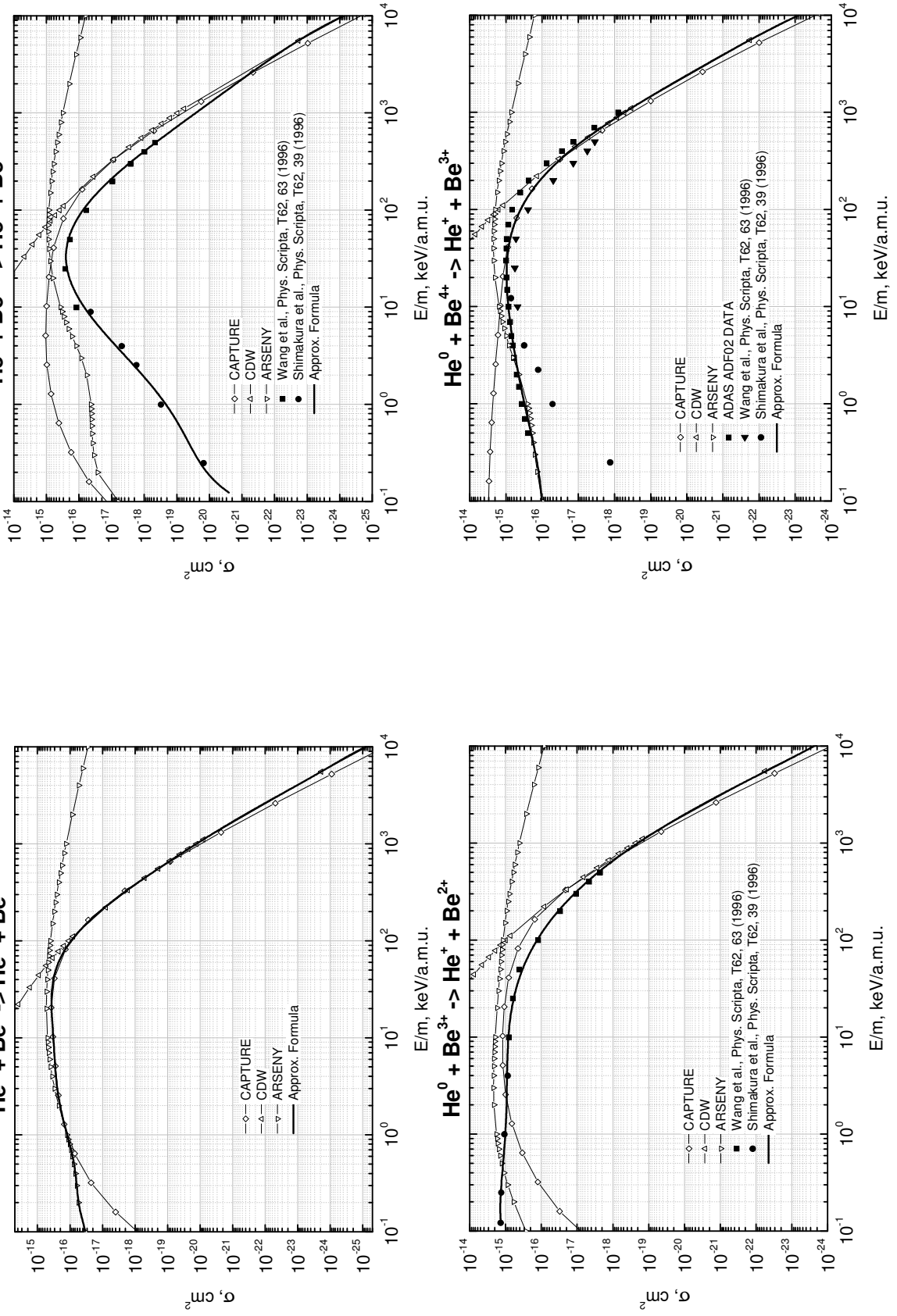


Fig. 11. $He^0 + Be^{k+} \rightarrow He^+ + Be^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3, 4.

Table 12. Parameters for $He^{+} + Be^{k+} \rightarrow He^{2+} + Be^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4.

Parameter	k = 1	k = 2	k = 3
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1109900000000000E+005	0.1109900000000000E+005	0.1109900000000000E+005
γ	0.9876300000000000E+000	0.9183200000000000E+000	0.9713900000000000E+000
A_0	-0.4731105537416457E+002	-0.4298560376068875E+002	-0.4617959650595964E+002
A_1	-0.2110034855851642E+001	-0.5761853324245895E+001	0.9886216124262892E+000
A_2	-0.1030530241117881E+002	-0.7120428580448313E+001	-0.1189523676843918E+002
A_3	0.6220155464190850E+000	-0.1031993313636049E+001	0.3451463059462497E+001
A_4	-0.2446761072325546E+000	-0.2344309869770425E+000	-0.4235391117246011E+001
A_5	0.6734124925006871E+000	0.8409665334859077E+000	0.4284183370409997E+001
A_6	-0.4324464073702924E-001	-0.2054082851243381E+000	-0.2561928915729322E+001
A_7	-0.1584753133894763E+000	0.7689346692024890E-001	0.1548766362748744E+001
A_8	-0.5434721206390707E-001	-0.1596685227686649E+000	-0.1297504797149121E+001
A_9	0.2527034351637893E-001	-0.3008005394170560E-001	0.8375640758390847E+000
A_{10}	0.3792955474557265E-001	0.8558543910872887E-001	-0.4727965556672210E+000
A_{11}	-0.3778662425901139E-001	0.1827627061764352E-001	0.2884604266076667E+000
A_{12}	-0.9743809023597973E-002	-0.1992354722963396E-001	-0.1742296113944795E+000
A_{13}	0.2914802451535213E-001	-0.1886566561159101E-001	0.3082424565563701E-001
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

Table 12. Parameters for $He^{+} + Be^{k+} \rightarrow He^{2+} + Be^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4 (continued).

Parameter	k = 4
E_{min}	0.2000000000000000E+000
E_{max}	0.1109900000000000E+005
γ	0.8572900000000000E+000
A_0	-0.4287092714245503E+002
A_1	-0.3103881322429266E+001
A_2	-0.7721342516391674E+001
A_3	-0.3943920537585114E+000
A_4	-0.6314903504922280E+000
A_5	0.9763608463849535E+000
A_6	-0.3064404795428654E+000
A_7	0.8968820526091806E-001
A_8	-0.9251748277073467E-001
A_9	-0.1230847011117193E+000
A_{10}	0.1345845123879335E+000
A_{11}	-0.9226630339505029E-001
A_{12}	0.6942895071459199E-001
A_{13}	-0.6368384961497865E-001
A_{14}	0.2877910784481908E-001
A_{15}	0.5392398525683287E-002

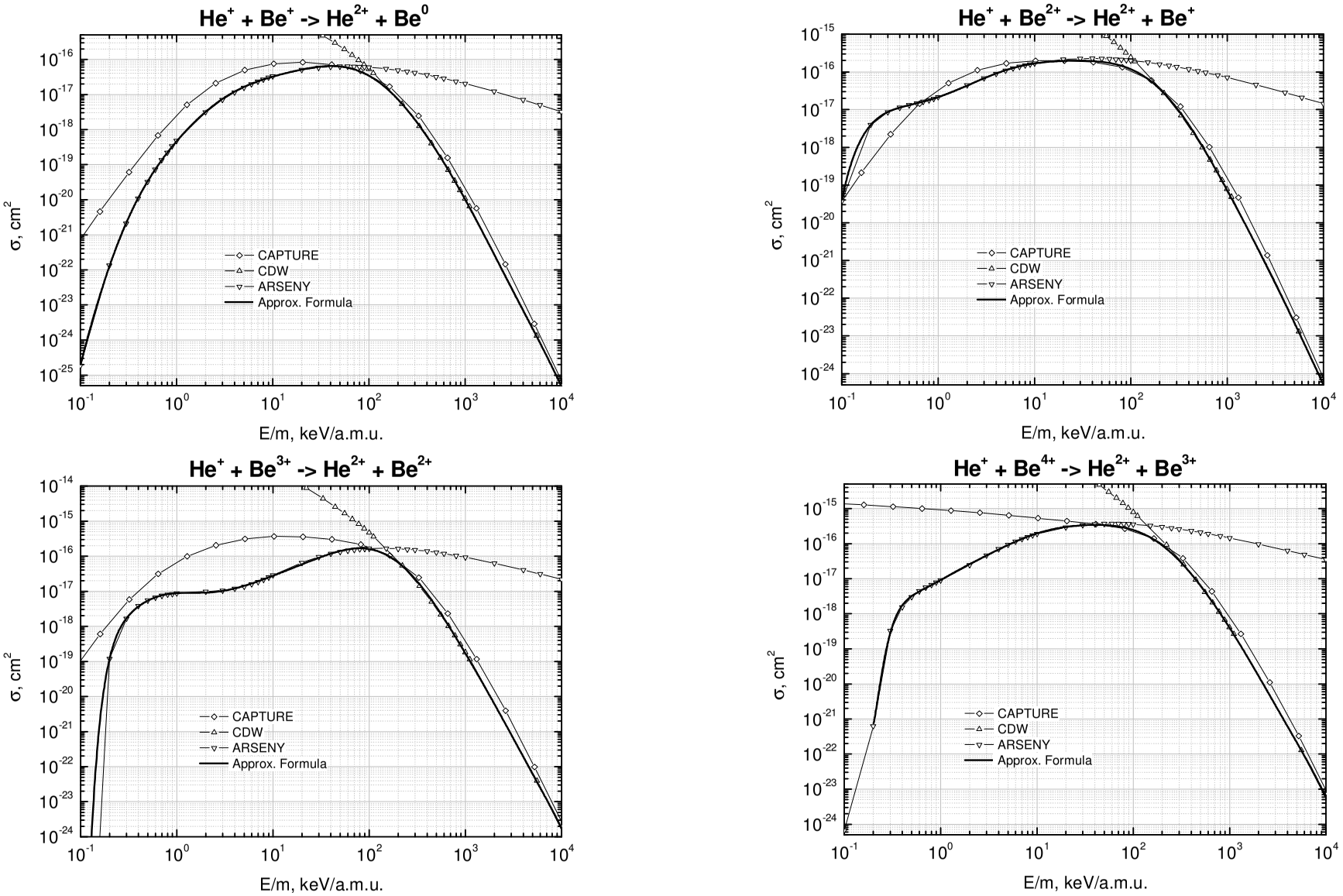


Fig. 12. $He^{+} + Be^{k+} \rightarrow He^{2+} + Be^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3, 4.

Table 13. Parameters for $H^+ + B^{k+} \rightarrow H^0 + B^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3, 4.

Parameter	k = 0	k = 1	k = 2
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E-001
E_{max}	0.1000000000000000E+005	0.1000000000000000E+005	0.1000000000000000E+005
γ	0.9745000000000000E+000	0.9916000000000000E+000	0.1000000000000000E+001
A_0	-0.4014912082217036E+002	-0.4365710666075402E+002	-0.6207793068409245E+002
A_1	-0.1050285143179286E+002	-0.4382087297466860E+001	0.2759378334746884E+002
A_2	-0.4304982274372136E+001	-0.7687628824543427E+001	-0.2724613635063077E+002
A_3	-0.6875255639763835E+000	0.8372333971835048E+000	0.8922207904440437E+001
A_4	0.3918824680212930E+000	-0.1056177759101018E+000	-0.3855643999506042E+001
A_5	-0.2793125603713723E-001	0.8687746057223311E-001	0.1626231891780491E+001
A_6	-0.3471281112168247E+000	-0.2318413814502395E+000	-0.4227468306250053E+000
A_7	0.1493480074984062E-001	-0.8900186458801061E-002	-0.5398993794562455E-001
A_8	0.2696380411860145E+000	0.1411644843162914E+000	-0.8094987279752226E-001
A_9	0.8224789862589829E-001	0.4859932208271771E-001	0.1465327281120569E+000
A_{10}	-0.1477065628421789E+000	-0.8421662948300719E-002	0.7038234756064941E-001
A_{11}	-0.9254575032344523E-001	-0.8325734197168777E-001	0.0000000000000000E+000
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

Table 13. Parameters for $H^+ + B^{k+} \rightarrow H^0 + B^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3, 4 (continued).

Parameter	k = 3	k = 4
E_{min}	0.2000000000000000E+000	0.2000000000000000E+000
E_{max}	0.1000000000000000E+005	0.1049000000000000E+005
γ	0.1000000000000000E+001	0.1027500000000000E+001
A_0	-0.8026180304895554E+002	-0.8396223679703829E+002
A_1	0.5252428741949236E+002	0.5738141695309866E+002
A_2	-0.3568335775633147E+002	-0.3828568186678509E+002
A_3	0.1076654252475376E+002	0.1283024806903578E+002
A_4	-0.4148471798511882E+001	-0.5289350686994649E+001
A_5	0.1243896574161078E+001	0.1699037891999876E+001
A_6	-0.9503186831499512E-002	-0.2757373576211471E+000
A_7	0.1487743749645299E+000	0.3375369086882640E+000
A_8	-0.1165307511916557E+000	-0.1648592597238273E+000
A_9	-0.4690464366552750E-001	-0.6669901776670493E-001
A_{10}	0.3075823137459658E-001	0.0000000000000000E+000
A_{11}	0.4909551732097617E-001	0.0000000000000000E+000
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000

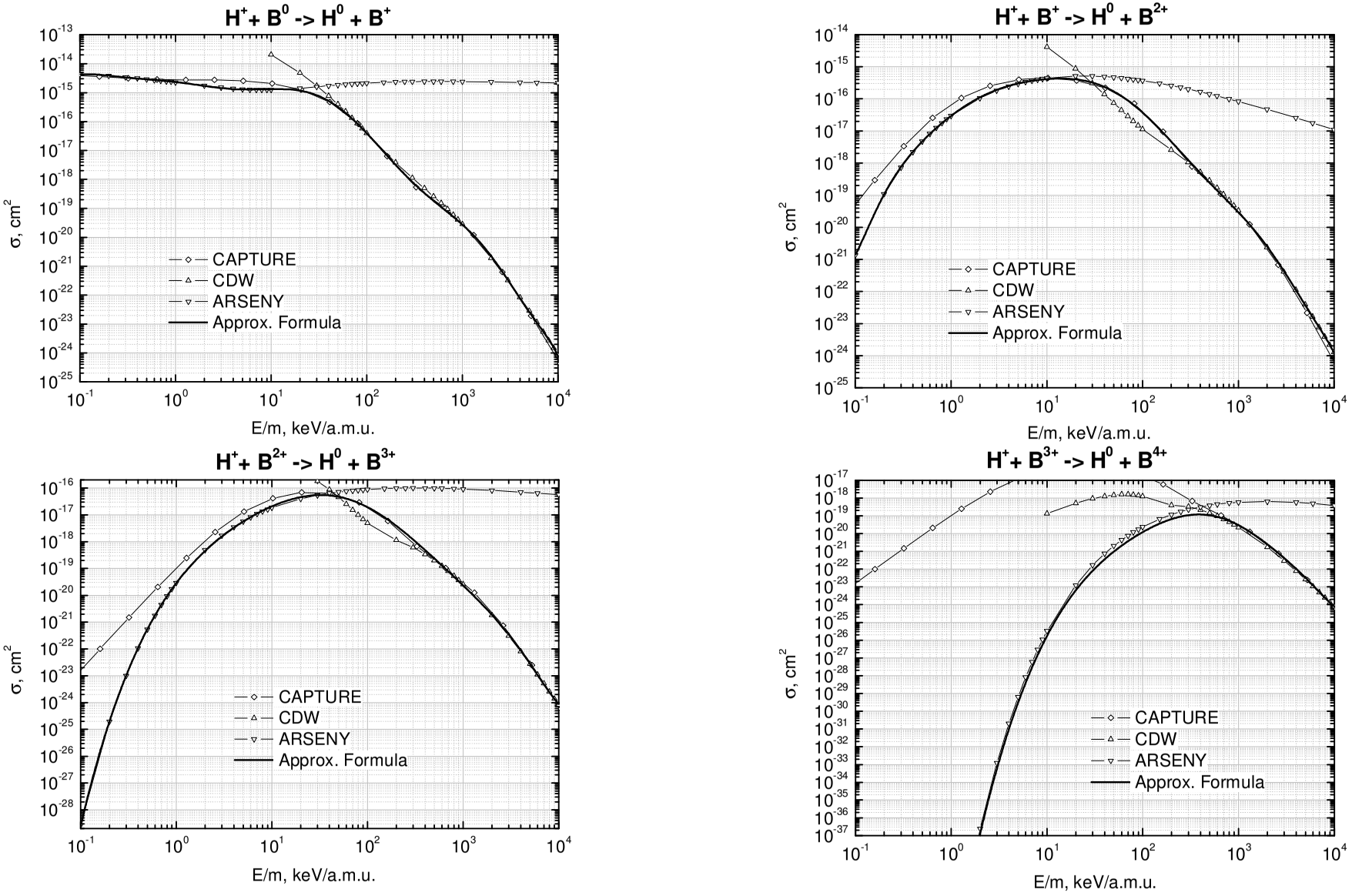


Fig. 13. $H^+ + B^{k+} \rightarrow H^0 + B^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2, 3, 4.

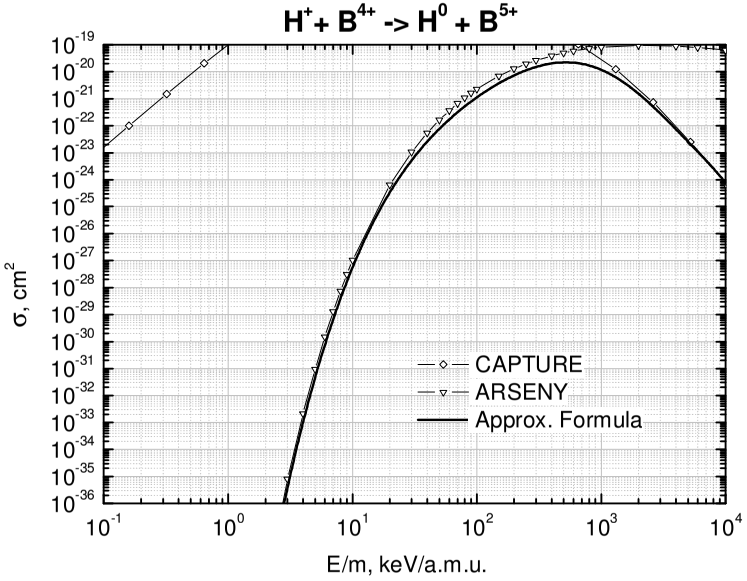


Fig. 13. $H^+ + B^{k+} \rightarrow H^0 + B^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2, 3, 4 (continued).

Table 14. Parameters for $H^0 + B^{k+} \rightarrow H^+ + B^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4, 5.

Parameter	k = 1	k = 2	k = 3
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.9259300000000000E+004	0.9259300000000000E+004	0.9259300000000000E+004
γ	0.1142530000000000E+001	0.1281900000000000E+001	0.1072400000000000E+001
A_0	-0.4399495504905992E+002	-0.4280867562053329E+002	-0.4215522852387166E+002
A_1	-0.1069131778386062E+002	-0.1224715227303748E+002	-0.1012161097717273E+002
A_2	-0.6422515174992196E+001	-0.5563542305263979E+001	-0.6687110900222789E+001
A_3	-0.1580845728089785E+000	0.4384261984615218E+000	-0.3675610983207533E+000
A_4	0.9547241060282937E+000	0.4622448550120757E+000	0.8479332506315180E+000
A_5	0.4009218307604514E-001	0.1123310413284185E+000	0.1607564860905141E+000
A_6	-0.4036489932215203E+000	-0.2254822206818146E+000	-0.2625671457560256E+000
A_7	0.2131011232456246E+000	0.1899186827864155E-001	0.1575417080924072E-001
A_8	-0.6339044215873316E-001	0.6938950122595143E-001	-0.6323565210422151E-001
A_9	-0.5423895415911804E-001	0.1435622739149096E-003	0.1441613759623433E-001
A_{10}	0.1703705331035289E-001	-0.2508329931825741E-001	-0.3679148678281089E-002
A_{11}	0.1578249171684044E-001	0.0000000000000000E+000	0.0000000000000000E+000
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

Table 14. Parameters for $H^0 + B^{k+} \rightarrow H^+ + B^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4, 5 (continued).

Parameter	k = 4	k = 5
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.9259300000000000E+004	0.9259300000000000E+004
γ	0.1061400000000000E+001	0.1032900000000000E+001
A_0	-0.4053719934383180E+002	-0.4032942284177014E+002
A_1	-0.9961056190498958E+001	-0.9558899608723454E+001
A_2	-0.5830437585858470E+001	-0.5541947945842287E+001
A_3	-0.3480951747596919E+000	-0.9675429932466121E+000
A_4	0.5549873526250120E+000	0.9233871404560803E+000
A_5	0.2274377665562833E+000	0.2522638895592774E+000
A_6	-0.2329456297373468E+000	-0.2430064812178341E+000
A_7	-0.8919219248054808E-001	-0.1363886546912253E+000
A_8	0.8123529044423873E-001	0.7040141666196251E-002
A_9	0.8272063048842018E-001	0.8778781578872041E-001
A_{10}	0.8165123633657833E-002	0.1049837576613612E-001
A_{11}	0.0000000000000000E+000	0.0000000000000000E+000
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000

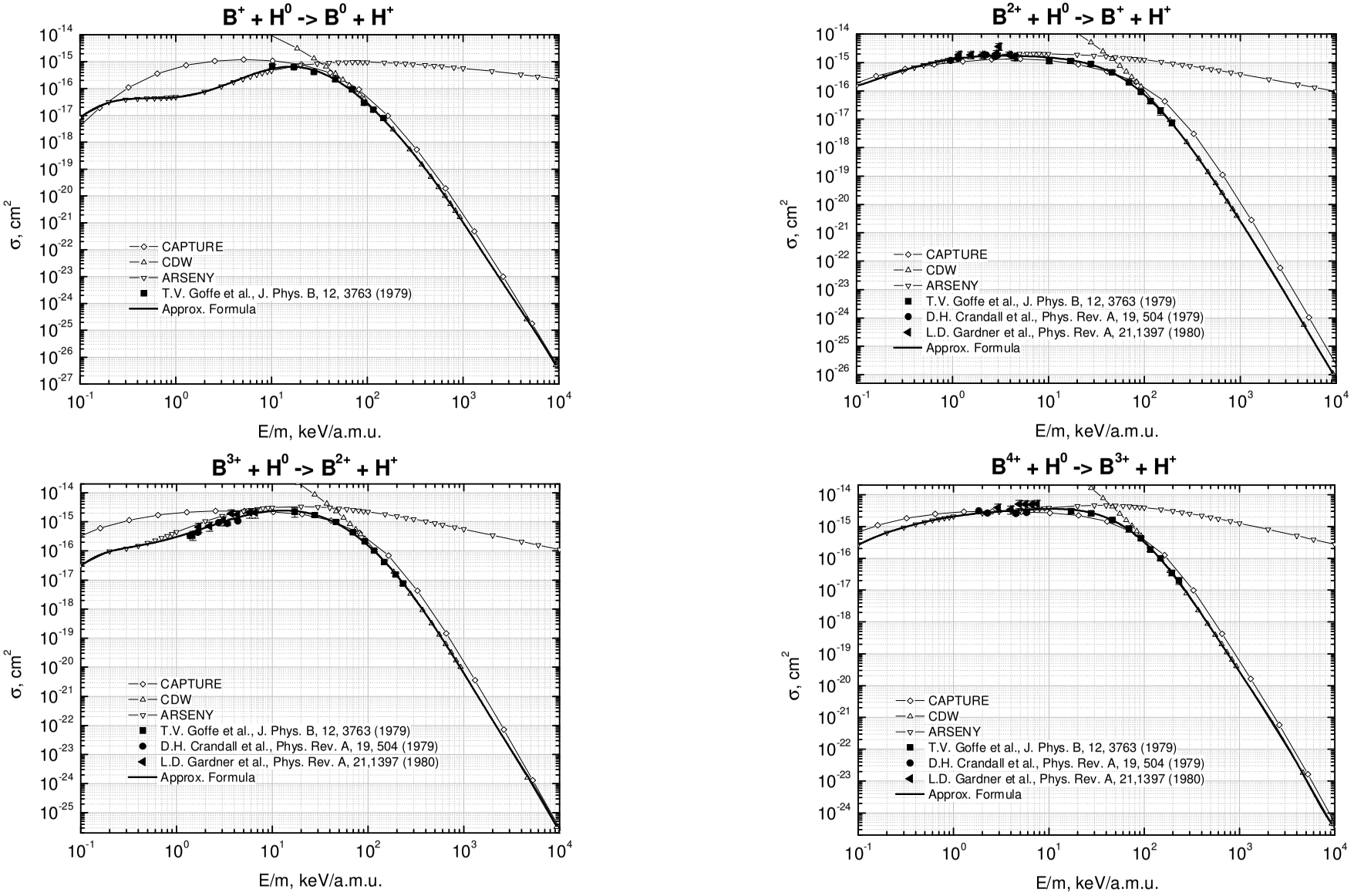


Fig. 14. $H^0 + B^{k+} \rightarrow H^+ + B^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3, 4, 5.

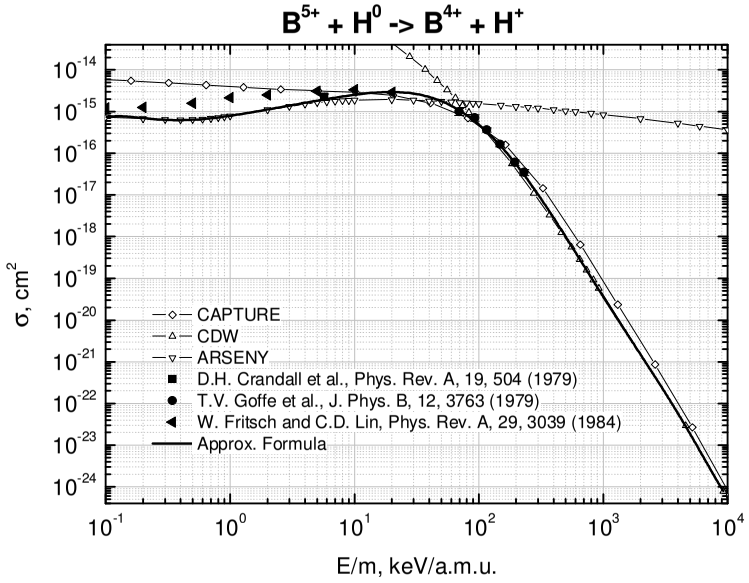


Fig. 14. $H^0 + B^{k+} \rightarrow H^+ + B^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3, 4, 5 (continued).

Table 15. Parameters for $He^{+} + B^{k+} \rightarrow He^{0} + B^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3, 4.

Parameter	k = 0	k = 1	k = 2
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1250000000000000E+005	0.1250000000000000E+005	0.1250000000000000E+005
γ	0.9752999999999999E+000	0.9177500000000000E+000	0.8369000000000000E+000
A_0	-0.4123936382848964E+002	-0.4089923527429701E+002	-0.4518878721843027E+002
A_1	-0.8791521332318437E+001	-0.9058705098239173E+001	-0.1782958589818751E+001
A_2	-0.5360055334674087E+001	-0.4405593522966413E+001	-0.8431821474732702E+001
A_3	-0.7524241156745360E+000	-0.1250213823856864E+001	-0.4340801179339075E+000
A_4	0.6975020573371086E+000	0.9987890350798468E-002	-0.4581513521535384E-001
A_5	-0.1692015863959019E+000	0.2604175058957937E+000	0.9699601127173356E-001
A_6	-0.3344521172205474E+000	-0.6742239354534228E-003	0.4222731982460014E-001
A_7	0.2101149956074916E+000	-0.9912836579557682E-001	-0.1713001429900775E+000
A_8	0.2187826221750613E+000	0.2014996408432597E-001	0.5371965226598908E-001
A_9	-0.7078035634431935E-001	0.8984132914568201E-001	0.3699243167350539E-001
A_{10}	-0.1548059158638025E+000	0.2067298816454556E-001	0.4669567170851970E-001
A_{11}	-0.7487205325940374E-001	-0.7807299528405941E-001	-0.6510446408321344E-001
A_{12}	0.3932138642539234E-001	-0.5489699013062045E-001	-0.2960550163364387E-001
A_{13}	0.5558309990402220E-001	0.3145836374207227E-001	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.9756633505997181E-001	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.4170899809094644E-001	0.0000000000000000E+000

Table 15. Parameters for $He^{+} + B^{k+} \rightarrow He^{0} + B^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3, 4 (continued).

Parameter	k = 3	k = 4
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1250000000000000E+005	0.1049000000000000E+005
γ	0.1175400000000000E+001	0.1000000000000000E+001
A_0	-0.7916639363135633E+002	-0.9043110262088165E+002
A_1	0.5286250123919299E+002	0.7023301939269471E+002
A_2	-0.4134185646181036E+002	-0.4592401663062275E+002
A_3	0.1772142045792605E+002	0.1574764866490529E+002
A_4	-0.9052104564113167E+001	-0.6145615108550554E+001
A_5	0.4836077781725909E+001	0.1787723839712938E+001
A_6	-0.2117440279535846E+001	-0.2200991060912247E+000
A_7	0.1156158599390861E+001	0.1385972398459954E+000
A_8	-0.9680569791547990E+000	-0.5907373604931955E-001
A_9	0.4834563032396976E+000	-0.4015024557642995E-001
A_{10}	-0.2700705891849394E+000	0.2531744522730916E-001
A_{11}	0.2129047482850689E+000	-0.6296426071642536E-002
A_{12}	-0.1741996624352812E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000

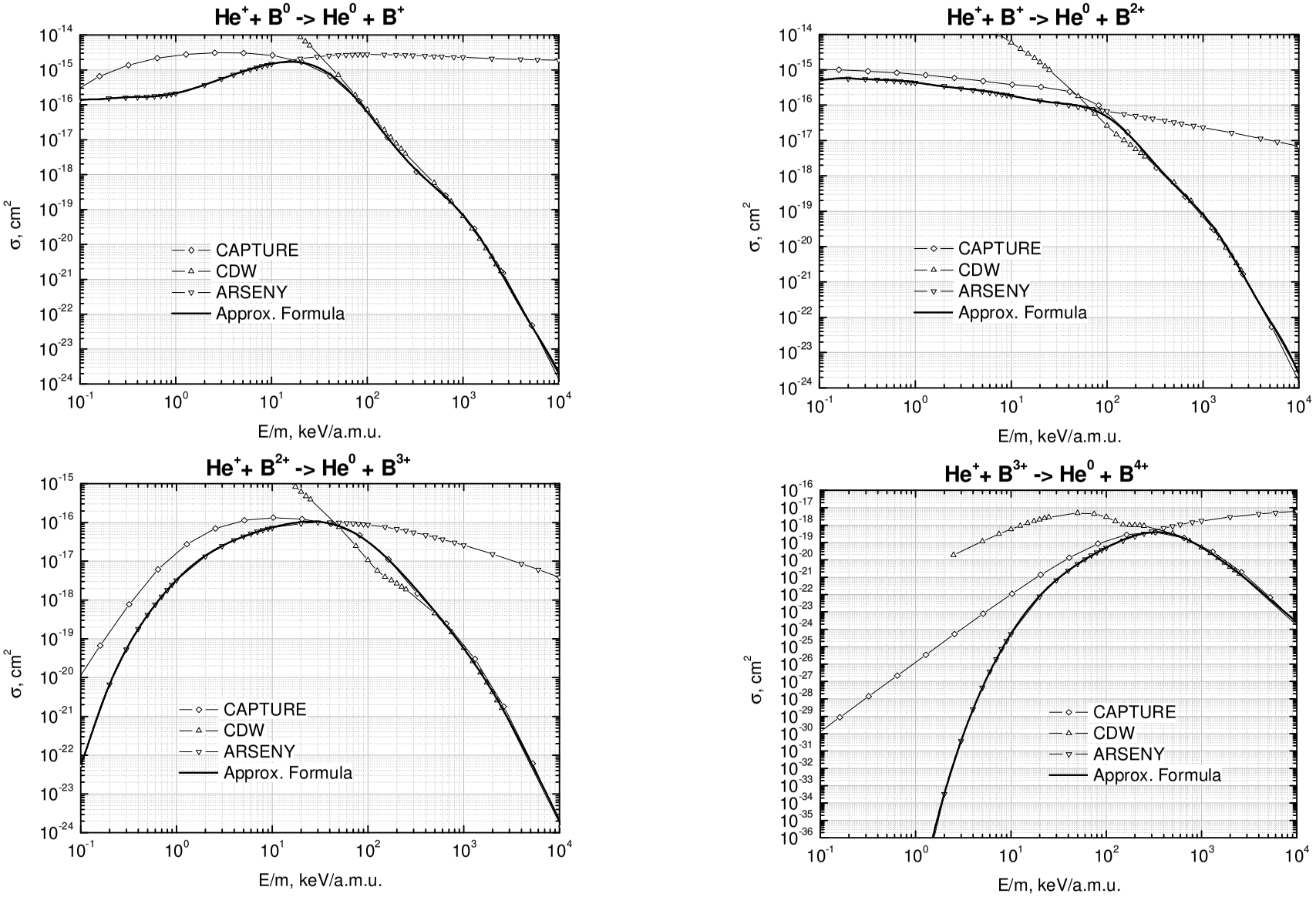


Fig. 15. $He^+ + B^{k+} \rightarrow He^0 + B^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2, 3, 4.

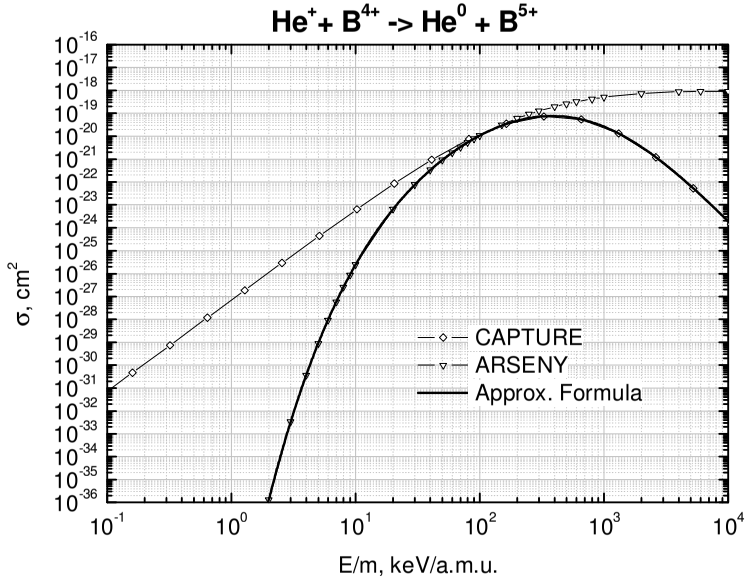


Fig. 15. $He^+ + B^{k+} \rightarrow He^0 + B^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2, 3, 4 (continued).

Table 16. Parameters for $He^{2+} + B^{k+} \rightarrow He^{+} + B^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3, 4.

Parameter	k = 0	k = 1	k = 2
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1250000000000000E+005	0.1250000000000000E+005	0.1250000000000000E+005
γ	0.9812300000000000E+000	0.1000000000000000E+001	0.1210350000000000E+001
A_0	-0.3916281270494434E+002	-0.4099743013531072E+002	-0.4226310842226025E+002
A_1	-0.8903470076775784E+001	-0.6163820662179866E+001	-0.6040483376647322E+001
A_2	-0.4805791363382943E+001	-0.4908064036965230E+001	-0.4525467252645747E+001
A_3	-0.6329579808893191E+000	-0.1311296678312530E+001	-0.1048960611695996E+001
A_4	0.1353427088819895E+000	0.3217273491633040E+000	0.2242852736511249E+000
A_5	-0.8117737506852143E-001	0.3152323702268149E+000	0.6314524078040935E+000
A_6	-0.2349281729042532E-001	-0.3014841614562951E+000	-0.3510649728495916E+000
A_7	0.1606723492632625E+000	0.5016470915170392E-001	0.3250309724069051E-001
A_8	0.1335945556270479E+000	0.1729225783805350E+000	0.8937050813769570E-001
A_9	-0.1467169019562162E-001	-0.2808204951928531E-001	0.6011450954452574E-001
A_{10}	-0.8494262395234126E-001	-0.1139389728346290E+000	-0.1827298661916446E+000
A_{11}	-0.4298286187055152E-001	-0.1059089495527320E-001	-0.9208916538487251E-002
A_{12}	0.4391395346844244E-001	0.3680550195697629E-001	0.7820425047972518E-001
A_{13}	0.4487778707901008E-001	0.1161685816397502E-001	0.4980159281275812E-001
A_{14}	-0.2473443577255814E-001	0.0000000000000000E+000	-0.6414448727218343E-001
A_{15}	-0.4616962820027396E-001	0.0000000000000000E+000	-0.5913934290155214E-001

Table 16. Parameters for $He^{2+} + B^{k+} \rightarrow He^{+} + B^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3, 4 (continued).

Parameter	k = 3	k = 4
E_{min}	0.2000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1250000000000000E+005	0.1049000000000000E+005
γ	0.9713900000000000E+000	0.1000000000000000E+001
A_0	-0.6453381267644214E+002	-0.7584762857097357E+002
A_1	0.3171666533715264E+002	0.5007911010046430E+002
A_2	-0.2686800296998083E+002	-0.3434577326733091E+002
A_3	0.9326773111102241E+001	0.1108710620239079E+002
A_4	-0.5189341665264584E+001	-0.4639476168035986E+001
A_5	0.2714007096156036E+001	0.1315536604200301E+001
A_6	-0.9603159652968926E+000	-0.8935373365091573E-001
A_7	0.5986813978202390E+000	0.1061540855803585E+000
A_8	-0.3780672059055584E+000	-0.3962508993799192E-001
A_9	0.1223270885485093E+000	-0.4230821583112735E-001
A_{10}	-0.8264072414636513E-002	0.3989912368362474E-002
A_{11}	0.8468127498964764E-001	0.2124128477562234E-001
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000

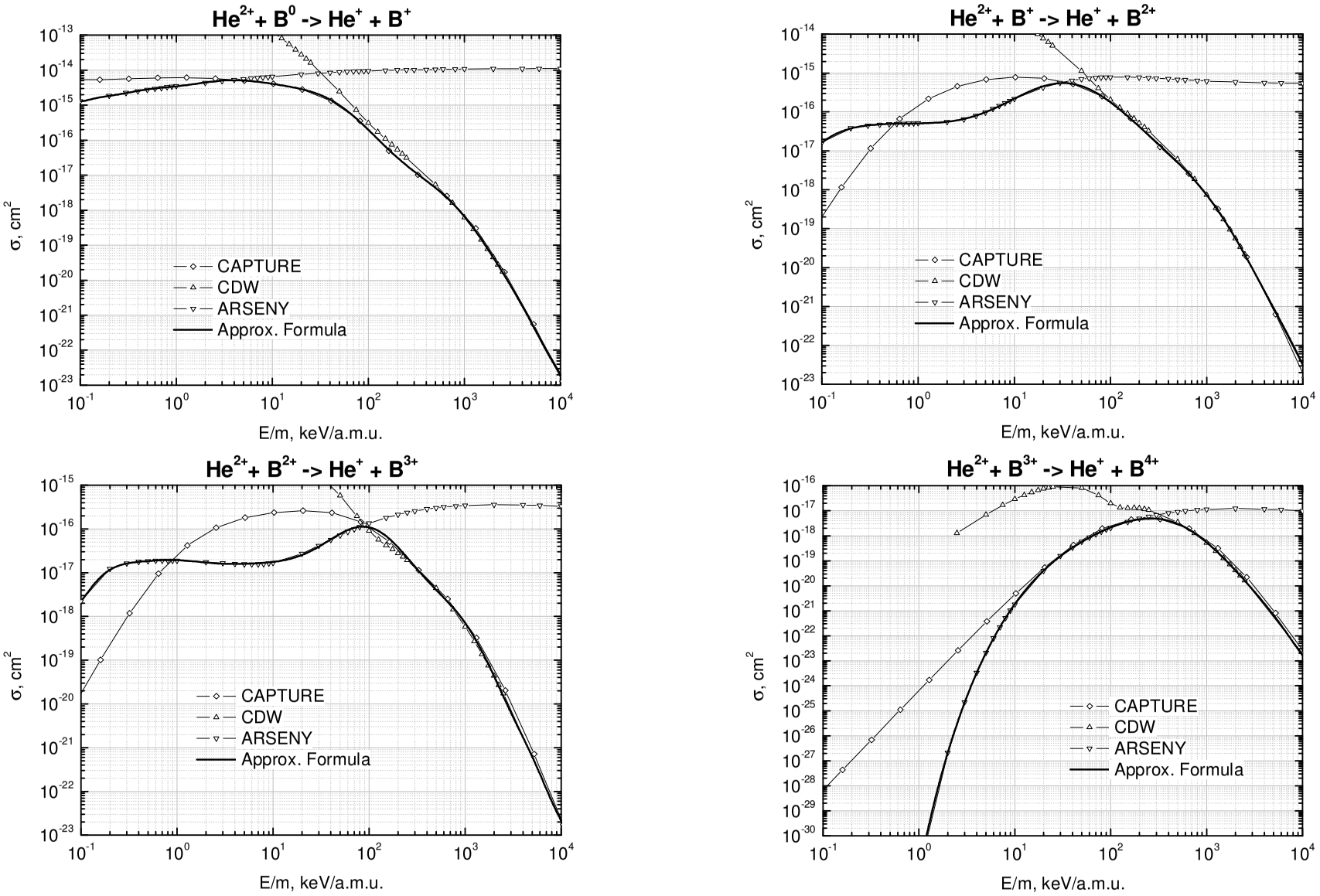


Fig. 16. $He^{2+} + B^{k+} \rightarrow He^{+} + B^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2, 3, 4.

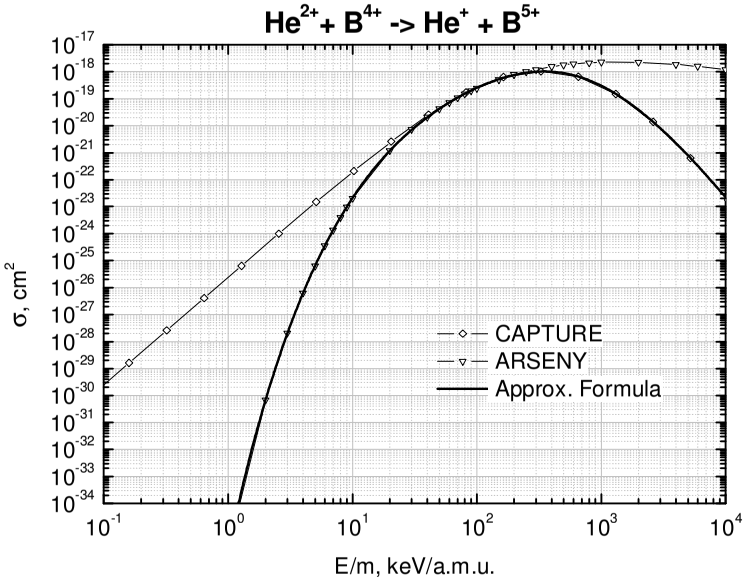


Fig. 16. $He^{2+} + B^{k+} \rightarrow He^{+} + B^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2, 3, 4 (continued).

Table 17. Parameters for $He^0 + B^{k+} \rightarrow He^+ + B^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4, 5.

Parameter	k = 1	k = 2	k = 3
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1056300000000000E+000
E_{max}	0.9259300000000000E+004	0.9259300000000000E+004	0.9259300000000000E+004
γ	0.9675300000000000E+000	0.1061220000000000E+001	0.1127580000000000E+001
A_0	-0.4723658031581454E+002	-0.4161236106190323E+002	-0.3983943550098319E+002
A_1	0.4760626590483595E+000	-0.7030483984706729E+001	-0.8737467171199542E+001
A_2	-0.1121123814577916E+002	-0.6397068812530067E+001	-0.4556140482585249E+001
A_3	0.8819637619313476E+000	-0.5662078863149018E+000	-0.8561198506080753E+000
A_4	-0.3375821817378366E+000	0.4312061700337245E+000	0.2836482874487955E+000
A_5	0.6263982953645861E+000	0.2967881274121220E+000	0.3150360682334246E+000
A_6	0.3566733071647697E-001	-0.1705070181951006E+000	-0.7063123942572080E-001
A_7	-0.2119529171281645E+000	0.7890069372014442E-001	-0.1271889050580515E+000
A_8	-0.8629026681697513E-001	-0.1743158764779315E+000	0.6917476406063723E-002
A_9	0.8109583124858027E-001	0.6480012373799557E-001	-0.1222358976612210E-001
A_{10}	0.1170779272636686E+000	0.4499546613330368E-001	0.4238012794910979E-001
A_{11}	-0.8132054656022819E-002	-0.4760942125956597E-001	0.3776049823567975E-002
A_{12}	-0.5379070759580792E-001	-0.1858977367426988E-002	-0.1550541361899378E-001
A_{13}	-0.1292649575271777E-001	-0.4092705901815865E-002	0.1881415258455960E-001
A_{14}	0.5186787916454675E-001	0.4306003218086980E-001	0.2253515827615851E-001
A_{15}	0.2903449474543599E-001	0.0000000000000000E+000	0.0000000000000000E+000

Table 17. Parameters for $He^0 + B^{k+} \rightarrow He^+ + B^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4, 5 (continued).

Parameter	k = 4	k = 5
E_{min}	0.1000000000000000E+000	0.8000000000000000E-001
E_{max}	0.9259300000000000E+004	0.9259300000000000E+004
γ	0.1000000000000000E+001	0.1026130000000000E+001
A_0	-0.4033539811859065E+002	-0.3911510669086896E+002
A_1	-0.6757829932416775E+001	-0.7408836050298767E+001
A_2	-0.4981335600396728E+001	-0.4394048447459459E+001
A_3	-0.1185408673067313E+001	-0.1319267475892043E+001
A_4	0.2713827809624834E+000	0.9078878922485724E-001
A_5	0.1628566416284560E+000	0.3905541561687218E+000
A_6	0.1291747364147311E-001	0.1027002017808589E-001
A_7	-0.1028679048641527E+000	-0.8517168587037177E-001
A_8	-0.3995771278229213E-001	-0.3795033641251971E-002
A_9	0.0000000000000000E+000	-0.4997743588421364E-001
A_{10}	0.0000000000000000E+000	-0.6656181596366976E-002
A_{11}	0.0000000000000000E+000	0.2106200848318554E-001
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000

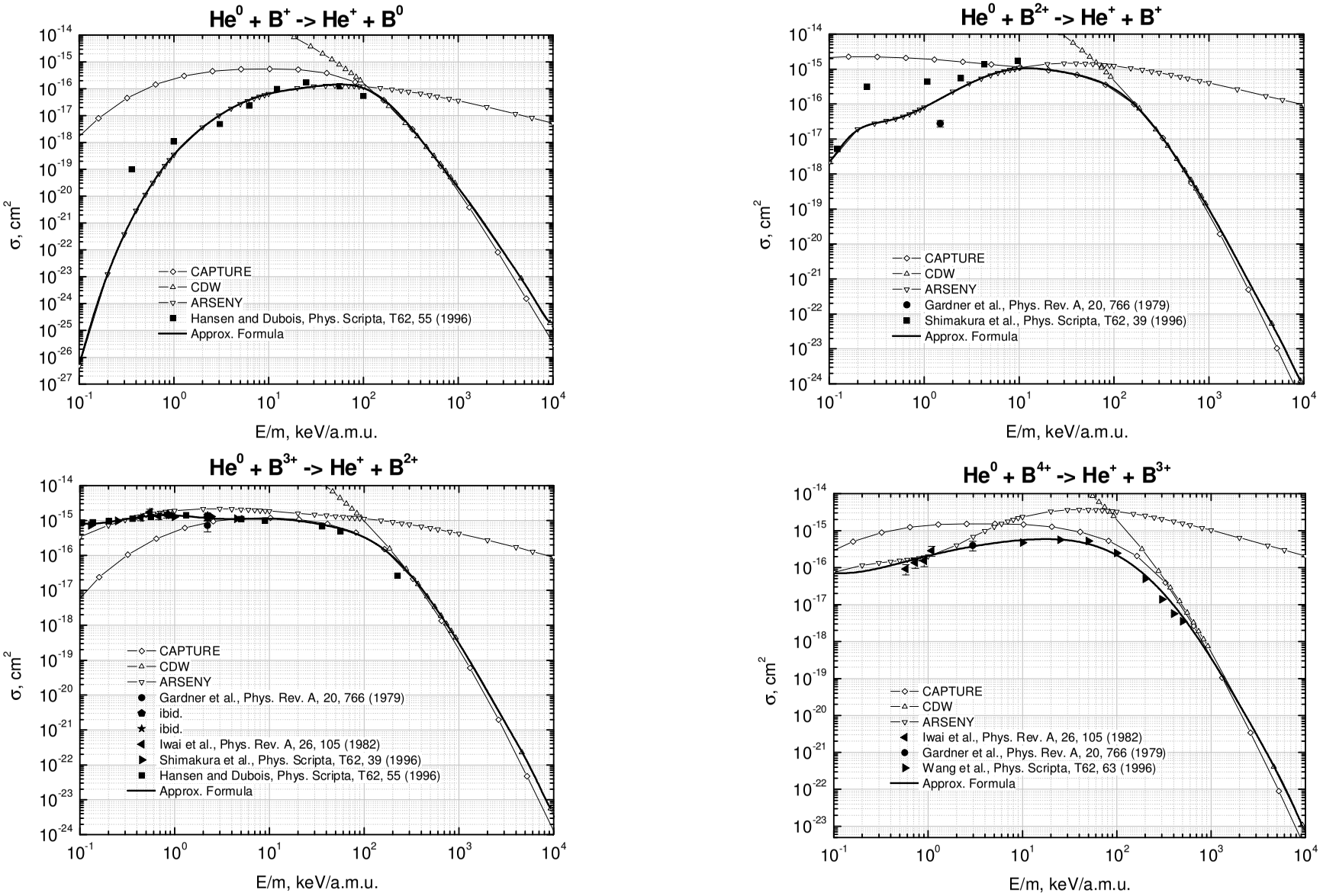


Fig. 17. $He^0 + B^{k+} \rightarrow He^+ + B^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3, 4, 5.

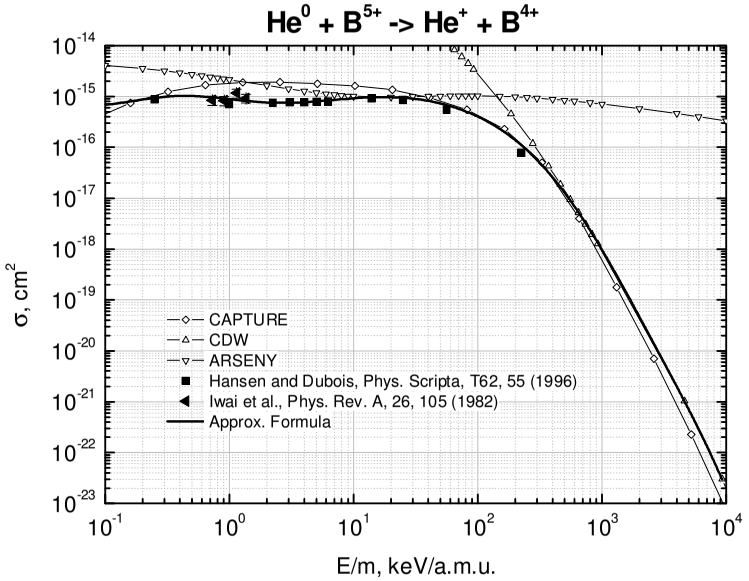


Fig. 17. $He^0 + B^{k+} \rightarrow He^+ + B^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3, 4, 5 (continued).

Table 18. Parameters for $He^{+} + B^{k+} \rightarrow He^{2+} + B^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4, 5.

Parameter	k = 1	k = 2	k = 3
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.9259300000000000E+004	0.9259300000000000E+004	0.9259300000000000E+004
γ	0.8792300000000000E+000	0.9974200000000000E+000	0.1001700000000000E+001
A_0	-0.4661048803914382E+002	-0.4462384875937476E+002	-0.4569130452752882E+002
A_1	-0.6056479688634705E+000	-0.2207850528716512E+001	0.1488693269101907E+001
A_2	-0.1020701867815380E+002	-0.9485345122451648E+001	-0.1145945322839397E+002
A_3	-0.1946662861975617E+000	0.1703505426838456E+001	0.3558863483575473E+001
A_4	-0.1416479775413770E+000	-0.2631060141976164E+001	-0.4416737330288275E+001
A_5	0.4341161843362058E+000	0.3164322895600366E+001	0.4377602997771758E+001
A_6	0.1893256486001311E+000	-0.2099880946026621E+001	-0.2801242909988932E+001
A_7	-0.1647039118142563E+000	0.1359901894294996E+001	0.1785150709625681E+001
A_8	-0.5936836068029608E-001	-0.1141224925876646E+001	-0.1435830942548589E+001
A_9	-0.1398761139870555E-001	0.8183187126087214E+000	0.1004036429164375E+001
A_{10}	0.6227282518223480E-001	-0.5492543007938152E+000	-0.5620721596252387E+000
A_{11}	0.0000000000000000E+000	0.3797161701937781E+000	0.3611877351775049E+000
A_{12}	0.0000000000000000E+000	-0.2316982778978680E+000	-0.1765986950748625E+000
A_{13}	0.0000000000000000E+000	0.1114848365426864E+000	0.5496097014266402E-001
A_{14}	0.0000000000000000E+000	-0.2395735270197829E-001	0.9984913558211510E-002
A_{15}	0.0000000000000000E+000	0.4176745650226527E-001	0.0000000000000000E+000

Table 18. Parameters for $He^{+} + B^{k+} \rightarrow He^{2+} + B^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4, 5 (continued).

Parameter	k = 4	k = 5
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.9259300000000000E+004	0.9259300000000000E+004
γ	0.8933600000000000E+000	0.9989700000000000E+000
A_0	-0.4073571389632453E+002	-0.4047242088420654E+002
A_1	-0.5564810410790998E+001	-0.5596455838584812E+001
A_2	-0.6006405212473009E+001	-0.5618257157921149E+001
A_3	-0.1181874942751739E+001	-0.6679040828025420E+000
A_4	-0.2474483719214832E+000	-0.2990455923833235E+000
A_5	0.3706251536209375E+000	0.5910871510543287E+000
A_6	0.2823745460876718E+000	-0.6841740885108707E-002
A_7	-0.6440439719895584E-001	-0.6642138992759214E-002
A_8	-0.1561619185911955E+000	-0.2122018401778546E+000
A_9	-0.6103765432195025E-001	0.1493954156529828E-001
A_{10}	0.4405668043319954E-001	0.2440799756170229E-001
A_{11}	0.4753748237936799E-001	0.2631846087838823E-001
A_{12}	0.2912744308473876E-001	0.1623550486798628E-001
A_{13}	-0.7636478233823565E-002	-0.2400160802710286E-001
A_{14}	-0.9839327959938026E-003	0.1239551190628763E-001
A_{15}	0.6694779408677030E-002	0.0000000000000000E+000

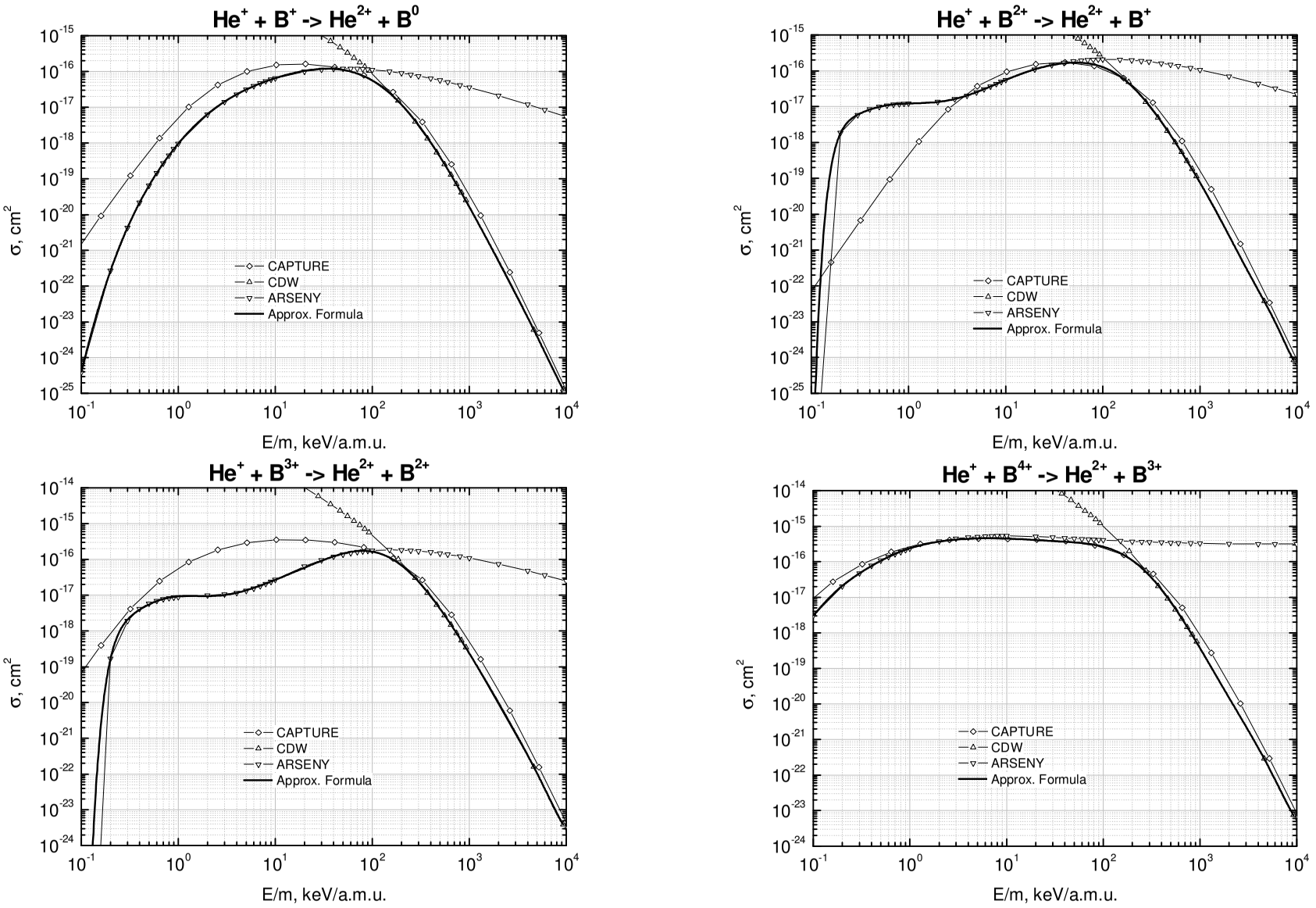


Fig. 18. $He^{+} + B^{k+} \rightarrow He^{2+} + B^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3, 4, 5.

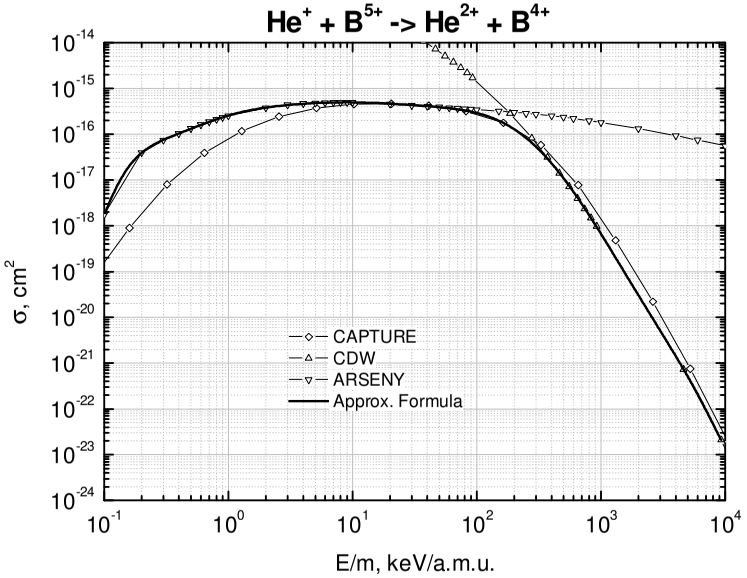


Fig. 18. $He^{+} + B^{k+} \rightarrow He^{2+} + B^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3, 4, 5 (continued).

Table 19. Parameters for $H^+ + C^{k+} \rightarrow H^0 + C^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3, 4, 5.

Parameter	k = 0	k = 1	k = 2
E_{min}	0.5308400000000000E-002	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1000000000000000E+005	0.1000000000000000E+005	0.8389000000000000E+007
γ	0.1051320000000000E+001	0.8747500000000000E+000	0.1000000000000000E+001
A_0	-0.4280088217508590E+002	-0.4478058085698805E+002	-0.6321388424909359E+002
A_1	-0.3847174500369429E+001	-0.1667174104787008E+001	-0.1685402966315151E+002
A_2	-0.8303841248235285E+001	-0.8666416614677363E+001	-0.2000848537839789E+002
A_3	-0.1272784281507118E+000	0.1943508038998064E+000	0.6236816392668862E+001
A_4	0.3202821077083545E+000	0.2793642357754543E+000	-0.1389132467524156E+001
A_5	0.2479805580143766E-001	0.2879518209347226E-001	0.6122151608385780E+000
A_6	0.1575381966666113E+000	-0.1218476743913077E+000	-0.4007312633535282E+000
A_7	-0.8901874130104495E-001	-0.1397068196439732E+000	0.1234224688951777E+000
A_8	-0.1433392134922326E+000	0.3429312924283429E-001	-0.1631371753947700E+000
A_9	0.1522664257717566E-001	0.6305363788353048E-001	0.8652480673247628E-001
A_{10}	0.2112895403629301E-001	0.0000000000000000E+000	0.2028427286109818E+000
A_{11}	-0.3165101585110966E-001	0.0000000000000000E+000	-0.1230031767001349E+000
A_{12}	0.6976153339471197E-001	0.0000000000000000E+000	0.5476346658173284E-001
A_{13}	0.3426096112612832E-001	0.0000000000000000E+000	0.1626372712886913E-001
A_{14}	-0.3845256025471072E-001	0.0000000000000000E+000	0.2655186077372102E+000
A_{15}	-0.1855130938720516E-002	0.0000000000000000E+000	-0.3348692616314667E-001

Table 19. Parameters for $H^+ + C^{k+} \rightarrow H^0 + C^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3, 4, 5 (continued).

Parameter	k = 3	k = 4	k = 5
E_{min}	0.1000000000000000E+000	0.5000000000000000E+000	0.1000000000000000E+000
E_{max}	0.8389000000000000E+007	0.1000000000000000E+005	0.8389000000000000E+005
γ	0.1000000000000000E+001	0.7865000000000000E+000	0.1090500000000000E+001
A_0	-0.6624066407245786E+002	-0.9662479917498882E+002	-0.1093159837111218E+003
A_1	-0.1142518327485139E+002	0.8009389989337527E+002	0.9319614223246371E+002
A_2	-0.2305229813256956E+002	-0.5096448443032854E+002	-0.7379436210438099E+002
A_3	0.7541390749724786E+001	0.1866670990377607E+002	0.3319507927349101E+002
A_4	-0.1814303072730717E+001	-0.9106791741012959E+001	-0.1530348872411272E+002
A_5	0.9679148188915683E+000	0.4035863053284498E+001	0.7401468104238553E+001
A_6	-0.6448212005819349E+000	-0.1134037409130241E+001	-0.3083381149212062E+001
A_7	0.2656302891359932E+000	0.3044106548265316E+000	0.1292359114039662E+001
A_8	-0.1553551049982130E+000	0.1436730077826916E+000	-0.8131360770718771E+000
A_9	0.2594723828995985E-001	-0.5965331194117344E+000	0.5979725442997814E+000
A_{10}	0.1512335356086399E+000	0.5707153929125349E+000	-0.3945377992229959E+000
A_{11}	-0.9069290345598420E-001	-0.3712255104241519E+000	0.1497483342615162E+000
A_{12}	-0.4028659017297001E-001	0.2398608988012148E+000	-0.1967818245866672E+000
A_{13}	0.3390362079802388E-001	-0.1785773033145866E+000	0.2249925491080647E+000
A_{14}	0.9303022881703958E-001	-0.1445274079838625E-001	-0.2207670766661216E+000
A_{15}	-0.4981399637368939E-001	0.8526857939776576E-001	0.1765448978751634E+000

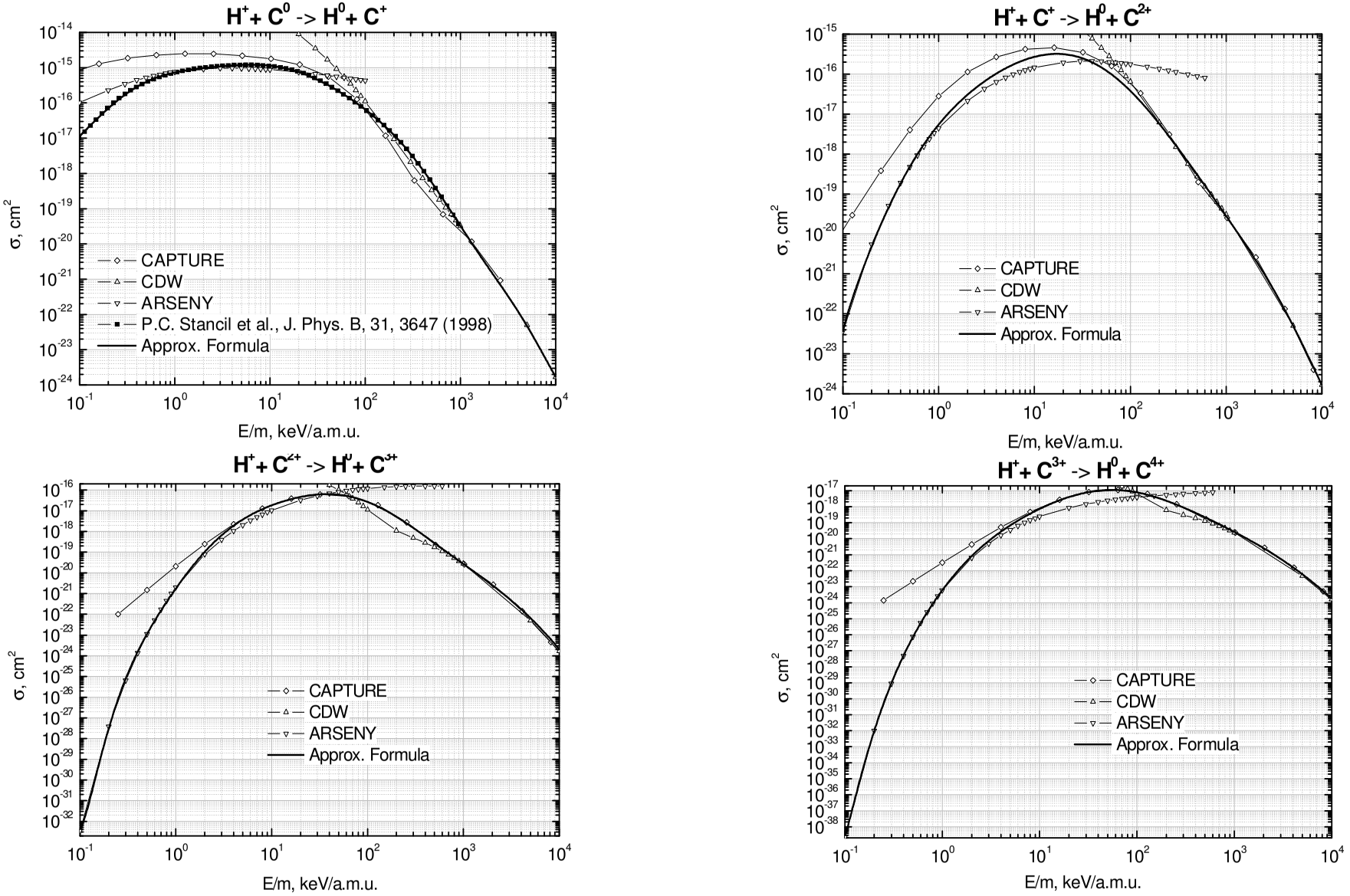
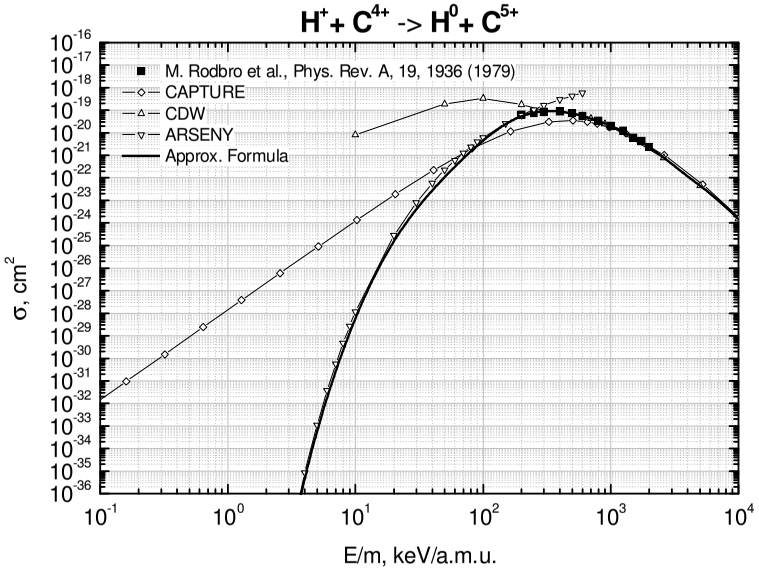


Fig. 19. $H^+ + C^{k+} \rightarrow H^0 + C^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2, 3, 4, 5.



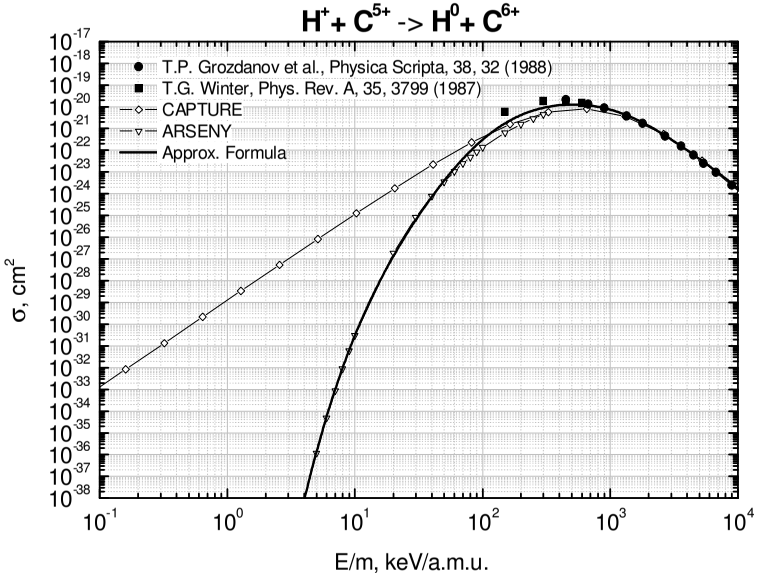


Fig. 19. $H^+ + C^{k+} \rightarrow H^0 + C^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2, 3, 4, 5 (continued).

Table 20. Parameters for $H^0 + C^{k+} \rightarrow H^+ + C^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4, 5, 6.

Parameter	k = 1	k = 2	k = 3
E_{min}	0.2000000000000000E-001	0.8000000000000000E-002	0.1000000000000000E-002
E_{max}	0.1000000000000000E+005	0.1000000000000000E+005	0.1000000000000000E+005
γ	0.9978399999999999E+000	0.1000000000000000E+001	0.1054300000000000E+001
A_0	-0.447946706136259 0E+002	-0.4409315152038832E+002	-0.4016161898976141E+002
A_1	-0.8335385461478975E+001	-0.7015201240088794E+001	-0.1030892985303403E+002
A_2	-0.1006738386257181E+002	-0.9626065237324100E+001	-0.6224164625885839E+001
A_3	-0.1323522324354930E+000	-0.9046203505937558E+000	-0.2888153546958292E+001
A_4	-0.3635875146253989E-001	0.1506543261988395E+000	0.1020564126784203E+000
A_5	0.6247604993139637E+000	0.6320194263596965E+000	0.8056680884770914E+000
A_6	0.3325175418959315E+000	0.1633929901898317E+000	0.1729765482890419E+000
A_7	-0.1760172141127426E+000	-0.1583481611661104E+000	-0.1780931565856719E+000
A_8	-0.1315187688199011E+000	-0.1530562096799798E+000	-0.8895377978496651E-001
A_9	-0.4291498897710933E-001	-0.3965330632307565E-002	-0.2330523193769451E-001
A_{10}	0.3980655831623423E-001	0.5976130496618814E-001	0.3279085109574904E-001
A_{11}	0.5851543502112149E-001	-0.7678978232025584E-002	0.4512942977282331E-001
A_{12}	0.0000000000000000E+000	-0.7850920189493614E-002	-0.6850880613915595E-002
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000	-0.5087495958647968E-001
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

Table 20. Parameters for $H^0 + C^{k+} \rightarrow H^+ + C^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4, 5, 6 (continued).

Parameter	k = 4	k = 5	k = 6
E_{min}	0.1000000000000000E-002	0.1200000000000000E-002	0.1000000000000000E-002
E_{max}	0.1000000000000000E+005	0.1000000000000000E+005	0.1000000000000000E+005
γ	0.1157320000000000E+001	0.1261720000000000E+001	0.9875100000000000E+000
A_0	-0.4046317235930461E+002	-0.3938934837965806E+002	-0.4061178754827218E+002
A_1	-0.9203322238574669E+001	-0.1031354901100740E+002	-0.5363222911807356E+001
A_2	-0.7440590518035378E+001	-0.5572976464108603E+001	-0.7874939359539759E+001
A_3	-0.1484893383384541E+001	-0.1850720005321012E+001	-0.2119000457144152E+001
A_4	0.9157928715137086E-001	0.6289529232070239E+000	0.3738851797083829E+000
A_5	0.5831928094576936E+000	0.6277105246382845E+000	0.1404101096134704E+000
A_6	0.2285729077304089E+000	-0.1075311431616588E+000	0.5373068635105275E+000
A_7	-0.2158859969595853E+000	-0.2615791765787560E+000	-0.9516471647951052E-001
A_8	-0.1514436811995614E+000	-0.4171215723109191E-001	-0.2345775280054506E+000
A_9	0.6322435249222508E-001	0.7716439756724351E-001	-0.7287746357220447E-001
A_{10}	0.5912585352323364E-001	0.3513244644352690E-001	-0.7184396969458873E-002
A_{11}	0.1013481454481407E-001	-0.9308484566987621E-002	0.1308023967889777E+000
A_{12}	-0.4861775900869699E-001	-0.5486181896993515E-001	0.2110492913562456E-002
A_{13}	-0.1987221112624910E-001	-0.1344252459679476E-001	-0.3328500628103218E-001
A_{14}	0.1607706587736863E-001	0.3098160249508804E-001	-0.3475616262874686E-001
A_{15}	0.3543440635479708E-001	0.3543455933328143E-001	-0.3432987216533989E-001

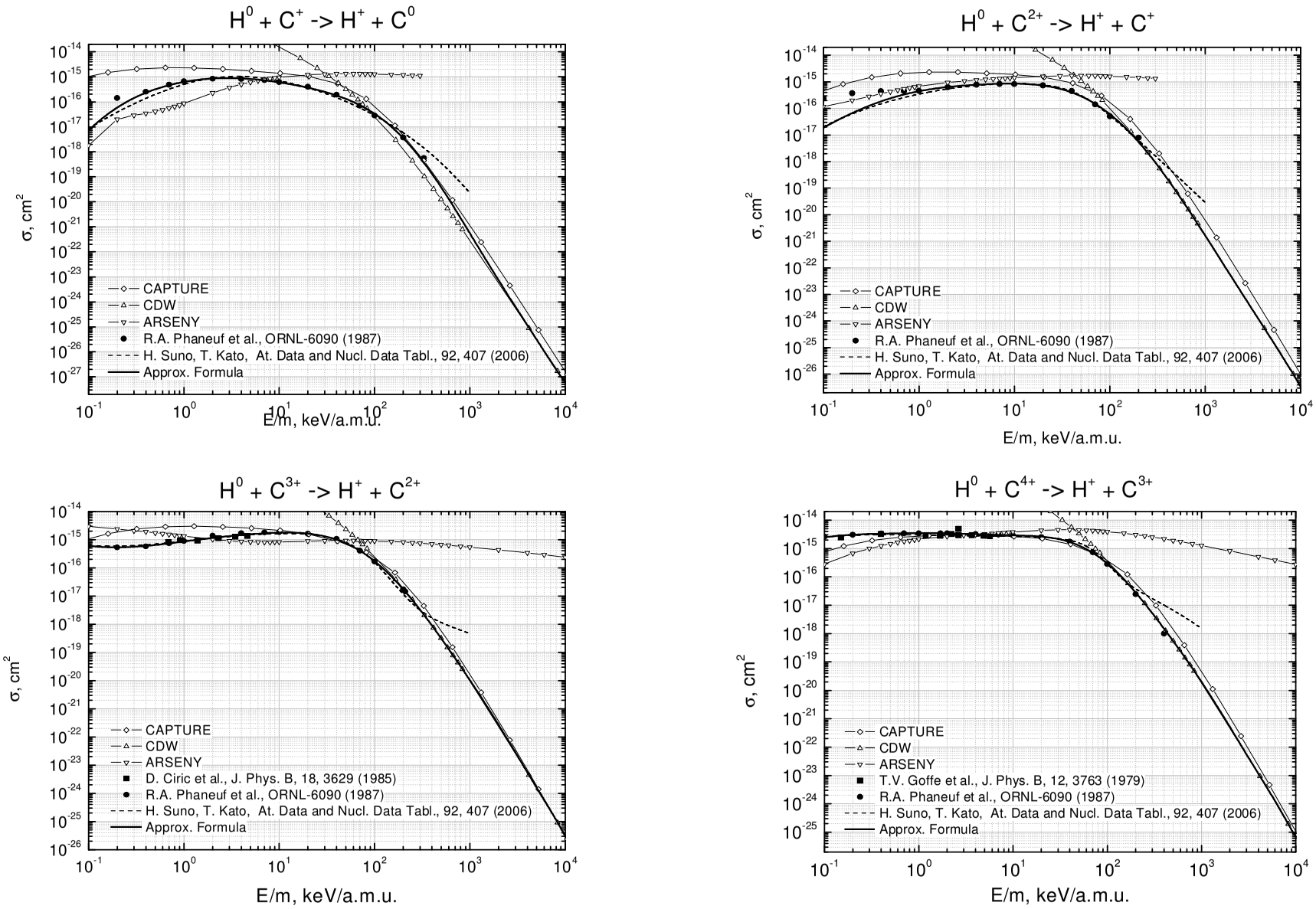
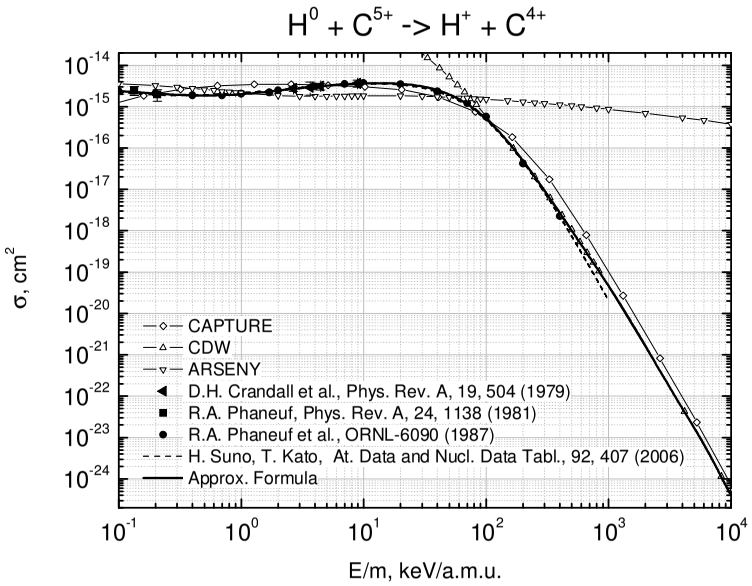


Fig. 20. $H^0 + C^{k+} \rightarrow H^+ + C^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3, 4, 5, 6.



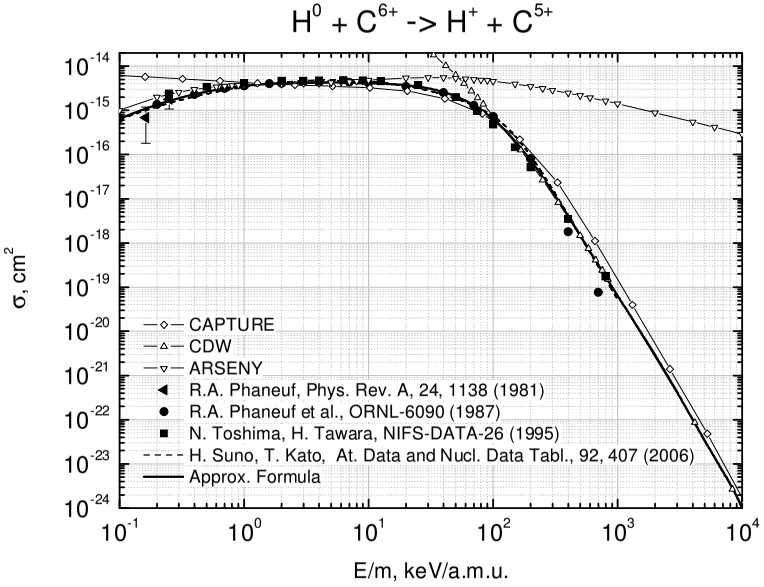


Fig. 20. $H^0 + C^{k+} \rightarrow H^+ + C^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3, 4, 5, 6 (continued).

Table 21. Parameters for $He^{+} + C^{k+} \rightarrow He^{0} + C^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3, 4, 5.

Parameter	k = 0	k = 1	k = 2
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1250000000000000E+005	0.1250000000000000E+005	0.1250000000000000E+005
γ	0.9115000000000000E+000	0.9421000000000000E+000	0.9427000000000000E+000
A_0	-0.4100189752898802E+002	-0.4060509610715005E+002	-0.4658204740749783E+002
A_1	-0.8286472968846493E+001	-0.9048228973793968E+001	0.6229371880114504E+000
A_2	-0.5133684138760108E+001	-0.4617981443085513E+001	-0.9842745262281261E+001
A_3	-0.1171467381722543E+001	-0.1060340851159817E+001	0.8715757136060462E+000
A_4	0.6429545768546686E+000	0.4048677576640760E+000	-0.2020752833985599E+000
A_5	0.1576871045691294E+000	0.1254075968842394E+000	0.2734877906066200E+000
A_6	-0.4920644118479556E+000	-0.2266390362104363E+000	-0.9848485363435480E-001
A_7	-0.1194642267421834E+000	-0.1045932790875578E+000	-0.1511633932678257E+000
A_8	0.2942422672804704E+000	0.6719998012308248E-001	0.6105934485802383E-001
A_9	0.1386858522713489E+000	0.1138767679773243E+000	0.8720845094586892E-001
A_{10}	-0.5857801066075460E-001	0.9362128152600217E-003	0.4870369048440264E-001
A_{11}	-0.9573900381073443E-001	-0.7635993494447452E-001	-0.4260568784376673E-001
A_{12}	-0.3191909875273848E-001	-0.3264937766751503E-001	-0.4451886378790509E-001
A_{13}	0.3257909839001840E-001	0.0000000000000000E+000	-0.2933935685607946E-001
A_{14}	0.5758735050104447E-001	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.5458294718937632E-001	0.0000000000000000E+000	0.0000000000000000E+000

Table 21. Parameters for $He^{+} + C^{k+} \rightarrow He^{0} + C^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3, 4, 5 (continued).

Parameter	k = 3	k = 4	k = 5
E_{min}	0.1000000000000000E+000	0.2000000000000000E+000	0.3000000000000000E+000
E_{max}	0.1250000000000000E+005	0.1250000000000000E+005	0.1049000000000000E+005
γ	0.9978000000000000E+000	0.8310700000000000E+000	0.9386500000000000E+000
A_0	-0.5091814415329035E+002	-0.9641628945121302E+002	-0.8897332998194027E+002
A_1	0.7035652519737120E+001	0.7622474803842339E+002	0.6504513338434462E+002
A_2	-0.1298885700000732E+002	-0.4190801055315162E+002	-0.3801896087256033E+002
A_3	0.2455160872815564E+001	0.8130129811530095E+001	0.1026989073907975E+002
A_4	-0.9308776978784092E+000	-0.8765631424642633E+000	-0.3089995601414332E+001
A_5	0.5193011825749950E+000	-0.1317015225824482E+001	0.1152382971535919E+000
A_6	-0.2103848438366764E+000	0.1140172853095220E+001	0.4313759279028710E+000
A_7	-0.1487835416713360E+000	-0.1795886335934751E+000	-0.1583029147396241E-001
A_8	0.5839722545009355E-001	0.3455473826161011E+000	0.1069597425809638E+000
A_9	0.9086755882972188E-001	-0.2271056434426969E+000	-0.1263398337256271E+000
A_{10}	0.4693374594027808E-001	-0.3735564506371786E-002	-0.5057251273776556E-002
A_{11}	-0.7563396430424198E-001	-0.1514876636299864E+000	-0.3535820794255323E-001
A_{12}	0.0000000000000000E+000	0.5368964386524599E-001	0.6634459214672268E-001
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

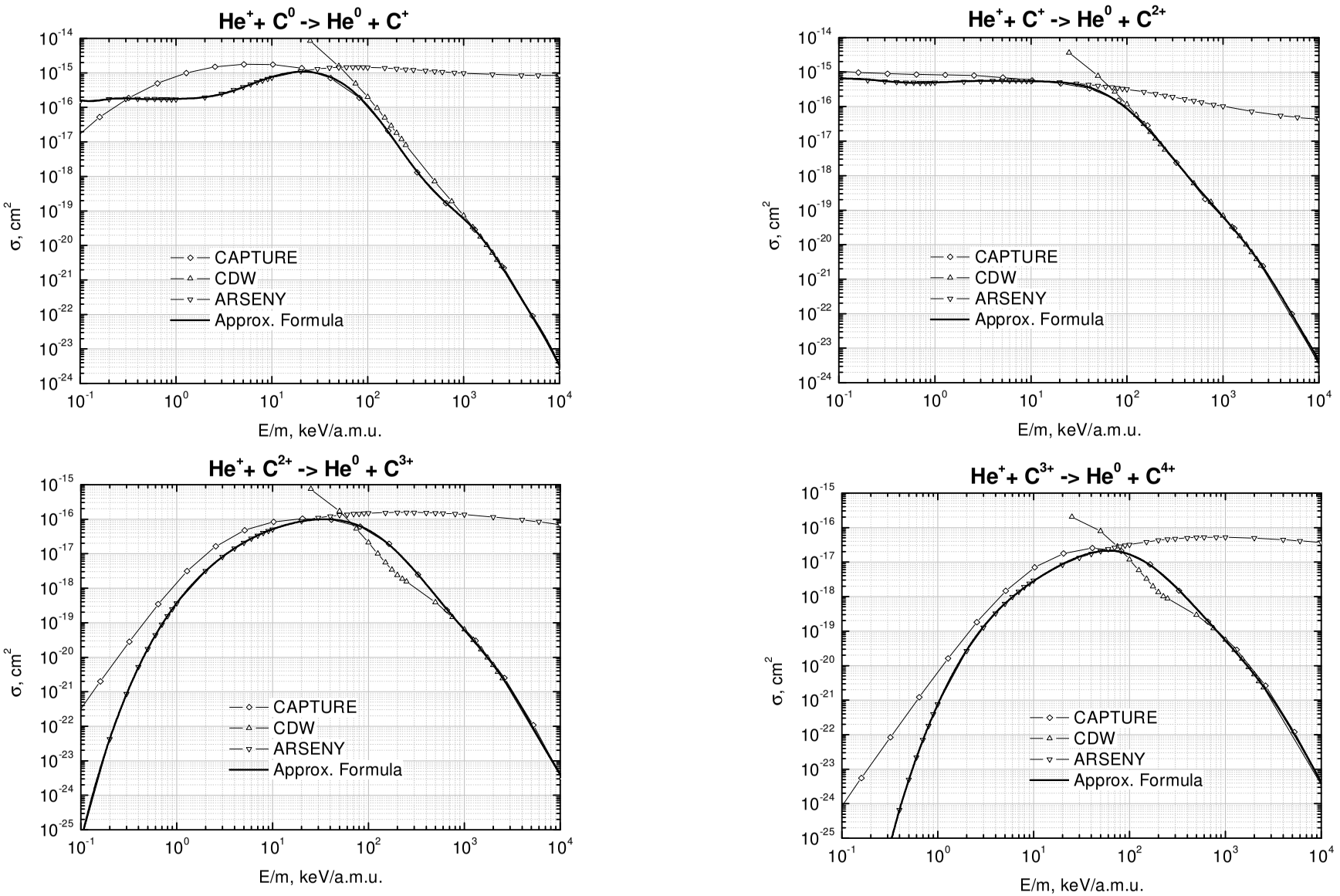
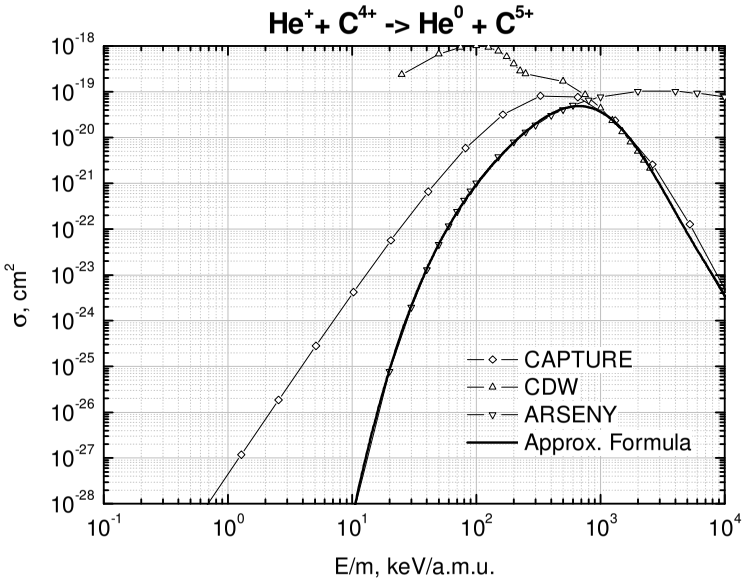


Fig. 21. $He^+ + C^{k+} \rightarrow He^0 + C^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2, 3, 4, 5.



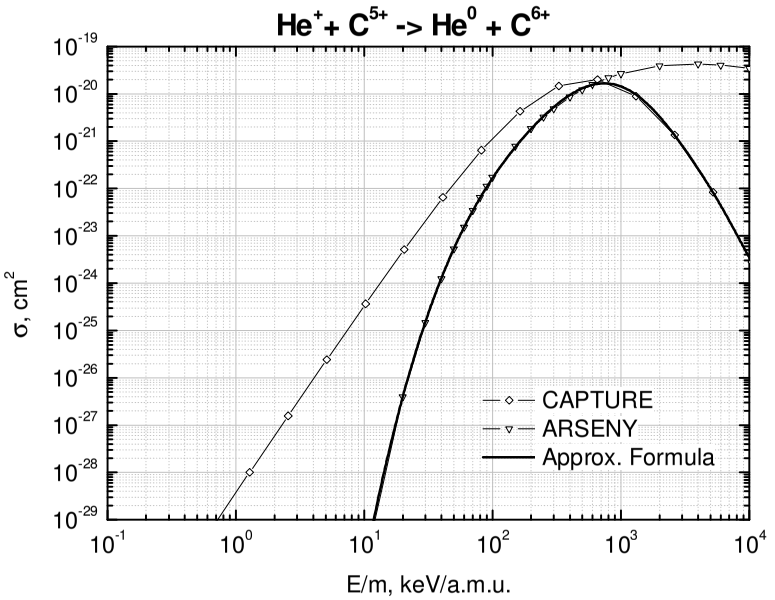


Fig. 21. $He^+ + C^{k+} \rightarrow He^0 + C^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2, 3, 4, 5 (continued).

Table 22. Parameters for $He^{2+} + C^{k+} \rightarrow He^{+} + C^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3, 4, 5.

Parameter	k = 0	k = 1	k = 2
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1250000000000000E+005	0.1250000000000000E+005	0.1250000000000000E+005
γ	0.9523200000000001E+000	0.1000000000000000E+001	0.1000000000000000E+001
A_0	-0.3899458897046787E+002	-0.4086797000768156E+002	-0.4087446269059550E+002
A_1	-0.8340025936236636E+001	-0.6152479836159830E+001	-0.5964181285664540E+001
A_2	-0.4711116606580712E+001	-0.4814100390943968E+001	-0.5344502909129411E+001
A_3	-0.5823858662016254E+000	-0.1289586292520384E+001	-0.5072709557299031E+000
A_4	0.1083474860564783E+000	0.2724622588423697E+000	-0.1715021594597424E+000
A_5	-0.7123111284131666E-002	0.4790424094624963E+000	0.2291406941825101E+000
A_6	-0.1574713080928830E+000	-0.3206312941819950E+000	-0.3718971619086223E-001
A_7	-0.2349611872654469E-001	-0.8040733953914810E-001	-0.9201885437539872E-002
A_8	0.1782715902966715E+000	0.1983640077399286E+000	-0.2598513493470178E-001
A_9	0.7374932473999106E-001	0.1316372216555492E+000	0.1108409519278643E+000
A_{10}	-0.6972521756088913E-001	-0.8195705689866355E-001	0.5275500934210816E-001
A_{11}	-0.9641049535044988E-001	-0.8953762517839758E-001	-0.4018067388322017E-001
A_{12}	-0.3158101682992075E-001	0.1152283425854110E-001	0.0000000000000000E+000
A_{13}	0.4705117283815809E-001	0.2491874143874376E-001	0.0000000000000000E+000
A_{14}	0.4662516547909091E-001	0.1823928546208040E-001	0.0000000000000000E+000
A_{15}	-0.1251840557886493E-001	-0.2455291934488625E-001	0.0000000000000000E+000

Table 22. Parameters for $He^{2+} + C^{k+} \rightarrow He^{+} + C^{(k+1)+}$ charge exchange cross-section approximations for k = 0, 1, 2, 3, 4, 5 (continued).

Parameter	k = 3	k = 4	k = 5
E_{min}	0.1000000000000000E+000	0.2000000000000000E+000	0.2000000000000000E+000
E_{max}	0.1250000000000000E+005	0.1250000000000000E+005	0.1049000000000000E+005
γ	0.9762100000000000E+000	0.1000000000000000E+001	0.1000000000000000E+001
A_0	-0.4192465826969306E+002	-0.7015802652936604E+002	-0.7760556561073162E+002
A_1	-0.4387165228784513E+001	0.3990009668589073E+002	0.5184232935940934E+002
A_2	-0.6024769276707499E+001	-0.2850661757802270E+002	-0.3330584481562499E+002
A_3	-0.2698590449785473E+000	0.8246569270810649E+001	0.1046859523252330E+002
A_4	-0.2936251843278536E+000	-0.3381872993149595E+001	-0.4188906882561274E+001
A_5	0.2331920665724438E+000	0.1145034609048990E+001	0.1076791742789534E+001
A_6	0.1564934343534559E-001	0.6162518771274163E-001	-0.5986051750622080E-001
A_7	-0.4202404557542327E-002	0.9856803168838246E-001	0.1161486958827053E+000
A_8	0.4521764207346771E-001	-0.6408283325871879E-001	-0.3992273814726570E-001
A_9	0.4949871877604554E-001	-0.3792079889330172E-001	-0.5145044577113158E-001
A_{10}	0.1921623749945840E-001	0.1252655425770869E-001	0.7166881859152081E-002
A_{11}	-0.3320315718728898E-001	0.1370173828424438E-001	0.2122064584972416E-001
A_{12}	-0.2607154550296976E-001	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	-0.2295029037418597E-001	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

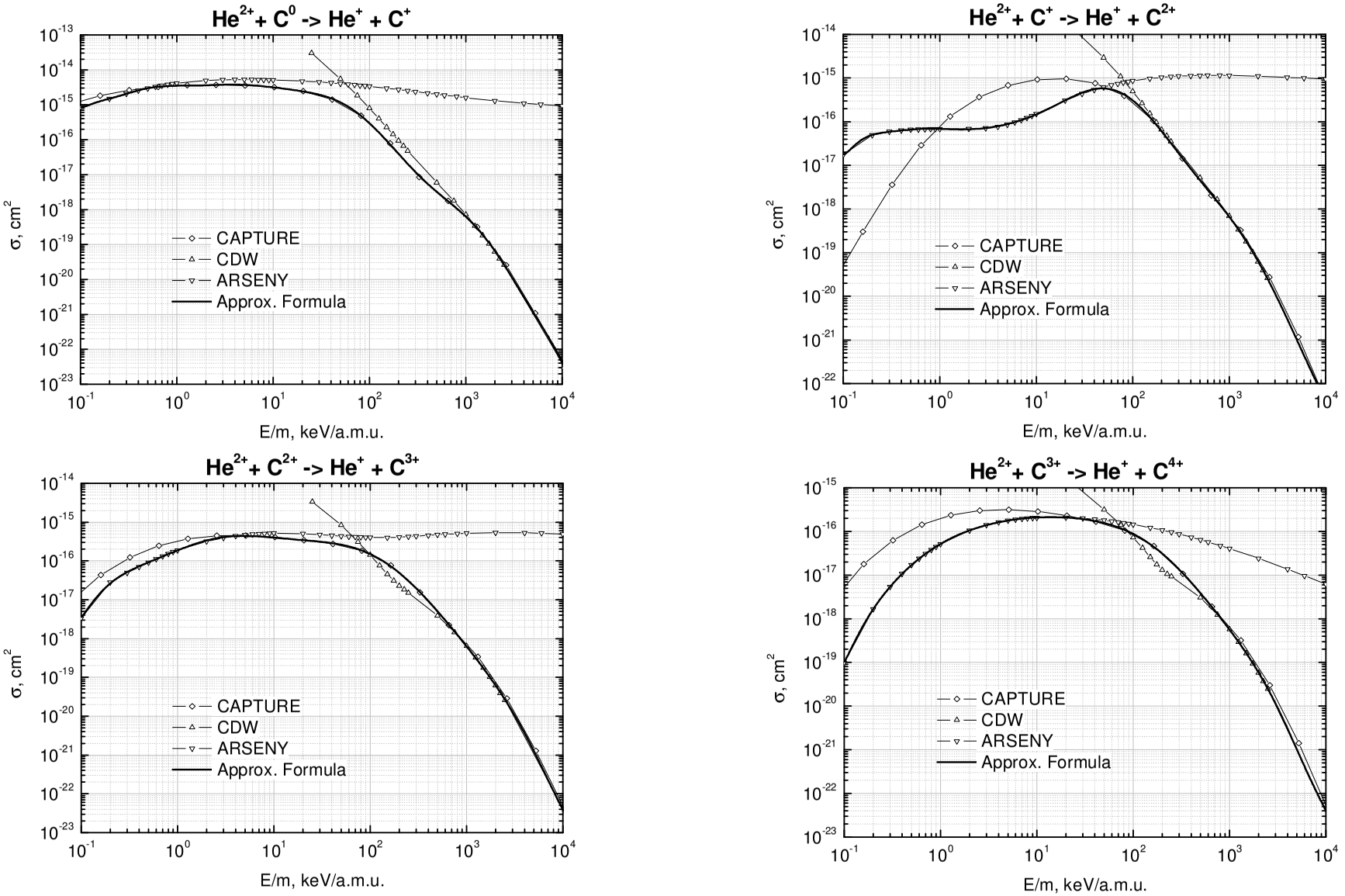
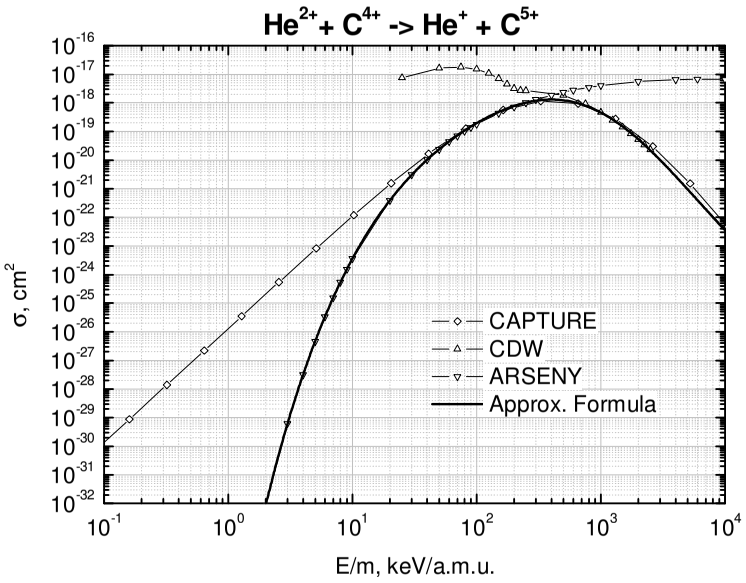


Fig. 22. $He^{2+} + C^{k+} \rightarrow He^{+} + C^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2, 3, 4, 5.



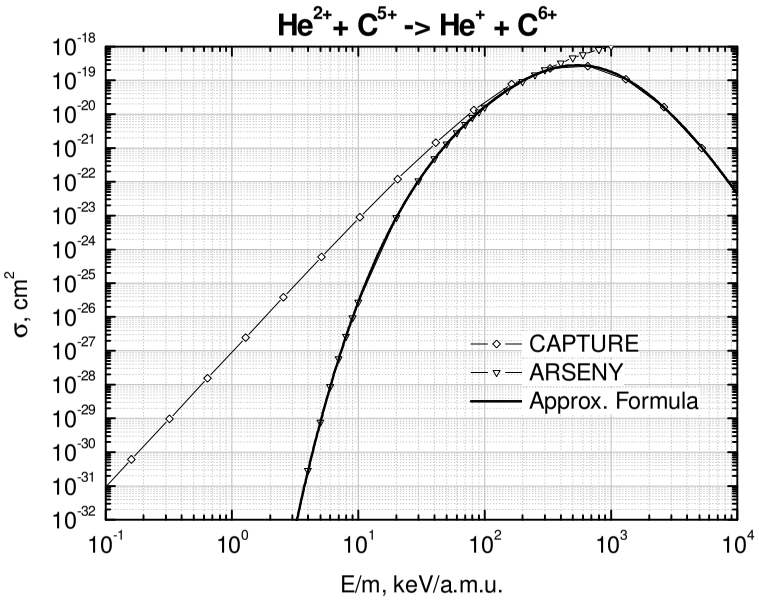


Fig. 22. $He^{2+} + C^{k+} \rightarrow He^{+} + C^{(k+1)+}$ charge exchange cross-sections for k = 0, 1, 2, 3, 4, 5 (continued).

Table 23. Parameters for $He^0 + C^{k+} \rightarrow He^+ + C^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4, 5, 6.

Parameter	k = 1	k = 2	k = 3
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1000000000000000E+005	0.1000000000000000E+005	0.1000000000000000E+005
γ	0.1005700000000000E+001	0.1000000000000000E+001	0.1026300000000000E+001
A_0	-0.4318012777425300E+002	-0.4131138411026459E+002	-0.3957184808455244E+002
A_1	-0.9347347061555109E+001	-0.1005962106184192E+002	-0.9051206916209473E+001
A_2	-0.6055540641541958E+001	-0.5128313989174739E+001	-0.4644436712007511E+001
A_3	-0.1407298503615330E+001	-0.1354940661801630E+001	-0.1197958206916222E+001
A_4	0.6513201683094330E+000	0.1414807466134185E+000	0.1527311682270749E+000
A_5	0.6033383509023352E+000	0.3839510244966492E+000	0.3159752501785885E+000
A_6	-0.2692703969515312E+000	0.1542613642889419E+000	0.5868385450233120E-001
A_7	-0.2013437648319736E+000	-0.3244190515979476E-001	-0.1186687305289216E+000
A_8	0.4231553460485089E-001	-0.8020517677157069E-001	-0.7959323597118818E-001
A_9	0.8168916006478524E-001	-0.3092564824351012E-001	-0.2034808170104472E-002
A_{10}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{11}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

Table 23. Parameters for $He^0 + C^{k+} \rightarrow He^+ + C^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4, 5, 6 (continued).

Parameter	k = 4	k = 5	k = 6
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1000000000000000E+005	0.1000000000000000E+005	0.1000000000000000E+005
γ	0.1062300000000000E+001	0.9973200000000000E+000	0.1000000000000000E+001
A_0	-0.4053587503963530E+002	-0.3891128958841355E+002	-0.3901232909859106E+002
A_1	-0.6496071321990724E+001	-0.7998096829568130E+001	-0.6879766374796309E+001
A_2	-0.5219391496328975E+001	-0.4683303268741092E+001	-0.4943320507972176E+001
A_3	-0.1065397603631988E+001	-0.1368964654549216E+001	-0.1171759543762431E+001
A_4	0.2735703145322569E+000	0.2104184397461950E+000	0.1063945182207166E+000
A_5	0.3186625123151891E+000	0.3480692270932729E+000	0.3071676874940316E+000
A_6	0.1432710077519402E-001	0.8438976742107722E-001	0.4956421944368253E-001
A_7	-0.1222506730301617E+000	-0.8475590392283827E-001	-0.6352158878080186E-001
A_8	-0.6508791750794551E-001	-0.7808914373081437E-001	-0.7876484250478140E-001
A_9	0.6513478876179486E-002	0.9706770168578047E-002	-0.1226341892694466E-001
A_{10}	0.0000000000000000E+000	0.5648538668757627E-001	0.0000000000000000E+000
A_{11}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

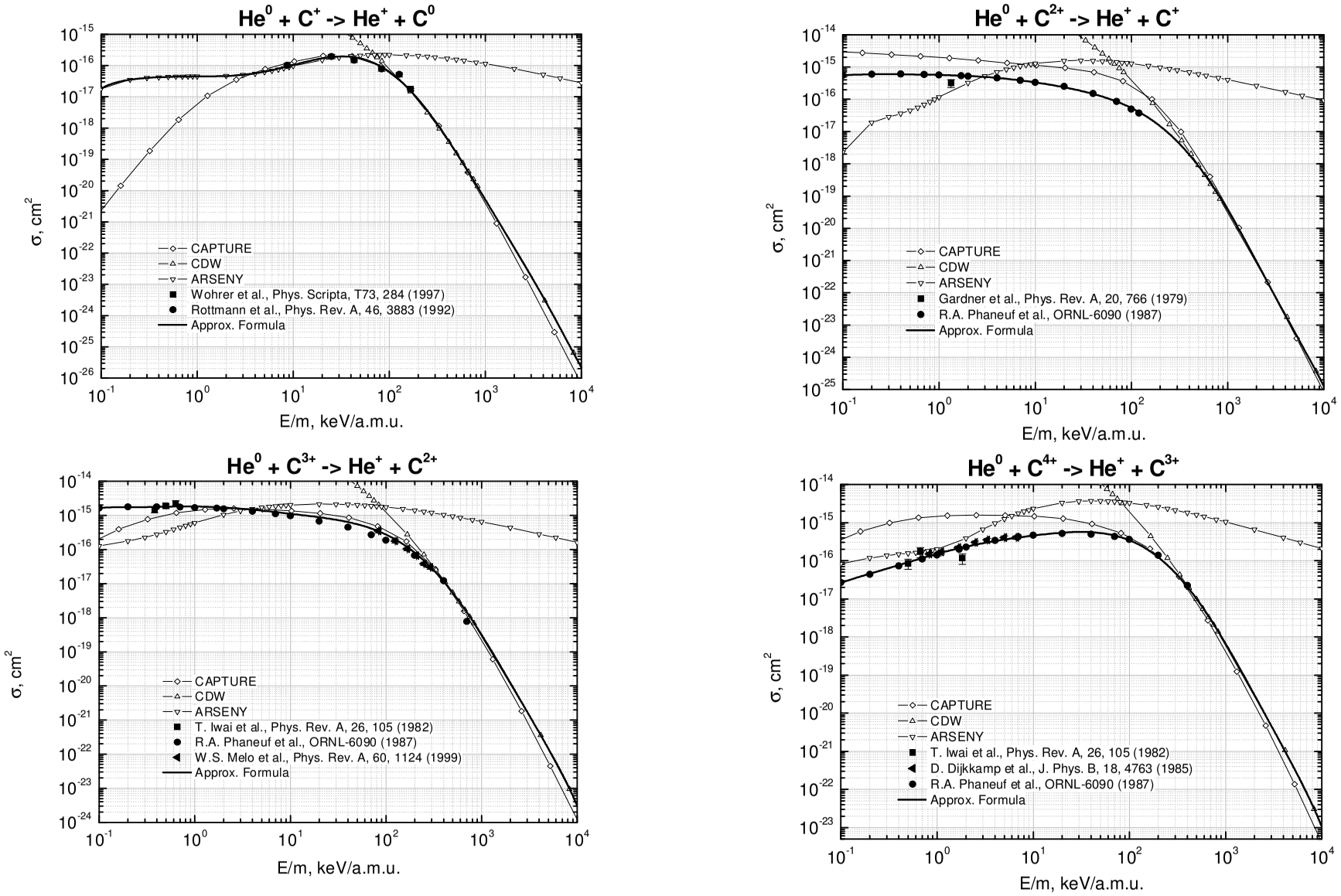
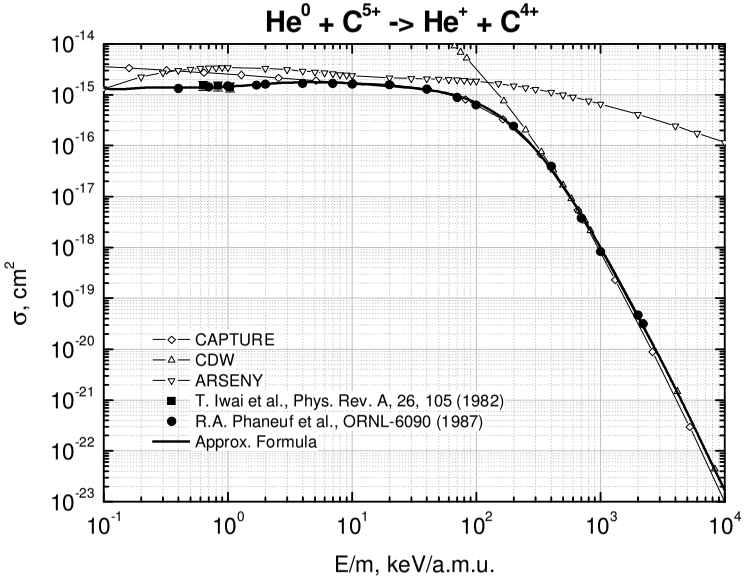


Fig. 23. $He^0 + C^{k+} \rightarrow He^+ + C^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3, 4, 5, 6.



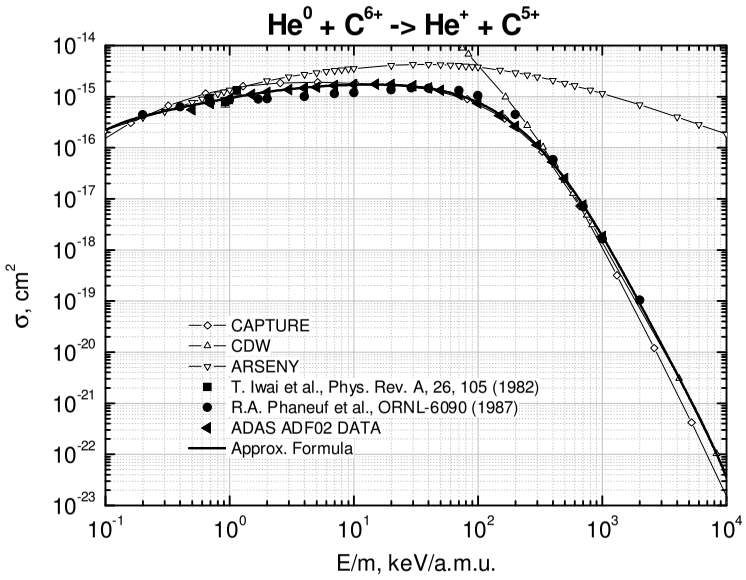


Fig. 23. $He^0 + C^{k+} \rightarrow He^+ + C^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3, 4, 5, 6 (continued).

Table 24. Parameters for $He^{+} + C^{k+} \rightarrow He^{2+} + C^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4, 5, 6.

Parameter	k = 1	k = 2	k = 3
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.8333300000000000E+005	0.8333300000000000E+004	0.8333300000000000E+004
γ	0.8975200000000000E+000	0.7923300000000000E+000	0.9312800000000000E+000
A_0	-0.5071771981016011E+002	-0.4611990508675307E+002	-0.4571136997030180E+002
A_1	-0.1043603249934757E+002	0.2255360380618290E+000	0.9764047799329683E+000
A_2	-0.1130829573460493E+002	-0.1126106812598397E+002	-0.1081565776175238E+002
A_3	-0.1299083853971750E+000	0.2295384016805387E+001	0.1871769350809569E+001
A_4	0.4885002145137206E+000	-0.4424636040493116E+001	-0.3017223224609888E+001
A_5	0.9588616912730696E+000	0.3477257898681828E+001	0.2870387914289449E+001
A_6	-0.3630104506807851E+000	-0.1427150498080166E+001	-0.1211367378980352E+001
A_7	-0.3082363494354836E+000	0.1238143128449222E+001	0.6075175529337794E+000
A_8	0.9755200390588603E-001	-0.1086385389404864E+001	-0.4503246925846563E+000
A_9	0.1686695758672159E+000	0.3568558484264491E+000	0.1051780037377373E+000
A_{10}	0.1162424373439296E-001	-0.1080429376698765E+000	-0.4915580871531459E-001
A_{11}	-0.1700196325059239E+000	0.1830510378108335E+000	0.1151405609853452E+000
A_{12}	0.2320226334854431E-001	-0.4374290831798274E-001	0.7229084293299909E-003
A_{13}	0.4502260860876509E-001	-0.8125553205883837E-001	-0.4292624701451590E-001
A_{14}	-0.7590557550844691E-002	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	-0.4831108421602654E-001	0.0000000000000000E+000	0.0000000000000000E+000

Table 24. Parameters for $He^{+} + C^{k+} \rightarrow He^{2+} + C^{(k-1)+}$ charge exchange cross-section approximations for k = 1, 2, 3, 4, 5, 6 (continued).

Parameter	k = 4	k = 5	k = 6
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.8333300000000000E+004	0.8333300000000000E+004	0.8333300000000000E+004
γ	0.9612800000000000E+000	0.9725600000000000E+000	0.9906400000000000E+000
A_0	-0.4069756988573624E+002	-0.4104014826249004E+002	-0.4206696786101200E+002
A_1	-0.6288264452632243E+001	-0.3980756642693856E+001	-0.1465691593426116E+001
A_2	-0.5866547009588856E+001	-0.6460126766255996E+001	-0.7829566780483845E+001
A_3	-0.1136527238364306E+001	-0.3330138720839120E+000	0.1117937497155153E+001
A_4	-0.2365893829019423E+000	-0.8239627532378783E+000	-0.2176332577456825E+001
A_5	0.5278761366754749E+000	0.1130358845730698E+001	0.2463253067001360E+001
A_6	0.1503814207863355E+000	-0.5025150330690454E+000	-0.1541945855620344E+001
A_7	-0.9196703660456537E-002	0.4891493221133928E+000	0.1119887434403423E+001
A_8	-0.2061457221406404E+000	-0.5110366975829349E+000	-0.9337451371466639E+000
A_9	-0.1972123671738720E-001	0.1836495972028435E+000	0.5170472837467088E+000
A_{10}	0.7064727951342495E-001	-0.1192266914415900E+000	-0.3955834104992140E+000
A_{11}	0.2089326226451488E-001	0.1516125094644052E+000	0.3158927371711839E+000
A_{12}	0.4351717462220734E-001	-0.9856274976590425E-002	-0.1058326461324473E+000
A_{13}	-0.3117789401009107E-001	0.1564153940004598E-001	0.7558385716294523E-001
A_{14}	0.1160699665106647E-001	-0.4194732297330919E-001	-0.8398260950566608E-001
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

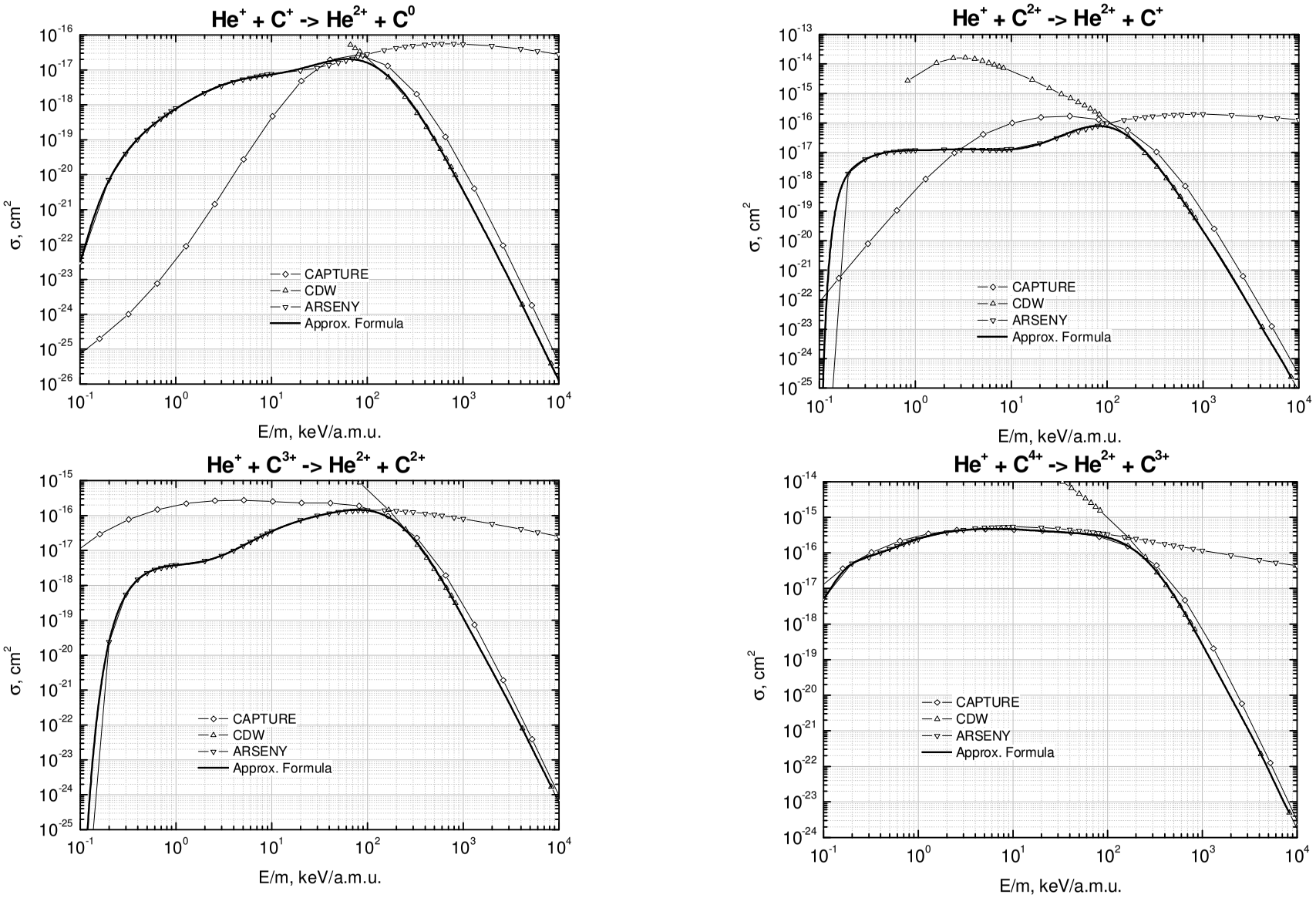
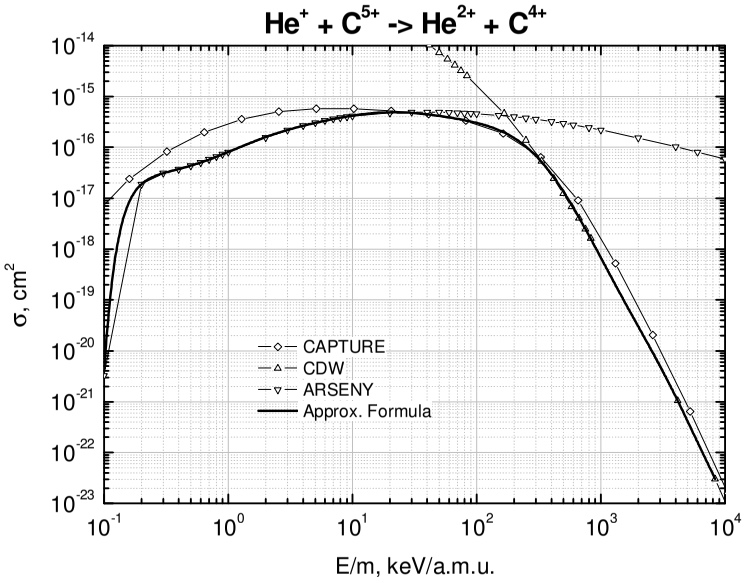


Fig. 24. $He^{+} + C^{k+} \rightarrow He^{2+} + C^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3, 4, 5, 6.



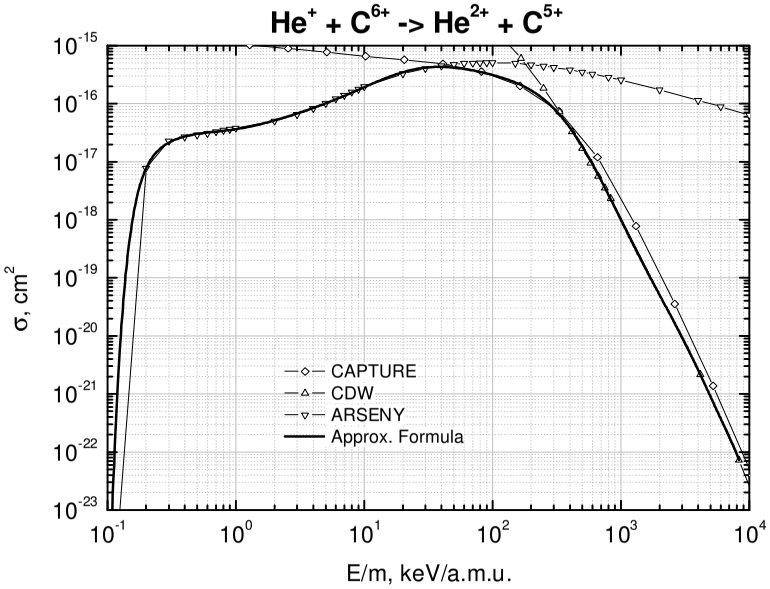


Fig. 24. $He^{+} + C^{k+} \rightarrow He^{2+} + C^{(k-1)+}$ charge exchange cross-sections for k = 1, 2, 3, 4, 5, 6 (continued).

Table 25. Parameters for $H^+ + Ne^{k+} \rightarrow H^0 + Ne^{(k+1)+}$ charge exchange cross-section approximations for k = 0, …, 7.

Parameter	k = 0	k = 1	k = 2
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1000000000000000E+005	0.1000000000000000E+005	0.1000000000000000E+005
γ	0.1000000000000000E+001	0.1000000000000000E+001	0.1000000000000000E+001
A_0	-0.4269182479753691E+002	-0.4866779742392058E+002	-0.5400433999673075E+002
A_1	-0.4555290785981220E+001	0.5329596668443921E+001	0.1390923329493971E+002
A_2	-0.7284581354152339E+001	-0.1237979454931189E+002	-0.1672873320085661E+002
A_3	0.1257600851563031E+001	0.2720239216797650E+001	0.4231412879669060E+001
A_4	0.2579364132262583E+000	-0.3443566642576888E+000	-0.1062264765767670E+001
A_5	0.4179994122460502E+000	0.7023422771356158E+000	0.8944451249883878E+000
A_6	-0.2079378997139353E+000	-0.2200875542372573E+000	-0.1238867710233763E+000
A_7	-0.3404167574271725E+000	-0.2881084015498779E+000	-0.1937971344485071E+000
A_8	-0.1678063803386122E+000	-0.1270042719020561E+000	-0.1710644780097611E+000
A_9	0.9307050805125561E-001	0.7007995553820914E-002	0.1681332539624617E-002
A_{10}	0.6006239258280759E-001	0.4551377292672486E-001	0.1846040663681078E-001
A_{11}	0.3152082633886965E-001	0.0000000000000000E+000	0.1834332878823172E-001
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

Table 25. Parameters for $H^+ + Ne^{k+} \rightarrow H^0 + Ne^{(k+1)+}$ charge exchange cross-section approximations for k = 0, …, 7 (continued).

Parameter	k = 3	k = 4	k = 5
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1000000000000000E+005	0.1000000000000000E+005	0.1049000000000000E+005
γ	0.1000000000000000E+001	0.1000000000000000E+001	0.1000000000000000E+001
A_0	-0.6063084551754357E+002	-0.7123632149446586E+002	-0.7258808372932431E+002
A_1	0.2446975770053448E+002	0.4146046222056116E+002	0.4278261142871509E+002
A_2	-0.2203666942027738E+002	-0.3097560011255333E+002	-0.3104380419290698E+002
A_3	0.6173809962040324E+001	0.9775577746423517E+001	0.9976761756048703E+001
A_4	-0.1940409551209071E+001	-0.3423160535772601E+001	-0.3781982458263084E+001
A_5	0.1159374028128730E+001	0.1497350655141799E+001	0.1440332483368214E+001
A_6	-0.1592220146642569E+000	-0.6082045738421944E-001	-0.1645046296462415E-001
A_7	-0.1283325532944616E+000	-0.8218067137117149E-001	-0.7930079100157564E-002
A_8	-0.1334438178922884E+000	-0.2067327942805935E+000	-0.1770427470366366E+000
A_9	-0.3875277362138090E-001	-0.8867915845396557E-001	-0.1241204058011552E+000
A_{10}	0.1300032531663698E-002	0.7728002433366489E-001	0.9848675097531022E-001
A_{11}	0.4616720634560672E-001	0.0000000000000000E+000	0.0000000000000000E+000
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

Table 25. Parameters for $H^+ + Ne^{k+} \rightarrow H^0 + Ne^{(k+1)+}$ charge exchange cross-section approximations for k = 0, …, 7 (continued).

Parameter	k = 6	k = 7
E_{min}	0.1000000000000000E+000	0.2000000000000000E+000
E_{max}	0.1000000000000000E+005	0.1000000000000000E+005
γ	0.1000000000000000E+001	0.1000000000000000E+001
A_0	-0.7934496456385675E+002	-0.7877329483421545E+002
A_1	0.5384597657371584E+002	0.5096282639671213E+002
A_2	-0.3713355656290247E+002	-0.3358144120857644E+002
A_3	0.1250686929230318E+002	0.1075555377031345E+002
A_4	-0.4452570623483432E+001	-0.3758166558876287E+001
A_5	0.1646647393733548E+001	0.1234860579538070E+001
A_6	-0.2207244758627663E+000	-0.6611674547699560E-001
A_7	-0.9664494457754344E-002	0.4430487069815121E-001
A_8	-0.1042130568458911E+000	-0.1827142018407301E+000
A_9	-0.6249355447048639E-001	-0.7691570091736422E-001
A_{10}	0.4260456768202810E-001	0.4089941533911005E-001
A_{11}	0.0000000000000000E+000	0.0000000000000000E+000
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000

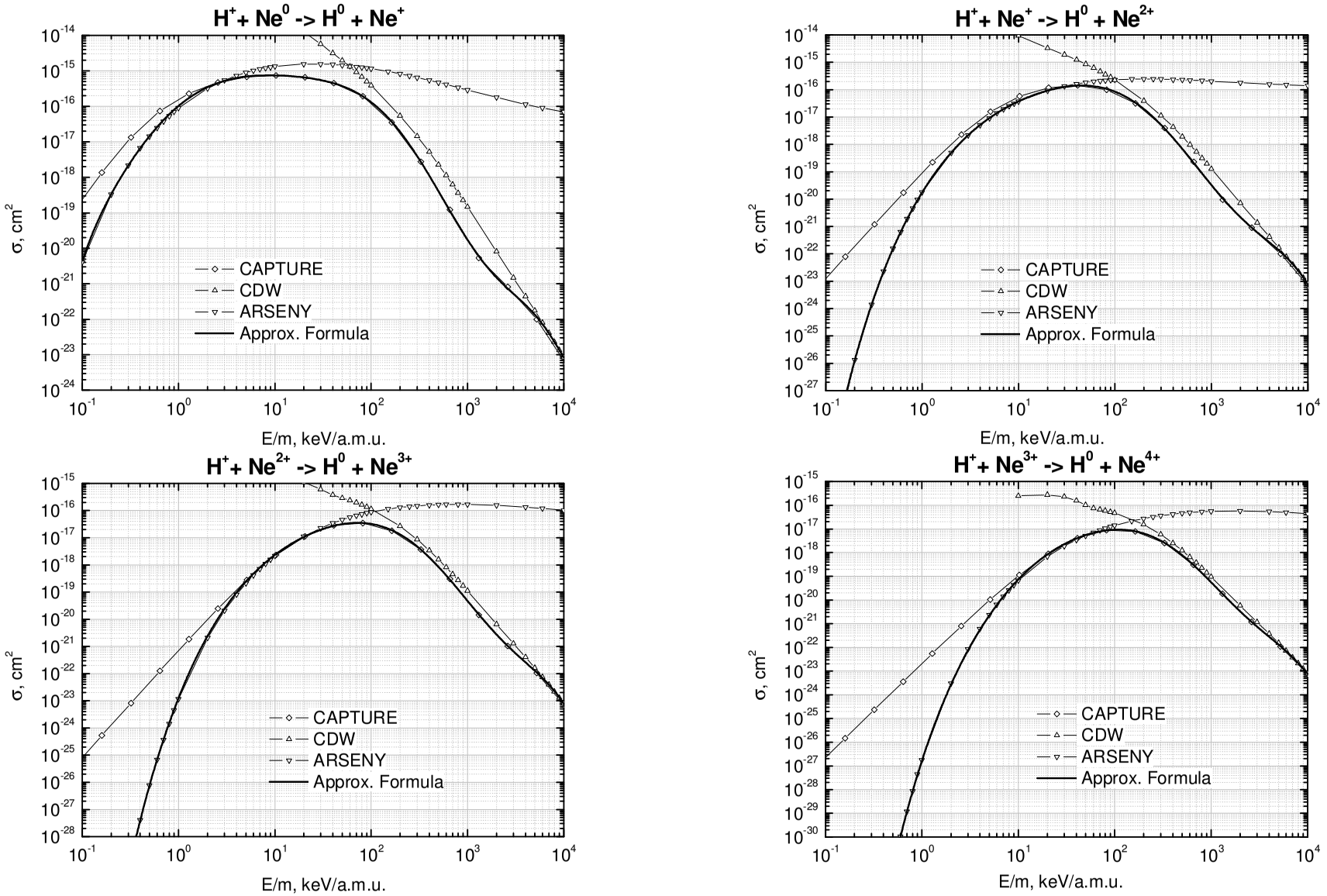


Fig. 25. $H^+ + Ne^{k+} \rightarrow H^0 + Ne^{(k+1)+}$ charge exchange cross-sections for k = 0, …, 7.

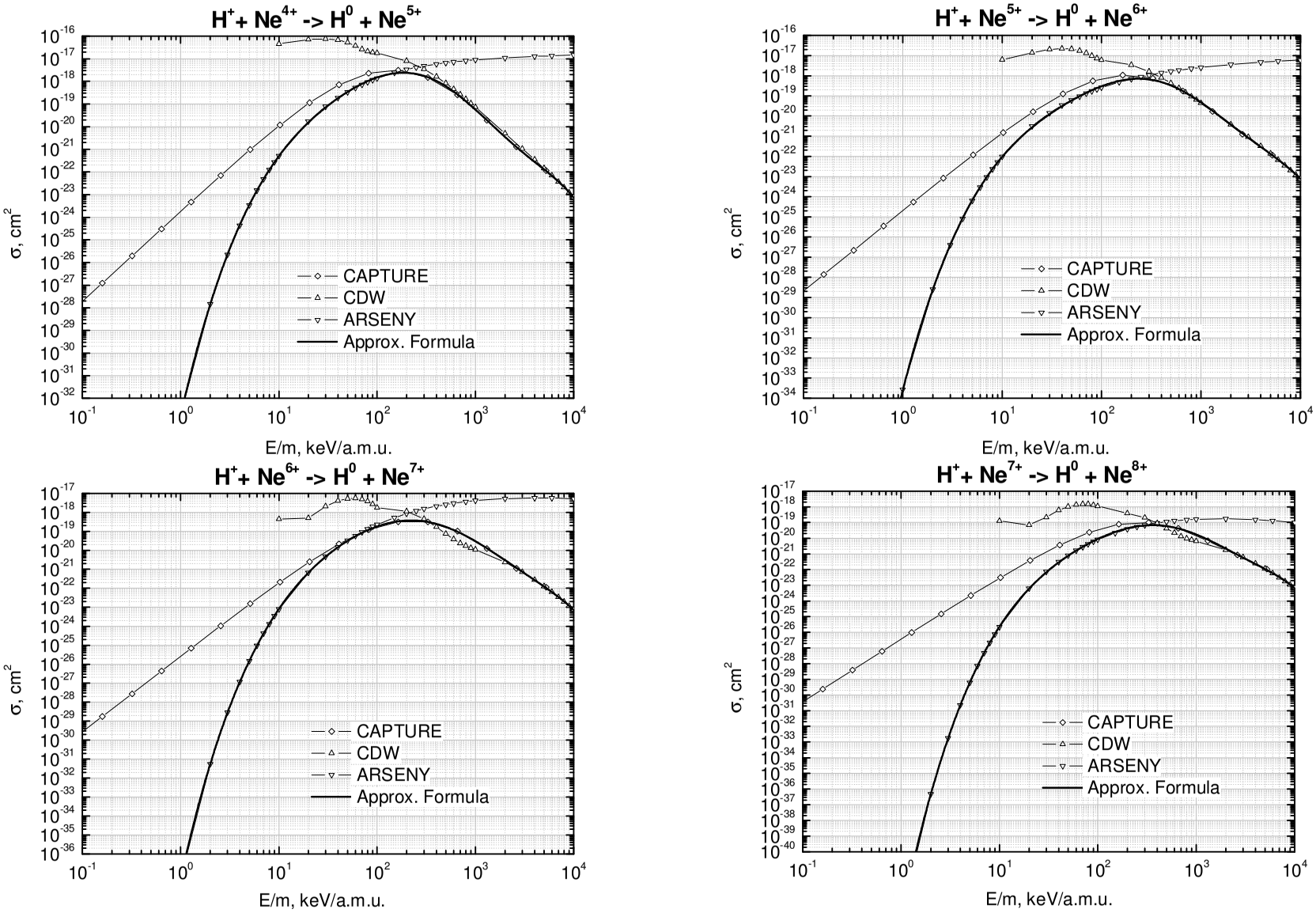


Fig. 25. $H^+ + Ne^{k+} \rightarrow H^0 + Ne^{(k+1)+}$ charge exchange cross-sections for k = 0, …, 7 (continued).

Table 26. Parameters for $H^0 + Ne^{k+} \rightarrow H^+ + Ne^{(k-1)+}$ charge exchange cross-section approximations for k = 1, …, 10.

Parameter	k = 1	k = 2	k = 3
E_{min}	0.1000000000000000E+000	0.7800000000000000E-001	0.1000000000000000E+000
E_{max}	0.4955400000000000E+005	0.4955400000000000E+005	0.4955400000000000E+005
γ	0.1123400000000000E+001	0.1102860000000000E+001	0.1000000000000000E+001
A_0	-0.4690419431662801E+002	-0.4651731565078446E+002	-0.4411235077018339E+002
A_1	-0.1709251637991202E+002	-0.1528655959386896E+002	-0.1645460810525241E+002
A_2	-0.7441279193840313E+001	-0.7607088625573708E+001	-0.7544264441474107E+001
A_3	0.4218196993373312E+000	-0.3341066169275271E+000	-0.4899716579561608E+000
A_4	0.1341219964659449E+001	0.1310920626036337E+001	0.1092299299506964E+001
A_5	-0.2183651893526707E+000	0.2659459248923960E+000	0.2498932101091059E+000
A_6	-0.5347698573681785E+000	-0.4468984054208410E+000	-0.3329301709381314E+000
A_7	0.2169306426567985E+000	-0.1707394907928587E+000	-0.1418852473925374E+000
A_8	0.1696862511925535E+000	0.2711974418884568E+000	0.2035366142457182E+000
A_9	-0.1561095767580886E+000	0.5855701924657725E-001	0.4075125306804378E-001
A_{10}	-0.2817347556442555E-001	-0.1778341232458047E+000	-0.1225240349580762E+000
A_{11}	0.1008206744285962E+000	-0.7967873611504838E-002	0.3590512405031348E-002
A_{12}	0.8732481443057589E-003	0.5100990065470638E-001	0.1202391704002474E-001
A_{13}	-0.3873057554927415E-001	0.8911057497917756E-001	0.1407926638936607E-001
A_{14}	0.0000000000000000E+000	-0.1169913056013241E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	-0.2474813437276058E-001	0.0000000000000000E+000

Table 26. Parameters for $H^0 + Ne^{k+} \rightarrow H^+ + Ne^{(k-1)+}$ charge exchange cross-section approximations for k = 1, …, 10 (continued).

Parameter	k = 4	k = 5	k = 6
E_{min}	0.7040000000000000E-001	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.4955400000000000E+005	0.4955400000000000E+005	0.4955400000000000E+005
γ	0.1000000000000000E+001	0.1110660000000000E+001	0.1097520000000000E+001
A_0	-0.4338446527564034E+002	-0.4383276567474972E+002	-0.4352403203055361E+002
A_1	-0.1617404758685009E+002	-0.1615930981236807E+002	-0.1587585015699069E+002
A_2	-0.7417309786292036E+001	-0.6888521740268490E+001	-0.6817012959346684E+001
A_3	-0.9257702030721430E+000	-0.6275965055457197E-001	-0.3643416937213181E+000
A_4	0.1082972583644363E+001	0.9725567312843976E+000	0.1100757668841152E+001
A_5	0.3570625426163287E+000	0.8745536935408767E-001	0.7503559321132640E-002
A_6	-0.3147749274323223E+000	-0.3025494028079634E+000	-0.2685971567814798E+000
A_7	-0.1443000195414089E+000	-0.9687463218281959E-002	0.8723242917503029E-002
A_8	0.1776488914357630E+000	0.1707033914970701E+000	0.1300484970260679E+000
A_9	0.9324965570551820E-001	-0.2790914359555267E-001	0.1496169458242103E-001
A_{10}	-0.8588389115456754E-001	-0.1188970302239261E+000	-0.9870606484638410E-001
A_{11}	-0.2139431352961285E-001	0.4798740300599379E-002	-0.2995462034221954E-001
A_{12}	0.2293718542440553E-001	0.2300452222404003E-001	0.6480209330745729E-001
A_{13}	0.1961379279580339E-001	0.2867799505999965E-001	0.4541934332013905E-001
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

Table 26. Parameters for $H^0 + Ne^{k+} \rightarrow H^+ + Ne^{(k-1)+}$ charge exchange cross-section approximations for k = 1, …, 10 (continued).

Parameter	k = 7	k = 8	k = 9
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.2050000000000000E+000
E_{max}	0.4955400000000000E+005	0.4955400000000000E+005	0.4955400000000000E+005
γ	0.1178230000000000E+001	0.1109750000000000E+001	0.1058610000000000E+001
A_0	-0.4337389304824704E+002	-0.4286758665099164E+002	-0.4223150900287138E+002
A_1	-0.1548034404764532E+002	-0.1520854174938390E+002	-0.1470916654877388E+002
A_2	-0.6319729399581928E+001	-0.6480513446786241E+001	-0.5773995725102377E+001
A_3	0.1368048668720964E+000	-0.2552908860108188E+000	-0.6397326311001679E-001
A_4	0.8493282194420024E+000	0.9136606092244977E+000	0.8635348142522712E+000
A_5	-0.1124303006255580E-002	0.1047230878571813E+000	0.1553340648277785E-002
A_6	-0.3002469062131832E+000	-0.3019315603443244E+000	-0.2559740019655019E+000
A_7	0.5717363150505897E-001	0.1041422615620115E-001	-0.2221218435645710E-001
A_8	0.1557390259837654E+000	0.1523832769072179E+000	0.1557314634579357E+000
A_9	-0.7233051726048884E-001	0.2454396584070817E-003	0.3044062651451434E-001
A_{10}	-0.1152455618670638E+000	-0.1285974717197376E+000	-0.1090860578185879E+000
A_{11}	0.1747913389170347E-001	-0.3746431386468422E-001	-0.4891310747388351E-001
A_{12}	0.5171758301699874E-001	0.4907515732876318E-001	0.6459586109981200E-001
A_{13}	0.2864930452693228E-001	0.4268100073967947E-001	0.2957753303400867E-001
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	-0.4618683006494938E-001
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

Table 26. Parameters for $H^0 + Ne^{k+} \rightarrow H^+ + Ne^{(k-1)+}$ charge exchange cross-section approximations for k = 1, …, 10 (continued).

Parameter	k = 10
E_{min}	0.1000000000000000E+000
E_{max}	0.4955400000000000E+005
γ	0.1398750000000000E+001
A_0	-0.4306351431007356E+002
A_1	-0.1503028410797286E+002
A_2	-0.4983797370172334E+001
A_3	0.9796232561964526E+000
A_4	0.6639636077642936E+000
A_5	-0.3372294855960947E+000
A_6	-0.1966778580198244E+000
A_7	0.1686907594852942E+000
A_8	0.7976825687890961E-001
A_9	-0.1231399331457860E+000
A_{10}	-0.9080511387423352E-002
A_{11}	0.4320267509228143E-001
A_{12}	-0.1090854248822779E-002
A_{13}	-0.2492241251754373E-001
A_{14}	-0.2053658931655187E-001
A_{15}	0.0000000000000000E+000

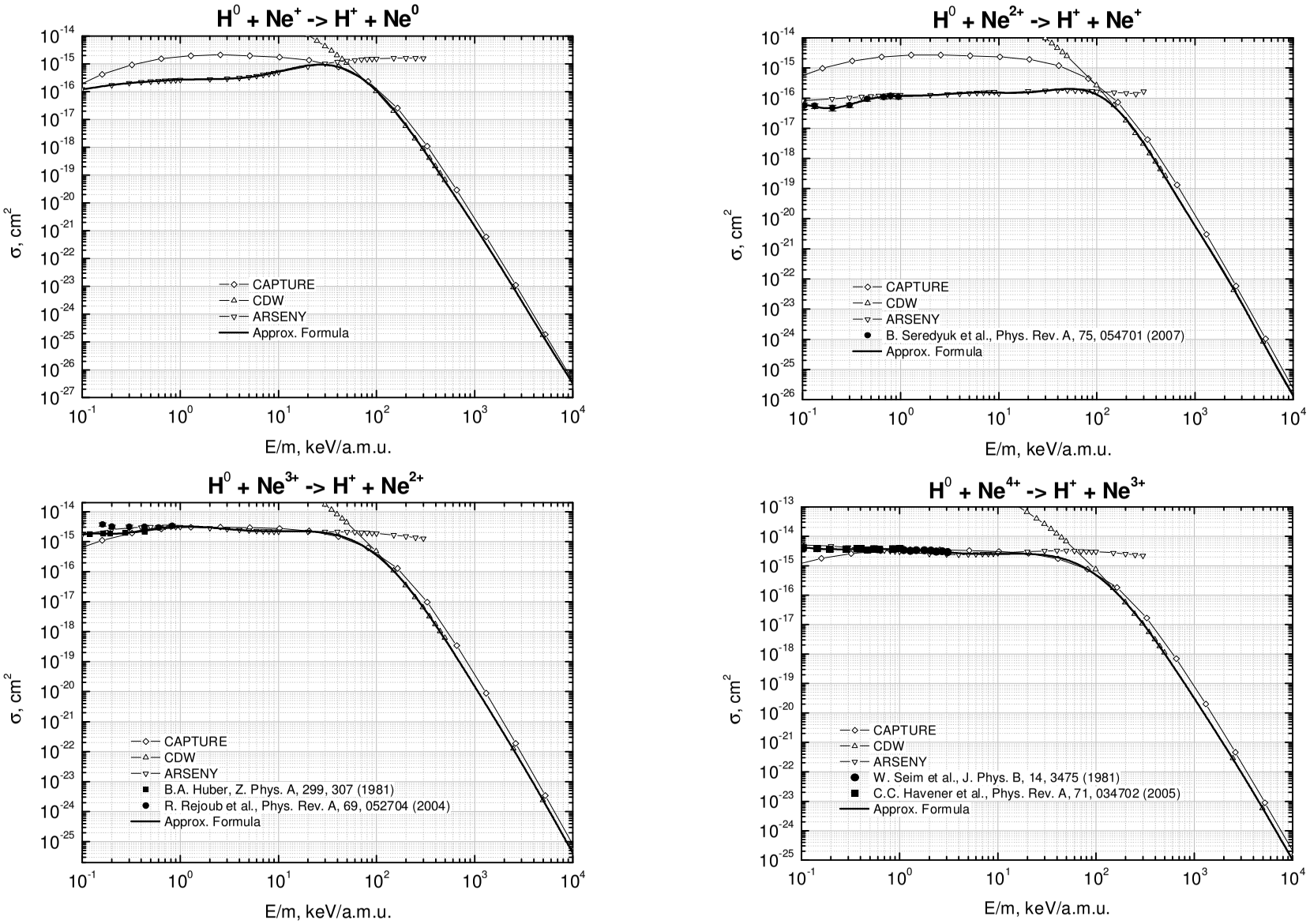
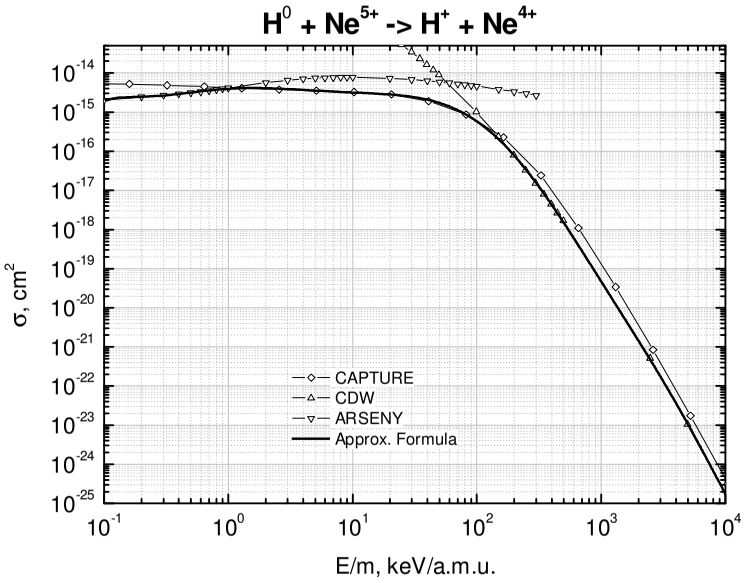
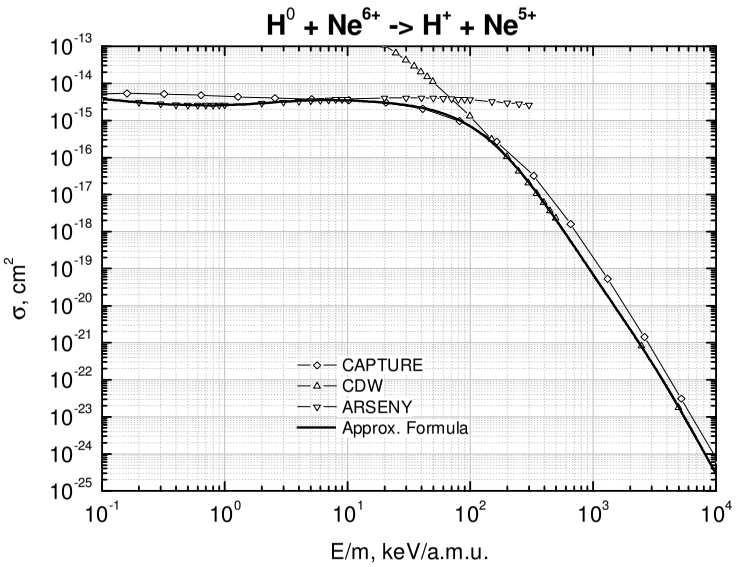
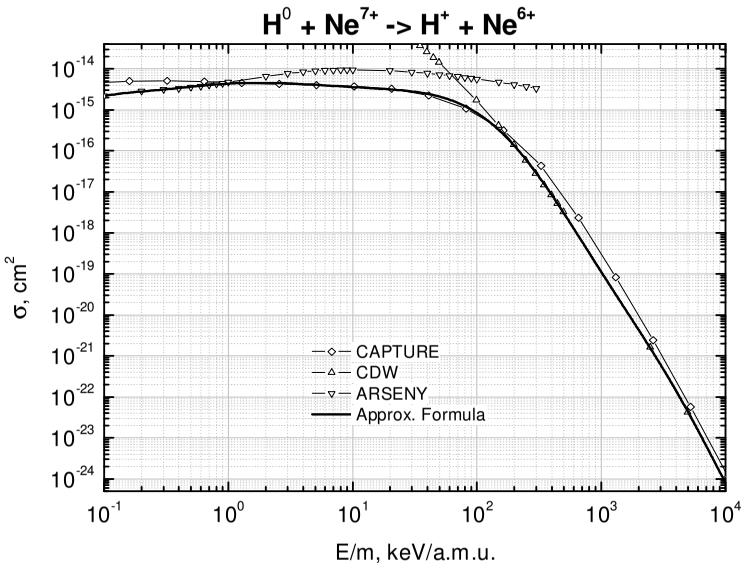


Fig. 26. $H^0 + Ne^{k+} \rightarrow H^+ + Ne^{(k-1)+}$ charge exchange cross-sections for k = 1, …, 10.







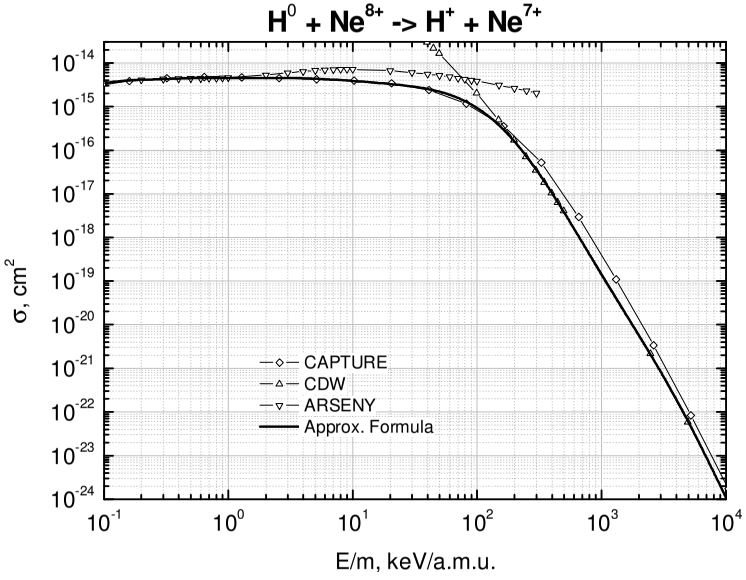
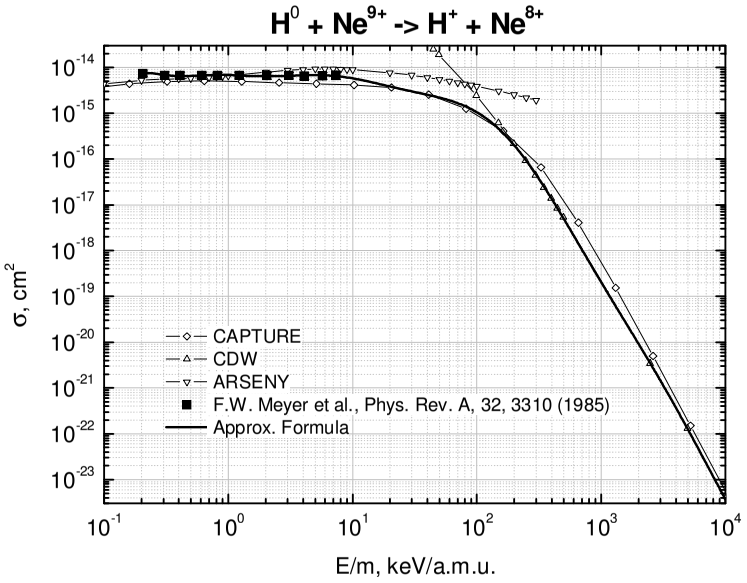


Fig. 26. $H^0 + Ne^{k+} \rightarrow H^+ + Ne^{(k-1)+}$ charge exchange cross-sections for k = 1, …, 10 (continued).



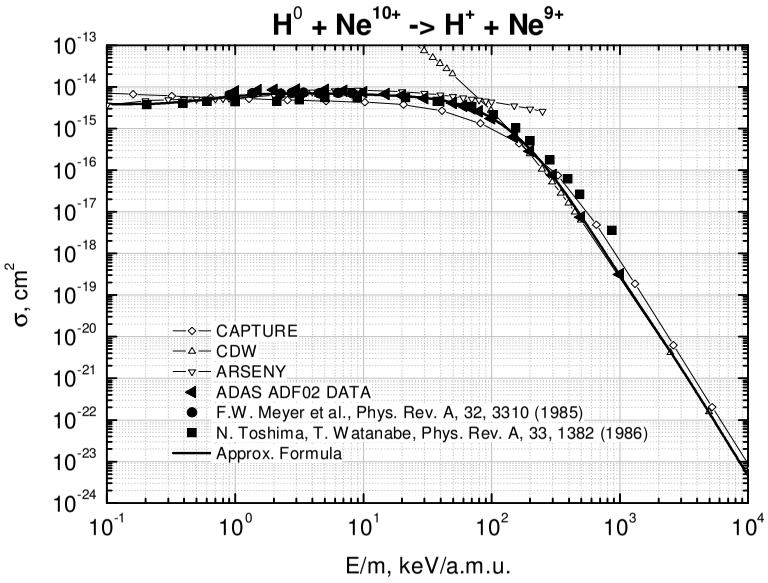


Fig. 26. $H^0 + Ne^{k+} \rightarrow H^+ + Ne^{(k-1)+}$ charge exchange cross-sections for k = 1, …, 10 (continued).

Table 27. Parameters for $He^{+} + Ne^{k+} \rightarrow He^{0} + Ne^{(k+1)+}$ charge exchange cross-section approximations for k = 0, …, 9.

Parameter	k = 0	k = 1	k = 2
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1049000000000000E+005	0.1250000000000000E+005	0.1250000000000000E+005
γ	0.1132500000000000E+001	0.9482000000000000E+000	0.1000000000000000E+001
A_0	-0.4009957687389484E+002	-0.4563499075010454E+002	-0.5046153980719250E+002
A_1	-0.9181869467454170E+001	0.5311621826283233E+000	0.8286410761904214E+001
A_2	-0.3714073408038963E+001	-0.9615519873435543E+001	-0.1403639679159661E+002
A_3	-0.1051531233720866E+000	0.1128699350080365E+001	0.3364068433756367E+001
A_4	0.6269257579240437E+000	0.4483846693082875E-001	-0.1114226440619151E+001
A_5	0.2354370347786005E+000	0.4541205426541375E+000	0.1062912861998457E+001
A_6	-0.3672299107532101E+000	-0.6601705775565807E-001	-0.4296972328794955E+000
A_7	-0.2954696782622505E+000	-0.2561738276650782E+000	0.2470596228310784E-001
A_8	0.1188939939299275E-001	-0.1603471594680114E+000	-0.2852636631545579E+000
A_9	0.1450323544098026E+000	0.3165905724786002E-001	0.1196463146213639E+000
A_{10}	0.9067727791706848E-001	0.1041287173885047E+000	0.8552066697994000E-002
A_{11}	0.0000000000000000E+000	0.1187452243498040E+000	0.1271791881971539E+000
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

Table 27. Parameters for $He^{+} + Ne^{k+} \rightarrow He^{0} + Ne^{(k+1)+}$ charge exchange cross-section approximations for k = 0, …, 9 (continued).

Parameter	k = 3	k = 4	k = 5
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1250000000000000E+005	0.1250000000000000E+005	0.1250000000000000E+005
γ	0.8712500000000000E+000	0.9613500000000000E+000	0.9618500000000000E+000
A_0	-0.5693958215154299E+002	-0.6044097770210162E+002	-0.6463660776246758E+002
A_1	0.1884208019835302E+002	0.2410551458300504E+002	0.3045826996016050E+002
A_2	-0.1803592114608345E+002	-0.2142183461270854E+002	-0.2443031427682715E+002
A_3	0.3088477499391665E+001	0.5471330958351974E+001	0.6722812519652487E+001
A_4	-0.6158443529202464E+000	-0.1761666900868871E+001	-0.2302544369886609E+001
A_5	0.2029093545578661E+000	0.6941594248971363E+000	0.7800406905679914E+000
A_6	0.5561507038539095E+000	0.2599505170449419E+000	0.2711891173688314E+000
A_7	-0.3761117904004818E+000	-0.2695074945305578E+000	-0.1773295941292495E+000
A_8	-0.4024945936513481E-001	-0.1421570951324440E+000	-0.1183025261898315E+000
A_9	-0.1445834409201606E+000	0.3209808371921247E-001	-0.1014670624790078E-001
A_{10}	0.1259846788034327E+000	0.2866243779374992E-001	0.6205452344428888E-001
A_{11}	-0.3684537095475270E-001	0.8129708113975907E-001	0.6064842988245574E-001
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

Table 27. Parameters for $He^{+} + Ne^{k+} \rightarrow He^{0} + Ne^{(k+1)+}$ charge exchange cross-section approximations for k = 0, …, 9 (continued).

Parameter	k = 6	k = 7	k = 8
E_{min}	0.1000000000000000E+000	0.2000000000000000E+000	0.1000000000000000E+000
E_{max}	0.1250000000000000E+005	0.1250000000000000E+005	0.1250000000000000E+005
γ	0.9875300000000000E+000	0.9897500000000000E+000	0.9813000000000000E+000
A_0	-0.7256753838169483E+002	-0.7279645659291739E+002	-0.1683428949311458E+003
A_1	0.4295567244974906E+002	0.4161309427369670E+002	0.1964395170290838E+003
A_2	-0.3125412086550060E+002	-0.2902758207289620E+002	-0.1136310758973260E+003
A_3	0.9895511364669440E+001	0.8767459345123598E+001	0.4392012364765036E+002
A_4	-0.3554413269694312E+001	-0.3046162669255688E+001	-0.1472052492818620E+002
A_5	0.1310651229483320E+001	0.1053247535654660E+001	0.3277529282549518E+001
A_6	0.3844483938735268E-001	0.6941739868951688E-001	-0.4529367053748534E+000
A_7	-0.3550904538901262E-001	-0.3635157489494496E-001	-0.2187325744838690E-002
A_8	-0.1370836131531154E+000	-0.1041233286470220E+000	0.2068377134553096E+000
A_9	-0.6596817504627882E-001	-0.3741611669448355E-001	-0.1055123536425942E+000
A_{10}	0.2239420888043392E-001	0.4774648276424830E-001	-0.1899953866043882E-001
A_{11}	0.2925485679074955E-001	0.5833280230314493E-001	0.1450718086736487E-001
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

Table 27. Parameters for $He^{+} + Ne^{k+} \rightarrow He^{0} + Ne^{(k+1)+}$ charge exchange cross-section approximations for k = 0, …, 9 (continued).

Parameter	k = 9
E_{min}	0.7000000000000000E+000
E_{max}	0.1049000000000000E+005
γ	0.1000000000000000E+001
A_0	-0.9591646009519646E+002
A_1	0.7470706517273071E+002
A_2	-0.4076443959332450E+002
A_3	0.1289030988319214E+002
A_4	-0.4099393174530882E+001
A_5	0.8066422475201915E+000
A_6	-0.1309699182491900E+000
A_7	0.9725717971445483E-001
A_8	-0.4417974498894324E-001
A_9	0.1253071423058615E-001
A_{10}	-0.6065287815525408E-002
A_{11}	0.1085351424246258E-001
A_{12}	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000

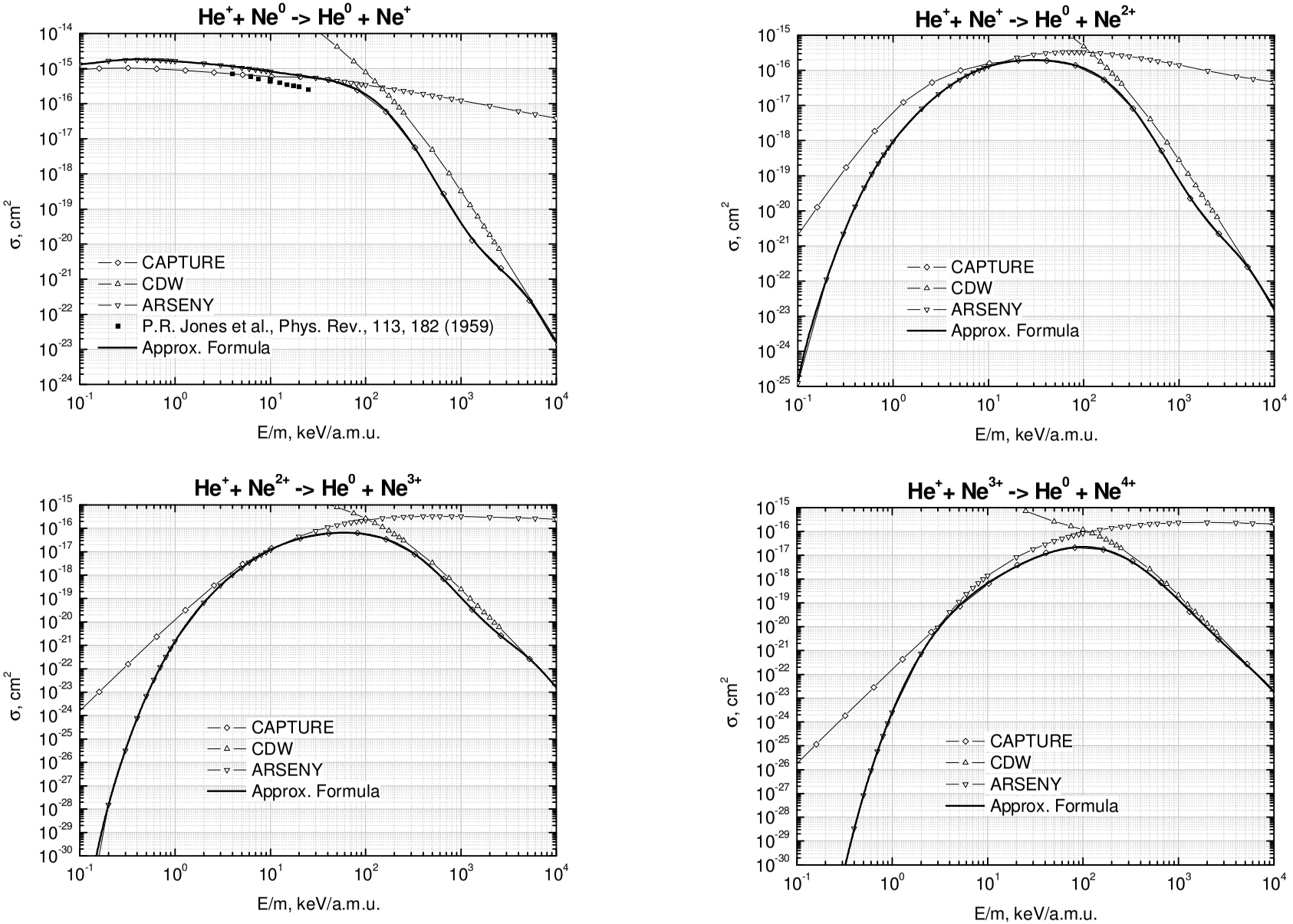


Fig. 27. $He^+ + Ne^{k+} \rightarrow He^0 + Ne^{(k+1)+}$ charge exchange cross-sections for k = 0, …, 9.

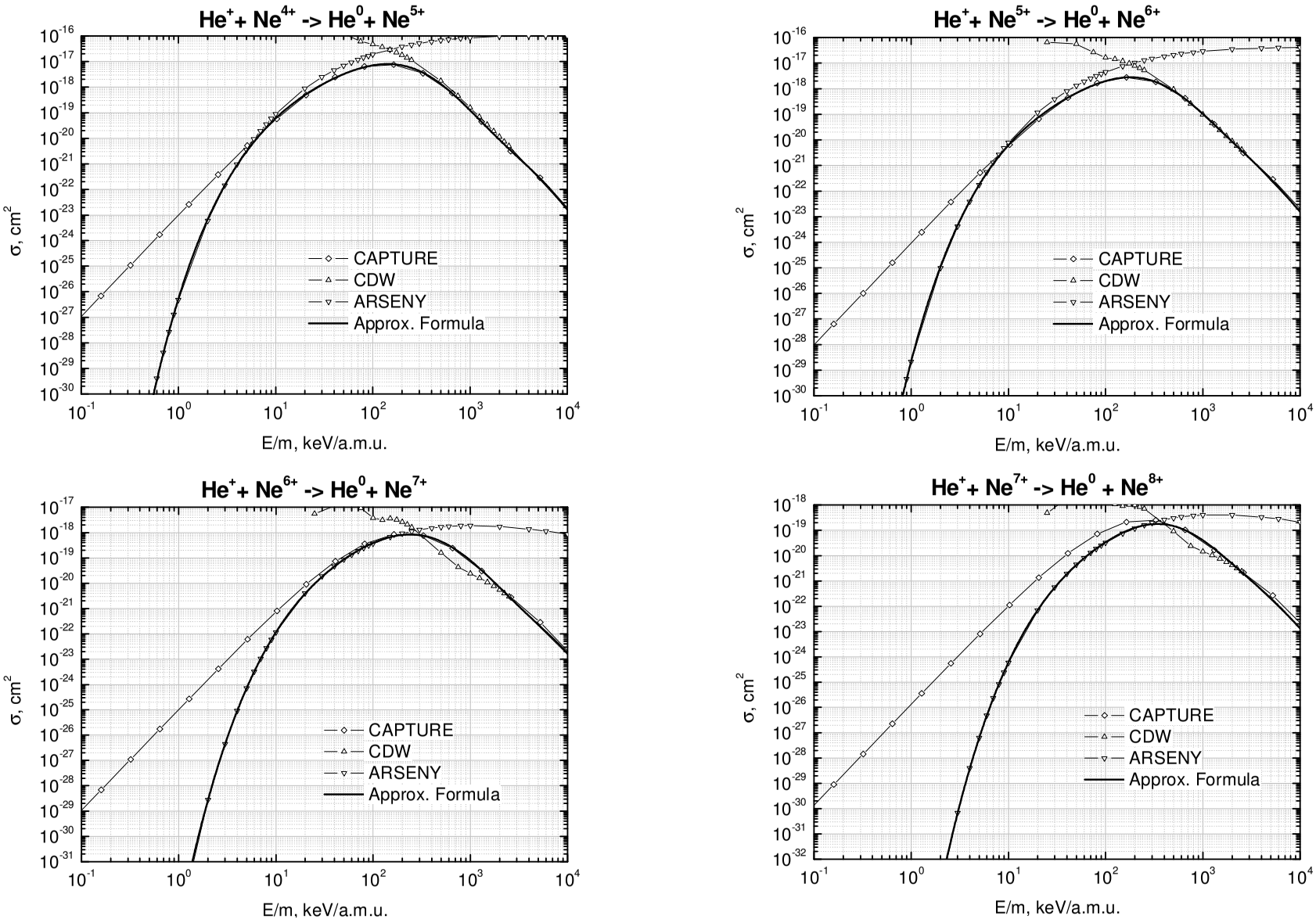
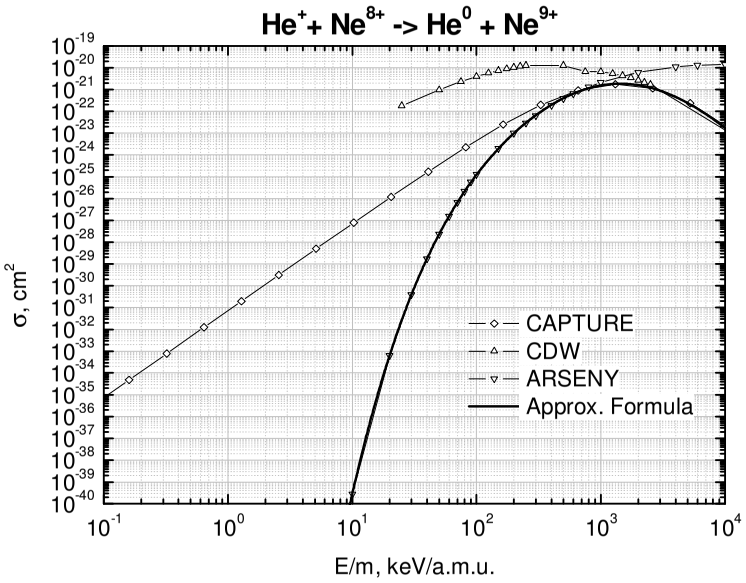


Fig. 27. $He^+ + Ne^{k+} \rightarrow He^0 + Ne^{(k+1)+}$ charge exchange cross-sections for k = 0, …, 9 (continued).



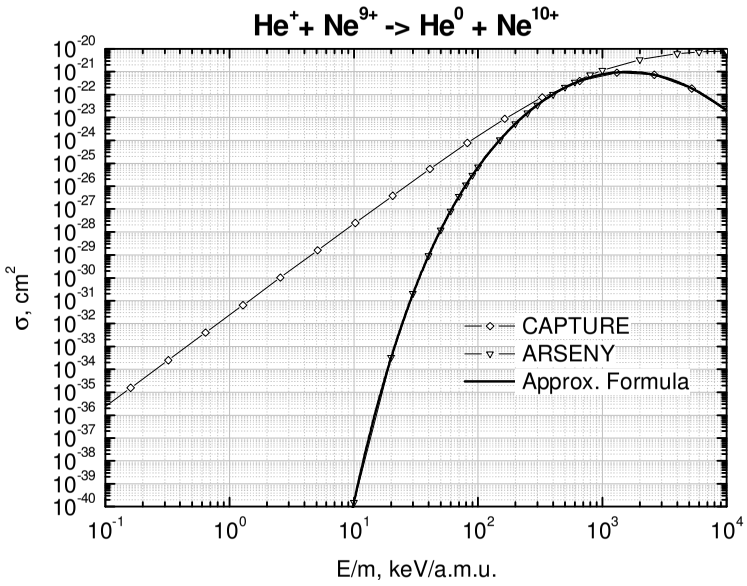


Fig. 27. $He^+ + Ne^{k+} \rightarrow He^0 + Ne^{(k+1)+}$ charge exchange cross-sections for k = 0, …, 9 (continued).

Table 28. Parameters for $He^{2+} + Ne^{k+} \rightarrow He^{+} + Ne^{(k+1)+}$ charge exchange cross-section approximations for k = 0, …, 9.

Parameter	k = 0	k = 1	k = 2
E_{min}	0.1000000000000000E+000	0.1000000000000000E-001	0.2000000000000000E-001
E_{max}	0.1500000000000000E+005	0.4194000000000000E+005	0.4194000000000000E+005
γ	0.9075400000000000E+000	0.1184500000000000E+001	0.1099500000000000E+001
A_0	-0.4016339663030643E+002	-0.4618075156320693E+002	-0.4642946293090877E+002
A_1	-0.6331886866971807E+001	-0.7425451984113876E+000	-0.2369248371019907E+000
A_2	-0.4487739333171747E+001	-0.1282067029328320E+002	-0.1273208195088218E+002
A_3	-0.1081798511783848E+001	0.4072270832488819E+001	0.3601571275381702E+001
A_4	0.3681640644629327E+000	-0.2618585934812432E+001	-0.2472988254777829E+001
A_5	0.3840726857006980E+000	0.1903165024186902E+001	0.1842501689155936E+001
A_6	-0.2100555306525219E+000	-0.1328145359387205E+001	-0.1151296242998033E+001
A_7	-0.2364291224734649E+000	0.5433509474145146E+000	0.4454379698158337E+000
A_8	-0.1136690799830814E+000	-0.4976646397629674E+000	-0.4772276189292606E+000
A_9	-0.1192226038312381E-001	0.6088726075294040E+000	0.4856172786630005E+000
A_{10}	0.1344891737098914E+000	-0.2098919003797341E+000	-0.1189391843897400E+000
A_{11}	0.1359243703565041E+000	0.8380163413962645E-001	0.1248972225333956E+000
A_{12}	0.2369247418564549E-001	-0.2510179981006086E+000	-0.2017378694067526E+000
A_{13}	-0.9299027193640727E-001	0.9265951093374160E-001	0.3531436018670767E-001
A_{14}	-0.7232569304030555E-001	-0.3320598292979329E-001	-0.3751535022854723E-001
A_{15}	0.2219395387726480E-002	0.7716659570069402E-001	0.8729858073422493E-001

Table 28. Parameters for $He^{2+} + Ne^{k+} \rightarrow He^{+} + Ne^{(k+1)+}$ charge exchange cross-section approximations for k = 0, …, 9 (continued).

Parameter	k = 3	k = 4	k = 5
E_{min}	0.5000000000000000E-001	0.5000000000000000E-001	0.5000000000000000E-001
E_{max}	0.4194000000000000E+005	0.4194000000000000E+005	0.4194000000000000E+005
γ	0.1168500000000000E+001	0.1098700000000000E+001	0.1123500000000000E+001
A_0	-0.5047094288926449E+002	-0.5548359272875025E+002	-0.6015191659110004E+002
A_1	0.5597322052858385E+001	0.1439964754492730E+002	0.2219657632100318E+002
A_2	-0.1591441398463926E+002	-0.2084841033119349E+002	-0.2565646815210676E+002
A_3	0.5275349814523242E+001	0.6949624038430392E+001	0.9720681855855863E+001
A_4	-0.2461241030622407E+001	-0.3185636149277065E+001	-0.4659091855399280E+001
A_5	0.1473962473982598E+001	0.1818729587062920E+001	0.2592865933595824E+001
A_6	-0.9835614011659327E+000	-0.9976845527843115E+000	-0.1390012701789678E+001
A_7	0.3779735543358200E+000	0.2415527418063977E+000	0.4731615498846042E+000
A_8	-0.2600872068603359E+000	-0.1429047882756609E+000	-0.2873310547360487E+000
A_9	0.2928913871180834E+000	0.1992283438593472E+000	0.2910002131404644E+000
A_{10}	-0.4238393049727298E-001	-0.3068527269696408E-001	-0.1164496590998074E+000
A_{11}	-0.8658383973988826E-002	0.6265189172817241E-001	0.8156349622065749E-001
A_{12}	-0.1319184403931569E+000	-0.9580880077312433E-001	-0.1127073627816067E+000
A_{13}	0.5135241610545087E-001	-0.2255061034324919E-001	-0.4828127167894332E-002
A_{14}	0.9190973024498545E-002	0.9379516272949150E-002	-0.9677942784133548E-002
A_{15}	0.3536968392377086E-001	0.5438129808632937E-001	0.4888774957788688E-001

Table 28. Parameters for $He^{2+} + Ne^{k+} \rightarrow He^{+} + Ne^{(k+1)+}$ charge exchange cross-section approximations for k = 0, …, 9 (continued).

Parameter	k = 6	k = 7	k = 8
E_{min}	0.5000000000000000E-001	0.1000000000000000E+000	0.5000000000000000E+000
E_{max}	0.4194000000000000E+005	0.4194000000000000E+005	0.4194000000000000E+005
γ	0.1145200000000000E+001	0.1061700000000000E+001	0.8207000000000000E+000
A_0	-0.6546888457148286E+002	-0.6695858386329728E+002	-0.9842837264111159E+002
A_1	0.3104399176531840E+002	0.3251717406628433E+002	0.7790370459465836E+002
A_2	-0.3132696870712960E+002	-0.2993498850251265E+002	-0.4318885084361690E+002
A_3	0.1322115822192662E+002	0.1091784986580975E+002	0.8065782471952360E+001
A_4	-0.6741749397541660E+001	-0.4784952676920977E+001	-0.7434284111275427E+000
A_5	0.3648440543654199E+001	0.2208308012252696E+001	-0.1311169031181906E+001
A_6	-0.1901487342648580E+001	-0.1006970784660955E+001	0.1220840685546942E+001
A_7	0.7767124347758301E+000	0.2226626536113837E+000	-0.3908203227582644E+000
A_8	-0.4789685874323967E+000	-0.8993150623501601E-001	0.1949175109369860E+000
A_9	0.4464919915350327E+000	0.1978510049935475E+000	-0.2247932854386984E+000
A_{10}	-0.2061617625937959E+000	-0.8548531284055842E-001	0.1581366851481790E+000
A_{11}	0.1396439519821695E+000	0.1689556064096776E-001	-0.3163557464915064E-001
A_{12}	-0.1313415576061950E+000	-0.7016808421071115E-001	0.1171564836447163E-001
A_{13}	0.4374713318979466E-001	-0.7888868391394009E-002	-0.2972252334145523E-001
A_{14}	-0.2495841772038981E-001	-0.1243813966152880E-001	0.1956548033118534E-001
A_{15}	0.6356183744878798E-001	0.4752595834154864E-001	0.1905496268143289E-001

Table 28. Parameters for $He^{2+} + Ne^{k+} \rightarrow He^{+} + Ne^{(k+1)+}$ charge exchange cross-section approximations for k = 0, …, 9 (continued).

Parameter	k = 9
E_{min}	0.6000000000000000E+000
E_{max}	0.4194000000000000E+005
γ	0.5823000000000000E+000
A_0	-0.1142988738903036E+003
A_1	0.9370171350551205E+002
A_2	-0.3370835189381592E+002
A_3	-0.6171886258637256E+001
A_4	0.5228973622559528E+001
A_5	-0.2517027995851108E+001
A_6	0.2867400978574575E+000
A_7	0.1333856100510138E+000
A_8	0.3256307092628307E+000
A_9	-0.1753771527429205E+000
A_{10}	0.9361907131867848E-001
A_{11}	-0.1890746757705643E+000
A_{12}	0.1534744297034270E+000
A_{13}	-0.9136094829259418E-001
A_{14}	0.7724567453830038E-001
A_{15}	-0.4041008369091543E-001

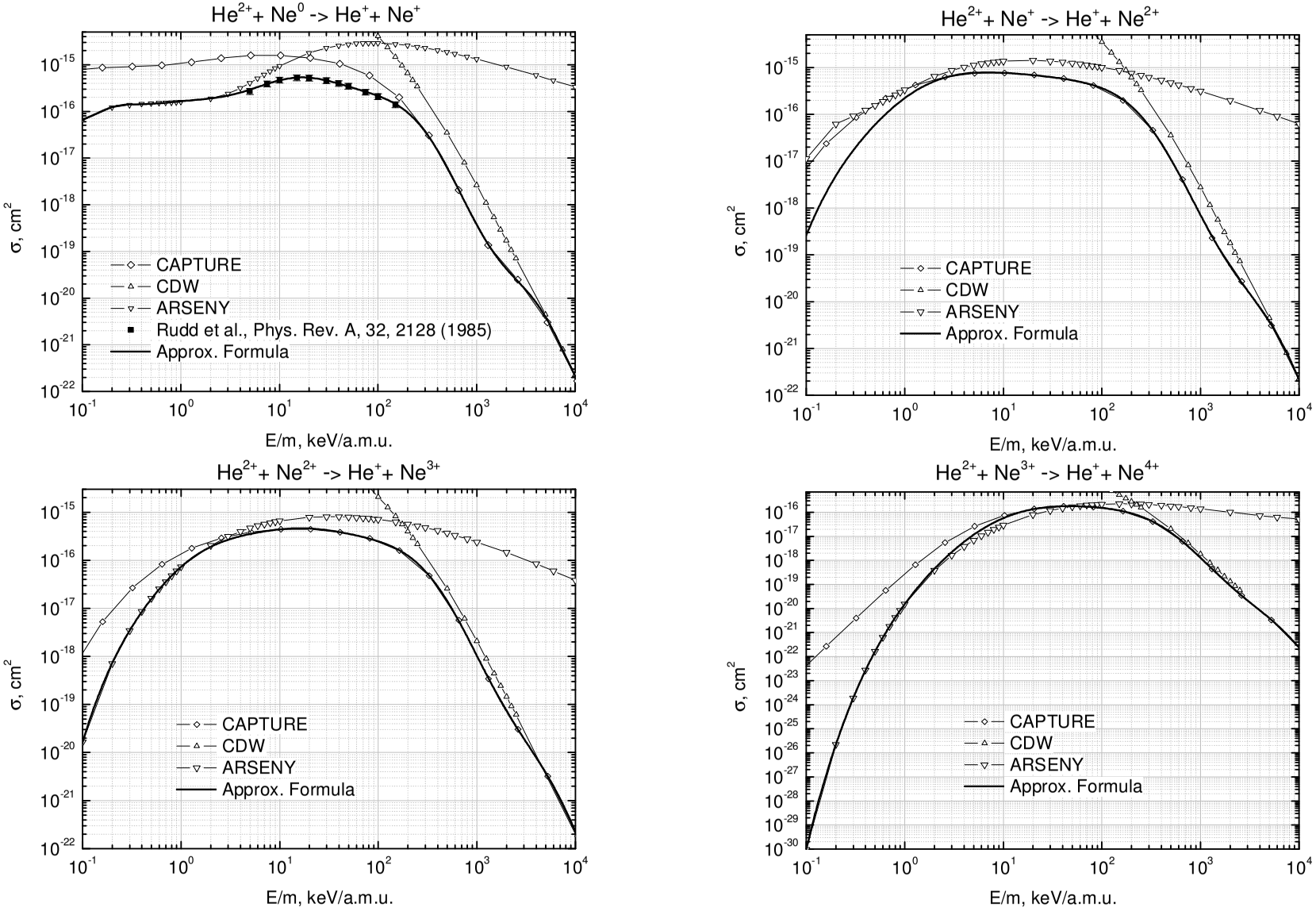


Fig. 28. $He^{2+} + Ne^{k+} \rightarrow He^{+} + Ne^{(k+1)+}$ charge exchange cross-sections for k = 0, …, 9.

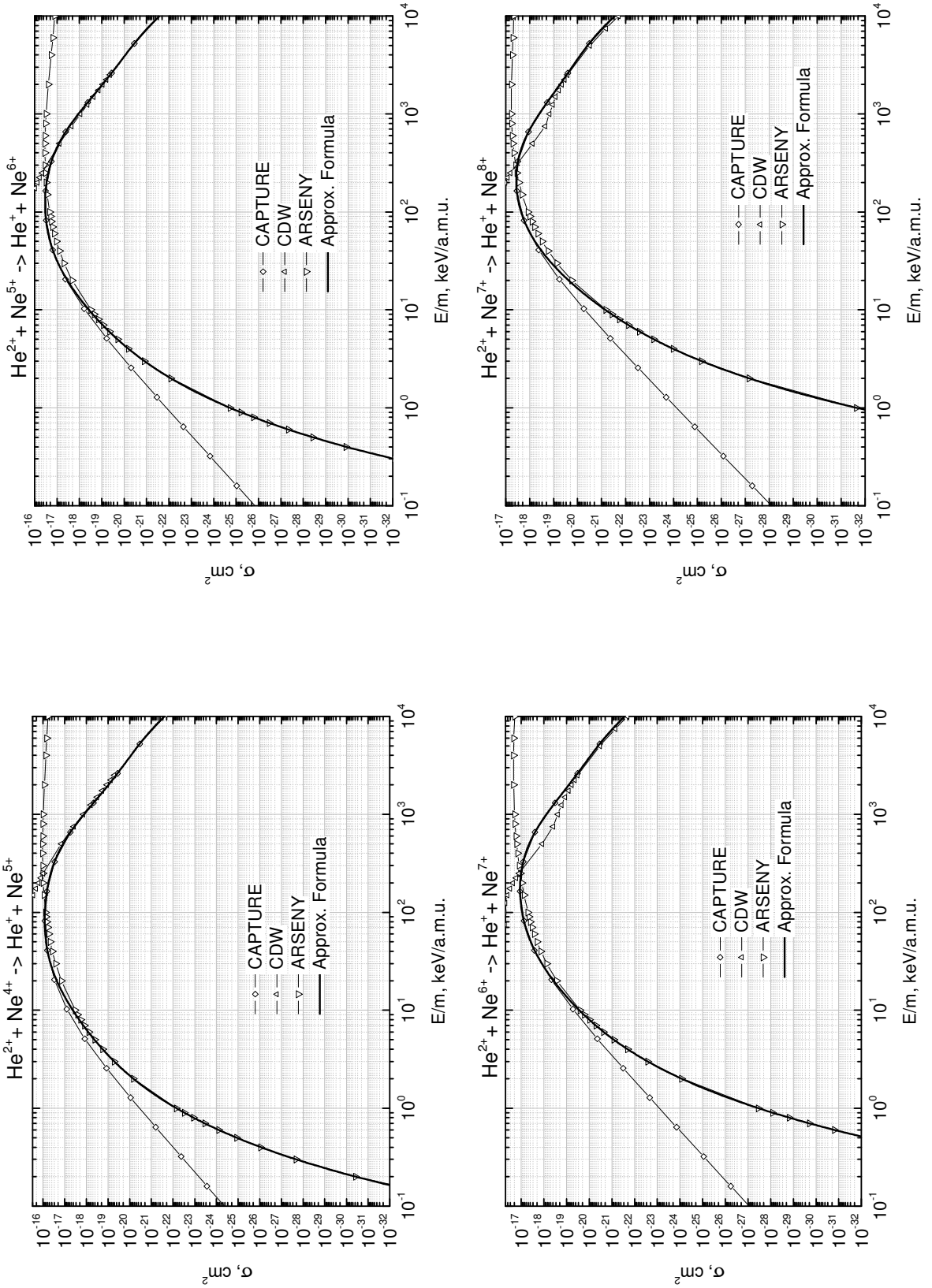
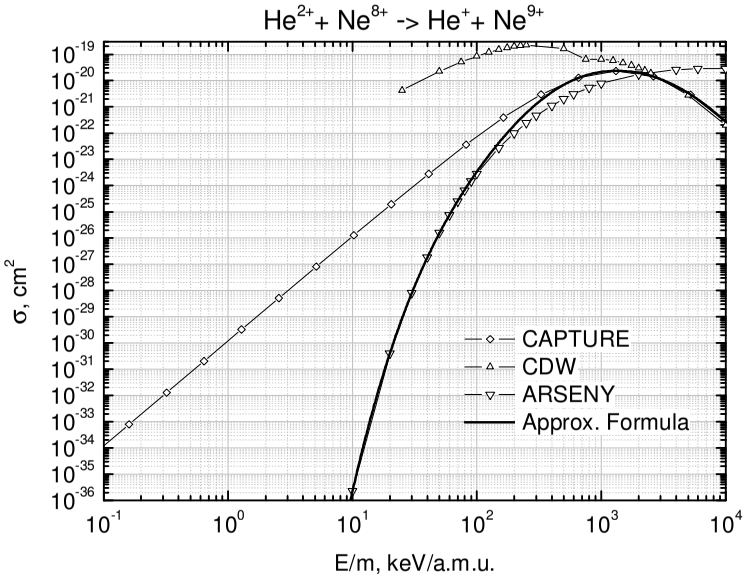


Fig. 28. $He^{2+} + Ne^{k+} \rightarrow He^{+} + Ne^{(k+1)+}$ charge exchange cross-sections for k = 0, …, 9 (continued).



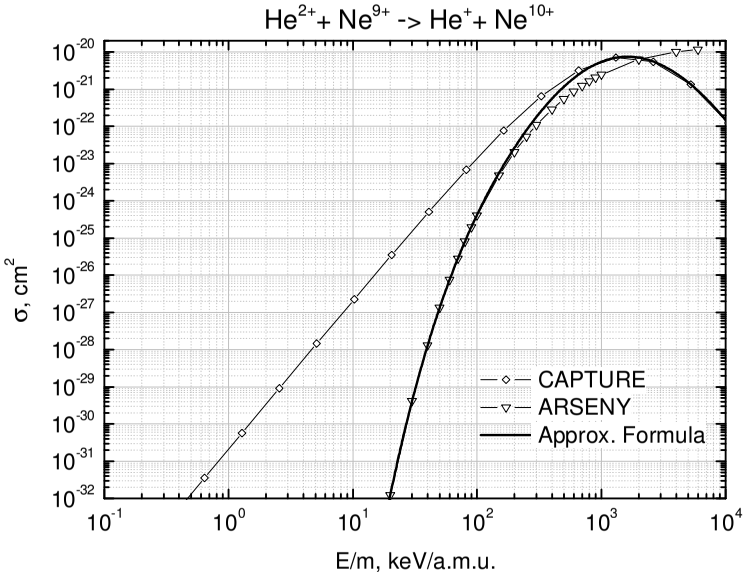


Fig. 28. $He^{2+} + Ne^{k+} \rightarrow He^{+} + Ne^{(k+1)+}$ charge exchange cross-sections for k = 0, …, 9 (continued).

Table 29. Parameters for $He^0 + Ne^{k+} \rightarrow He^+ + Ne^{(k-1)+}$ charge exchange cross-section approximations for k = 1, …, 10.

Parameter	k = 1	k = 2	k = 3
E_{min}	0.1000000000000000E+000	0.4000000000000000E-001	0.1000000000000000E+000
E_{max}	0.4955400000000000E+005	0.1350000000000000E+005	0.4955400000000000E+005
γ	0.1051200000000000E+001	0.1023780000000000E+001	0.9875600000000000E+000
A_0	-0.4660353945834083E+002	-0.4217759551675265E+002	-0.4352689777957542E+002
A_1	-0.1206647972047885E+002	-0.8347252479090656E+001	-0.1263053529686926E+002
A_2	-0.8723386765346698E+001	-0.6172150843119483E+001	-0.7854021548225457E+001
A_3	-0.2526081491470714E+000	-0.1372976467005317E+001	-0.1029235237179205E+001
A_4	0.1300913585702818E+001	0.1715224791920113E-001	0.1019006351660264E+001
A_5	0.1498023242552035E+000	0.4252299956200419E+000	0.2818156553781103E+000
A_6	-0.3976018389617896E+000	0.1180739253685429E+000	-0.1028382214880776E+000
A_7	0.4060447559284780E-001	0.2109962592515203E-001	-0.1225117443091643E+000
A_8	0.3730946039100528E-001	-0.1451795792616330E+000	-0.9187553637229455E-001
A_9	0.1256542673313759E+000	-0.4980564903557243E-001	0.1171141551696206E+000
A_{10}	-0.1430097880497786E+000	-0.5409285933602044E-002	0.5388929751934946E-001
A_{11}	-0.3065541631366641E-001	0.2007959025540809E-001	-0.1308516287681750E+000
A_{12}	0.6855563628443229E-001	0.2927316380549144E-001	-0.2726409486562937E-002
A_{13}	-0.1415165612434935E-001	0.1249719799959108E-001	0.5554051912631879E-001
A_{14}	-0.1078754066380676E-001	0.0000000000000000E+000	0.1913574973352901E-001
A_{15}	0.3545268929690453E-002	0.0000000000000000E+000	0.6119763316815607E-002

Table 29. Parameters for $He^0 + Ne^{k+} \rightarrow He^+ + Ne^{(k-1)+}$ charge exchange cross-section approximations for k = 1, …, 10 (continued).

Parameter	k = 4	k = 5	k = 6
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.6800000000000000E-001
E_{max}	0.4955400000000000E+005	0.4955400000000000E+005	0.4955400000000000E+005
γ	0.1021000000000000E+001	0.1323900000000000E+001	0.8395700000000000E+000
A_0	-0.4234326543950808E+002	-0.4351987375337862E+002	-0.4126704438353983E+002
A_1	-0.1372734741187067E+002	-0.1367859473819293E+002	-0.1179779308911509E+002
A_2	-0.6822450430539424E+001	-0.6239409012185135E+001	-0.7524535221759577E+001
A_3	-0.1045794135651028E+001	0.3337589630140402E+000	-0.2123930356181817E+001
A_4	0.6500526773566266E+000	0.6621663410380572E+000	0.1362189954815166E+000
A_5	0.5442511282452884E+000	0.1403398759265433E+000	0.6258331604537296E+000
A_6	-0.2320715013530366E+000	-0.2417468364116768E+000	0.2259626019862078E+000
A_7	-0.1900941574620255E+000	-0.5397503315016504E-001	-0.1802991219249410E+000
A_8	0.2615157440984674E-001	0.1118754638524775E+000	-0.1072323185600027E+000
A_9	0.5451223506244240E-001	-0.2313908217712186E-001	0.0000000000000000E+000
A_{10}	0.1979852526904799E-001	-0.5479288011668496E-001	0.0000000000000000E+000
A_{11}	-0.5216716120529242E-001	0.2381166694655006E-001	0.0000000000000000E+000
A_{12}	0.0000000000000000E+000	0.8999898119137508E-002	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.3926406794786318E-001	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

Table 29. Parameters for $He^0 + Ne^{k+} \rightarrow He^+ + Ne^{(k-1)+}$ charge exchange cross-section approximations for k = 1, …, 10 (continued).

Parameter	k = 7	k = 8	k = 9
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.1000000000000000E+000
E_{max}	0.4955400000000000E+005	0.4955400000000000E+005	0.4955400000000000E+005
γ	0.8153400000000000E+000	0.7512900000000000E+000	0.7816300000000000E+000
A_0	-0.4057279097893353E+002	-0.4019490198766324E+002	-0.3987672398519653E+002
A_1	-0.1161219441454260E+002	-0.1133739671093219E+002	-0.1060055321611519E+002
A_2	-0.6867223421344121E+001	-0.6949125209547699E+001	-0.6280405018012566E+001
A_3	-0.2096710203758013E+001	-0.2508878290041644E+001	-0.2226011233355419E+001
A_4	0.4465353938672005E-001	-0.1469096856858723E+000	0.8261561830331439E-001
A_5	0.5727966745827072E+000	0.5505425078424800E+000	0.5621455546716838E+000
A_6	0.1282255290288756E+000	0.3309339733160614E+000	0.1051838813043564E+000
A_7	-0.1806339183038910E+000	-0.4527944872505323E-001	-0.8133442388436578E-001
A_8	-0.1102178553407031E+000	-0.9255311722988052E-001	-0.9116632773471718E-001
A_9	0.0000000000000000E+000	-0.1969148568014011E-002	-0.3282352908096749E-001
A_{10}	0.0000000000000000E+000	0.5557712233030992E-001	0.0000000000000000E+000
A_{11}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{12}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{13}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{14}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000	0.0000000000000000E+000	0.0000000000000000E+000

Table 29. Parameters for $He^0 + Ne^{k+} \rightarrow He^+ + Ne^{(k-1)+}$ charge exchange cross-section approximations for k = 1, …, 10 (continued).

Parameter	k = 10
E_{min}	0.1000000000000000E+000
E_{max}	0.4955400000000000E+005
γ	0.1041500000000000E+001
A_0	-0.4050284043725809E+002
A_1	-0.1159420361467983E+002
A_2	-0.5719525811158054E+001
A_3	-0.1075074881367320E+001
A_4	0.6434404413541307E+000
A_5	0.4266820006708806E+000
A_6	-0.2243396232998758E+000
A_7	-0.1338945075949134E+000
A_8	0.8359658099240291E-001
A_9	0.4554240820668812E-001
A_{10}	-0.5835343063069758E-001
A_{11}	-0.6797712262754901E-001
A_{12}	0.3642292423637079E-001
A_{13}	0.4629802229965789E-001
A_{14}	0.0000000000000000E+000
A_{15}	0.0000000000000000E+000

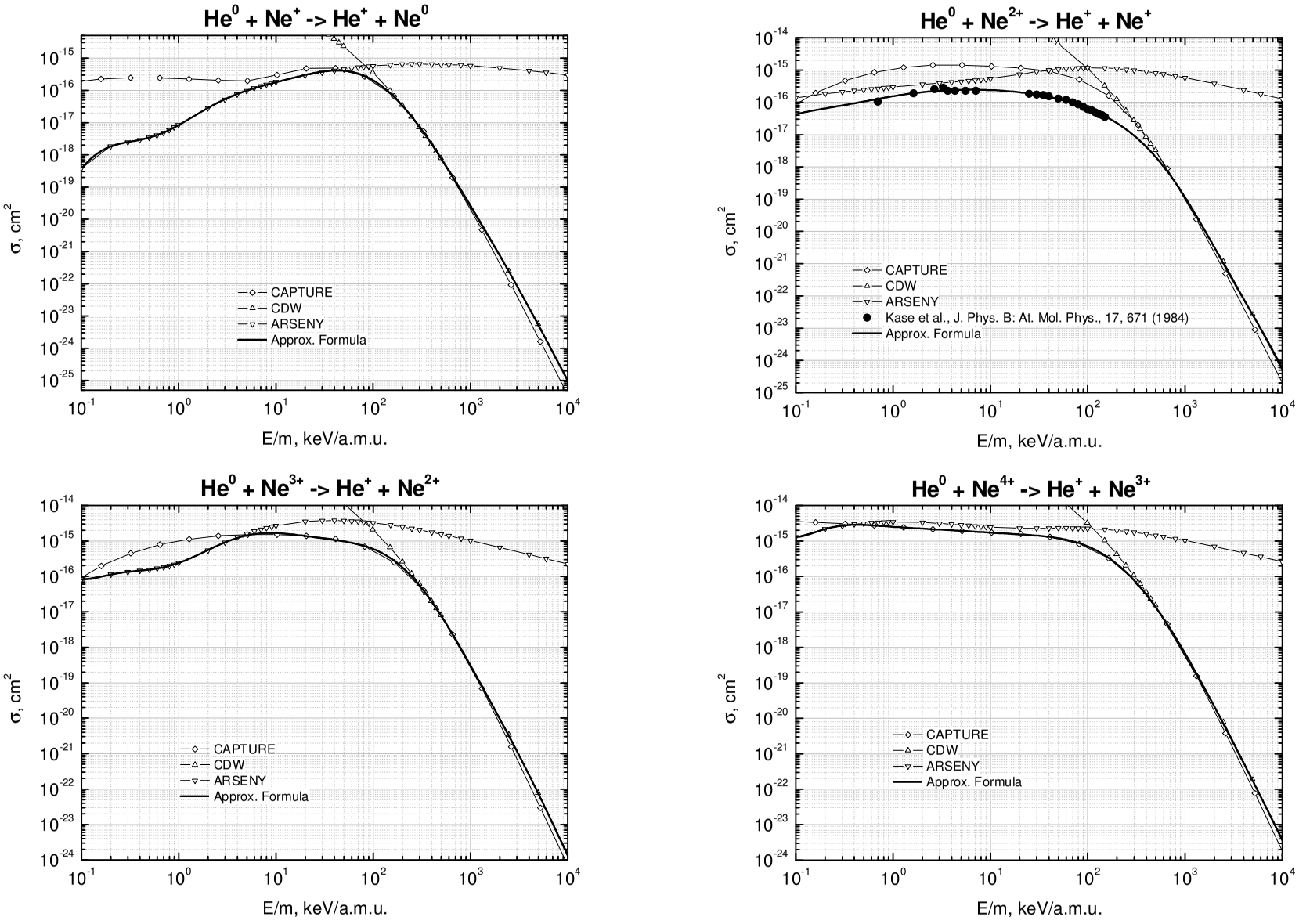


Fig. 29. $He^0 + Ne^{k+} \rightarrow He^+ + Ne^{(k-1)+}$ charge exchange cross-sections for k = 1, …, 10.

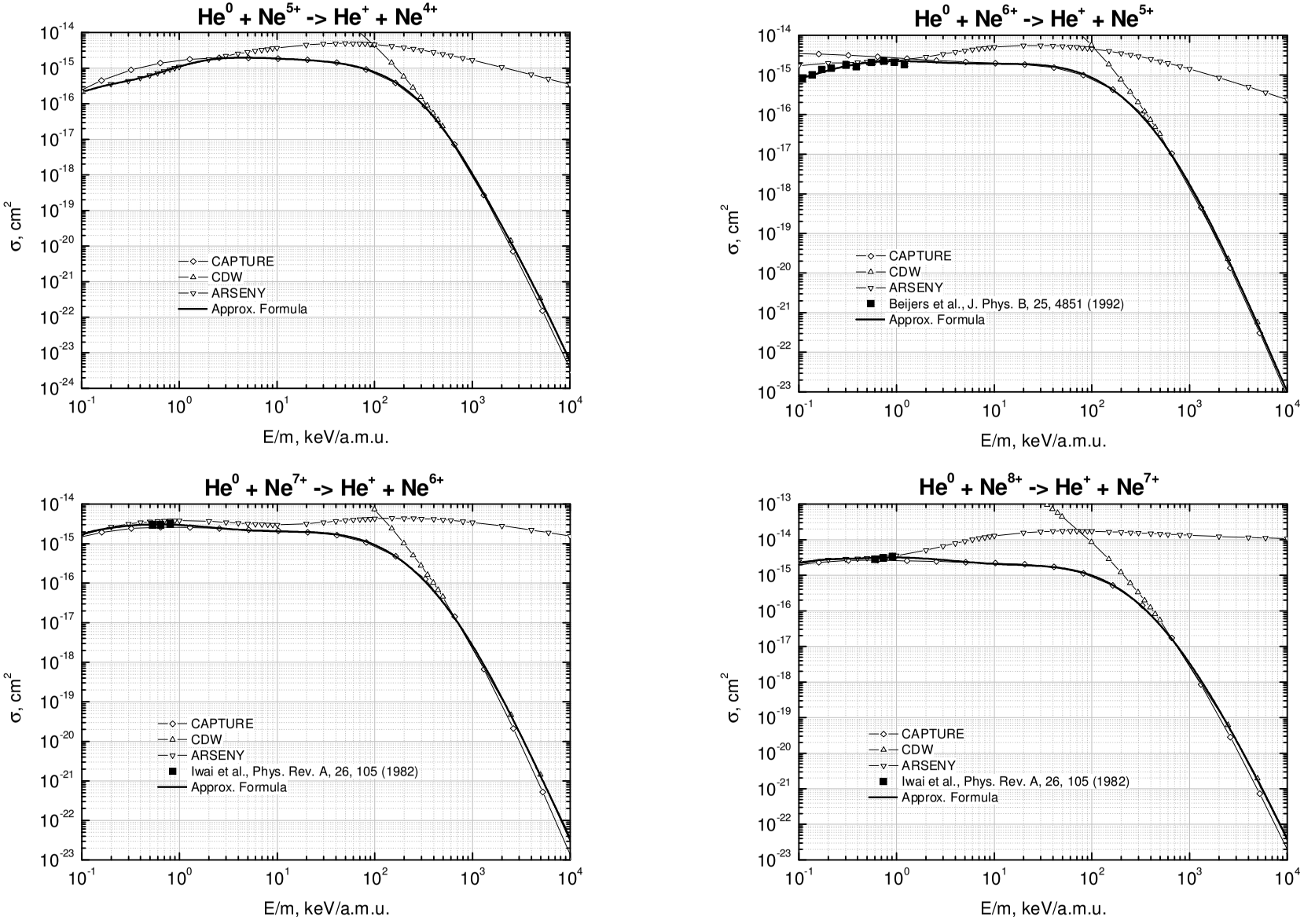
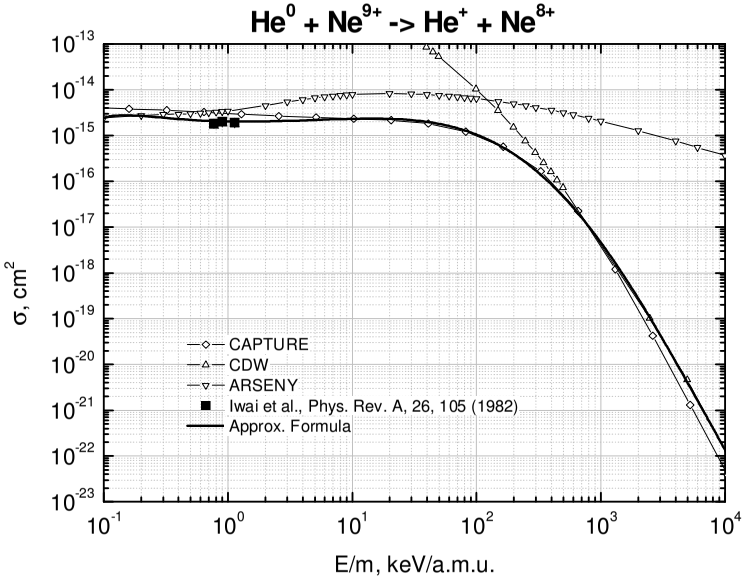


Fig. 29. $He^0 + Ne^{k+} \rightarrow He^+ + Ne^{(k-1)+}$ charge exchange cross-sections for k = 1, …, 10 (continued).



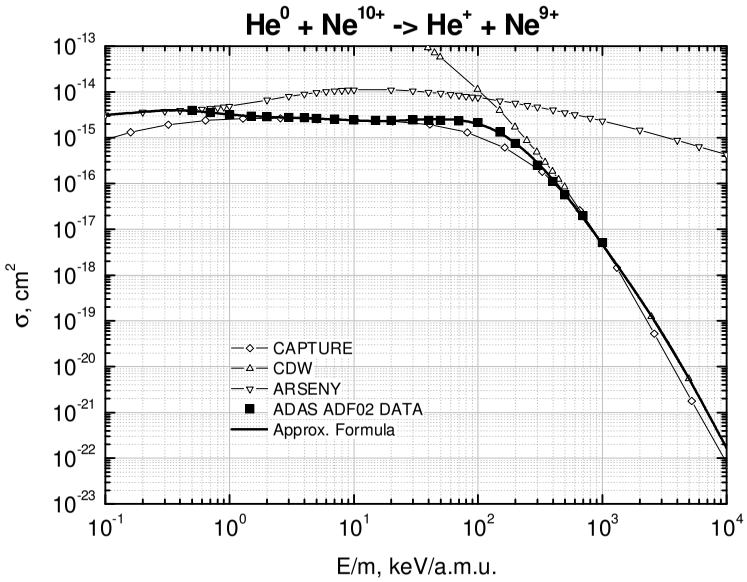


Fig. 29. $He^0 + Ne^{k+} \rightarrow He^+ + Ne^{(k-1)+}$ charge exchange cross-sections for k = 1, …, 10 (continued).

Table 30. Parameters for $He^{+} + Ne^{k+} \rightarrow He^{2+} + Ne^{(k-1)+}$ charge exchange cross-section approximations for k = 1, …, 10.

Parameter	k = 1	k = 2	k = 3
E_{min}	0.2000000000000000E+000	0.2000000000000000E+000	0.4000000000000000E+000
E_{max}	0.4955400000000000E+005	0.4955400000000000E+005	0.1000000000000000E+005
γ	0.9178600000000000E+000	0.9486700000000000E+000	0.9537800000000000E+000
A_0	-0.4766143932596133E+002	-0.4694109154555353E+002	-0.4192899919858383E+002
A_1	-0.1098175056057050E+002	-0.9839986649332326E+001	-0.7950385434311730E+001
A_2	-0.7958676224485690E+001	-0.8598257697490519E+001	-0.4018252947459998E+001
A_3	-0.1826649892688463E+001	-0.1164949961176789E+001	-0.1768128593267215E+001
A_4	0.1101698151130948E+001	0.9371526141026079E+000	-0.1574182320608831E+000
A_5	0.8983813532827906E+000	0.8330481103834300E+000	0.4651241173937991E+000
A_6	-0.5155451857917155E+000	-0.6833291438661123E+000	0.2905845239417345E+000
A_7	-0.3047648160982629E+000	-0.8632104018817012E-001	-0.6422936665012897E-001
A_8	0.2001439962428441E+000	0.3704969654441635E-001	-0.1746508323981471E+000
A_9	0.1885269045661006E+000	0.1145538313872613E+000	-0.6489968946743212E-001
A_{10}	-0.7381986647597653E-001	0.2023016888578293E-001	0.6832716284763822E-001
A_{11}	-0.1056045993458067E+000	-0.1178967503382295E+000	0.7756266043895904E-001
A_{12}	0.2119642821880384E-001	-0.8971737507566037E-002	0.1895738902194992E-001
A_{13}	0.5917705114457673E-001	0.6400620186403461E-001	-0.5645503793512803E-001
A_{14}	-0.1396553166156478E-002	0.3508094572092540E-001	-0.5166736577380680E-001
A_{15}	-0.5801362395267277E-001	-0.7659886758146058E-001	0.3129480985929879E-002

Table 30. Parameters for $He^{+} + Ne^{k+} \rightarrow He^{2+} + Ne^{(k-1)+}$ charge exchange cross-section approximations for k = 1, …, 10 (continued).

Parameter	k = 4	k = 5	k = 6
E_{min}	0.2000000000000000E+000	0.1000000000000000E+000	0.2000000000000000E+000
E_{max}	0.1500000000000000E+005	0.4955400000000000E+005	0.4955400000000000E+005
γ	0.9972600000000000E+000	0.9876500000000000E+000	0.9457800000000000E+000
A_0	-0.4200023851734950E+002	-0.4343369862740082E+002	-0.4365142049904580E+002
A_1	-0.8049966240708640E+001	-0.1170767347981068E+002	-0.1004978786011470E+002
A_2	-0.5934982669222158E+001	-0.7308359914301095E+001	-0.7723077613978694E+001
A_3	-0.1572090022616006E+001	-0.1586852901702263E+001	-0.1139988546807600E+001
A_4	0.4021987468247407E+000	0.7281227265242072E+000	0.6754796854995366E+000
A_5	0.5418133312002688E+000	0.7073613572268258E+000	0.5237229822617031E+000
A_6	-0.2955717997059480E-001	-0.1982754796841406E+000	-0.2435217400781574E+000
A_7	-0.2428154986925316E+000	-0.1786865743879030E+000	0.9864073551853069E-002
A_8	-0.9213243104303041E-001	0.1221511806918397E-001	-0.1404915447123343E+000
A_9	0.1180523489036730E+000	0.7991548317865853E-001	0.1423101355600216E+000
A_{10}	0.7839329457124244E-001	0.1470340645897345E-002	0.1055133074341790E-001
A_{11}	-0.2406079394730071E-001	-0.2745292441732537E-001	-0.5916667642160088E-001
A_{12}	-0.4637340673715926E-001	-0.5225191420856919E-001	-0.6179666354634968E-001
A_{13}	-0.1041005698229771E-001	0.7742845652267480E-003	0.1877397339108110E-001
A_{14}	0.2366721741351050E-001	0.6890162154849866E-001	0.7651406567131672E-001
A_{15}	0.1274301000278972E-001	0.2006789630339145E-001	-0.6927908950288280E-002

Table 30. Parameters for $He^{+} + Ne^{k+} \rightarrow He^{2+} + Ne^{(k-1)+}$ charge exchange cross-section approximations for k = 1, …, 10 (continued).

Parameter	k = 7	k = 8	k = 9
E_{min}	0.1000000000000000E+000	0.1000000000000000E+000	0.2000000000000000E+000
E_{max}	0.1000000000000000E+005	0.1000000000000000E+005	0.1000000000000000E+005
γ	0.9748599999999999E+000	0.9753200000000000E+000	0.9390500000000001E+000
A_0	-0.3929109434199452E+002	-0.3953306666293690E+002	-0.3969625829745497E+002
A_1	-0.7077650501927776E+001	-0.6181069683381583E+001	-0.5106157083505489E+001
A_2	-0.4438865881332850E+001	-0.4835640799645755E+001	-0.4934588490455002E+001
A_3	-0.1560797872273765E+001	-0.1680316452454450E+001	-0.1363320040683231E+001
A_4	-0.3597764616724382E+000	-0.1057167688899354E+000	0.1357908752804785E+000
A_5	0.3879545537918263E+000	0.4925403436594091E+000	0.3484288513373920E+000
A_6	0.2731314741742860E+000	0.8144380830240151E-001	0.6268004500714788E-001
A_7	-0.5041350034509590E-001	-0.5159181486090886E-001	0.8758189422471982E-002
A_8	-0.1787214905103098E+000	-0.7159496230498839E-001	-0.1318738005889800E+000
A_9	-0.9896688901169032E-001	-0.5846529582137014E-001	-0.6600280541116874E-001
A_{10}	0.6051323261722760E-001	0.1858873761872669E-001	0.7134568809920240E-001
A_{11}	0.9106806728037740E-001	0.8919441143806997E-001	0.7369344747437533E-001
A_{12}	0.4003676173222839E-001	0.6283794565010485E-001	0.2254376774420239E-001
A_{13}	-0.4539058552198883E-001	-0.3761697937991614E-001	-0.4113677408745159E-001
A_{14}	-0.6881041096568716E-001	-0.5238678111702076E-001	-0.4156946713548582E-001
A_{15}	-0.1758016561908311E-001	-0.1213489014872425E-001	-0.9349937966072129E-002

Table 30. Parameters for $He^{+} + Ne^{k+} \rightarrow He^{2+} + Ne^{(k-1)+}$ charge exchange cross-section approximations for k = 1, …, 10 (continued).

Parameter	k = 10
E_{min}	0.1000000000000000E+000
E_{max}	0.1000000000000000E+005
γ	0.9827300000000000E+000
A_0	-0.3919385739125092E+002
A_1	-0.5869035271406172E+001
A_2	-0.4027090957488472E+001
A_3	-0.1950721538394551E+001
A_4	0.6748871851916820E-001
A_5	0.4485570187791572E+000
A_6	0.1330684592408253E+000
A_7	-0.6748956199432339E-001
A_8	-0.9079905745874713E-001
A_9	-0.7333584851602769E-001
A_{10}	0.3943363754986991E-001
A_{11}	0.9037792437583375E-001
A_{12}	0.3684921906021627E-001
A_{13}	-0.7821484499190477E-002
A_{14}	-0.1895782974553784E-001
A_{15}	-0.1370091754452095E-001

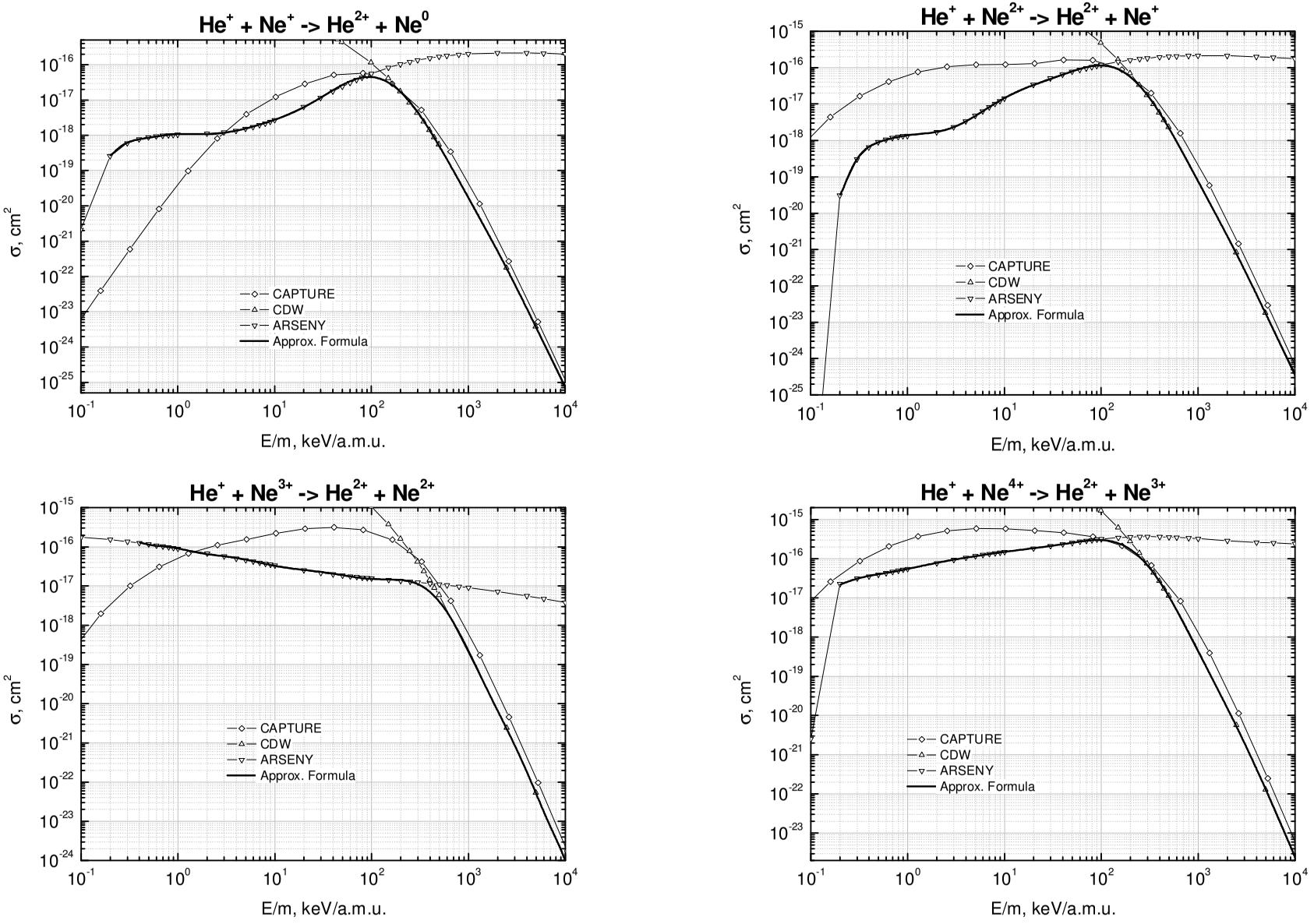


Fig. 30. $He^+ + Ne^{k+} \rightarrow He^{2+} + Ne^{(k-1)+}$ charge exchange cross-sections for k = 1, …, 10.

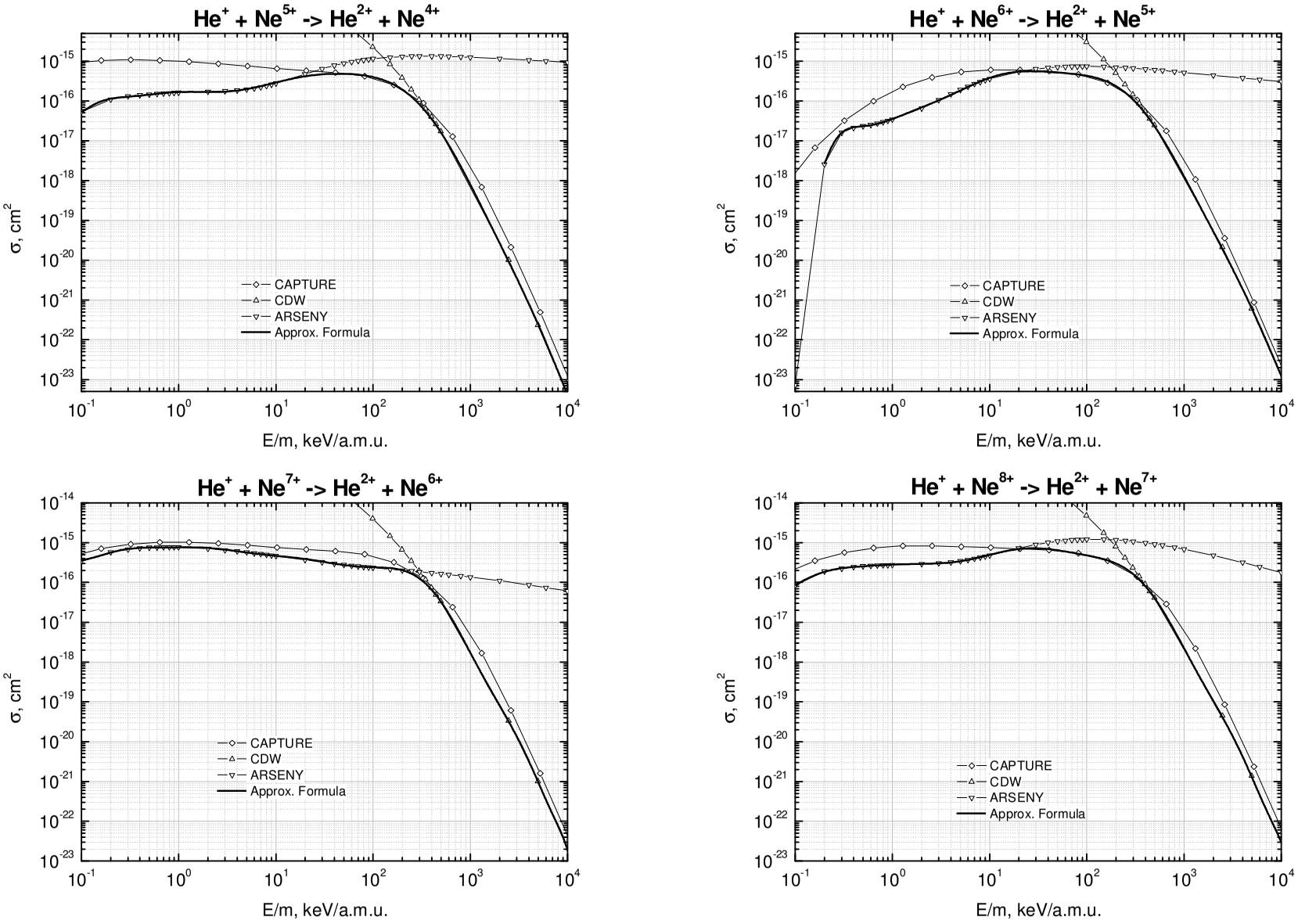
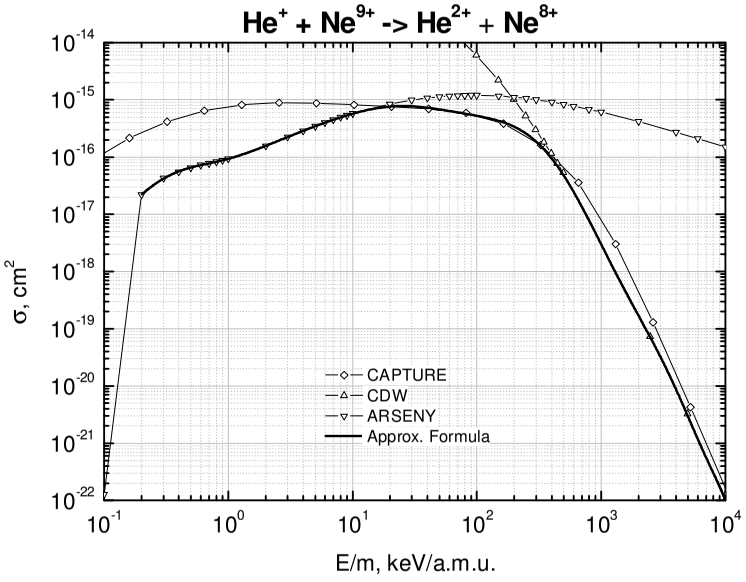


Fig. 30. $He^{+} + Ne^{k+} \rightarrow He^{2+} + Ne^{(k-1)+}$ charge exchange cross-sections for k = 1, …, 10 (continued).



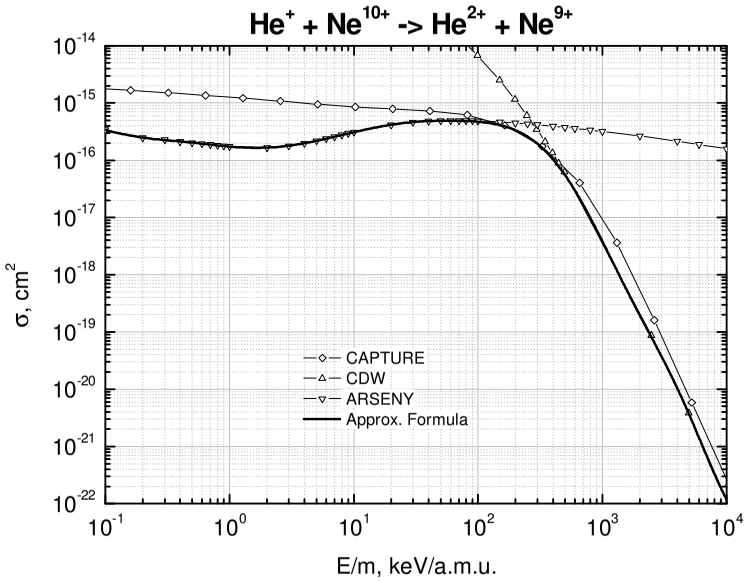


Fig. 30. $He^{+} + Ne^{k+} \rightarrow He^{2+} + Ne^{(k-1)+}$ charge exchange cross-sections for k = 1, …, 10 (continued).