BOLTZMANN EQUATION INTEGRATION
IN THERMIONIC CONVERTER CONDITIONS
PART II: TERMS IN BOLTZMANN EQUATION

BY

MARIA L. STOENESCU

**PLASMA PHYSICS
LABORATORY**

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

**PRINCETON UNIVERSITY
PRINCETON, NEW JERSEY**

This work was supported by U. S. Energy Research and Development Administration Contract 2798. Reproduction, translation, publication, use and disposal, in whole or in part, by or for the United States Government is permitted.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

Printed in the United States of America.

Available from
National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151

Price: Printed Copy \$ * ; Microfiche \$3.00

<u>*Pages</u>	<u>NTIS Selling Price</u>
1-50	\$ 4.00
51-150	5.45
151-325	7.60
326-500	10.60
501-1000	13.60

Boltzmann Equation Integration in Thermionic Converter Conditions
Part II: Terms in Boltzmann Equation

Maria L. Stoenescu

Princeton Plasma Physics Laboratory
Princeton University, Princeton, N. J. 08540

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

PPPL-1346

June 1977

EB
DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

TABLE OF CONTENTS

Acknowledgements	i
Summary	ii
List of Figures	iii
Description of terms considered in Boltzmann equation	1
Results	9
Figures	24
Appendixes	
A. Binary collisions	
B. Coulomb interactions	

ACKNOWLEDGEMENTS

Addressed to: Donald E. Smith, who devised and performed the larger amount of numerical computations.

To: Timothy M. Smith, who performed a substantial amount of computations and to Frank Hawrusik, who became more recently involved in computations for thermionic studies.

SUMMARY

The terms in Boltzmann kinetic equation corresponding to elastic short range collisions, inelastic excitational collisions, coulomb interactions and electric field acceleration are evaluated numerically for a standard distribution function minimizing the computational volume by expressing the terms as linear combinations with recalculable coefficients, of the distribution function and its derivatives. The present forms are suitable for spatial distribution calculations.

LIST OF FIGURES

0. Binary collisions
 1. Standard electron velocity distribution function.
 2. Elastic collision integral for standard f_e .
 3. Inelastic collision integral for standard f_e and one excitation transition.
 4. Coulomb term for electron-ion interactions and standard f_e .
 5. Coulomb term for electron-electron interaction and standard f_e .
 6. Electric field term for standard f_e .
 7. Elastic collision integral.
 8. Coulomb term, electron-ion collisions.
 9. Electric field term.
 10. Sum of terms in Figs. 2, 5, 6
 11. Spatial derivative of electron velocity distribution function.
- } scaled to
arbitrary reference

DESCRIPTION OF TERMS CONSIDERED IN BOLTZMANN EQUATION

Boltzmann equation describes the time variation of the local density of particles of given velocity (number of particles represented by a unit cell of the phase — configuration and velocity — space) when subjected to various physical processes. A system of similar equations describes therefore the velocity distribution function of a group of particles, identified through their velocities.

The processes taken into account are short range collisions, elastic and inelastic, long range Coulomb interactions and electric field acceleration:

$$\frac{\partial f}{\partial t} + \vec{v} \text{ grad } f + \frac{F}{m} \text{ grad}_{\vec{v}} f = \left(\frac{\partial f}{\partial t} \right)^{\text{el coll}} + \left(\frac{\partial f}{\partial t} \right)^{\text{in coll}} + \left(\frac{\partial f}{\partial t} \right)^{\text{Coul}} \quad (1)$$

The spatial gradient term describes the substitution of the particles represented by a unit volume of the phase space, due to the fluid flow. It is the only term which describes the spatial variation of the distribution function.

Elastic or inelastic collisions transform a particle velocity $\vec{v}$ into $\vec{v}'$ (Fig. 0) according to formulas (A34), (A35), (A53) and (A66) of Appendix A derived from momentum (A25) and energy (A40) conservation equations for two colliding particles.

The elastic collision term in Boltzmann equation represents the phase space particle density time rate of change, as the balance of particles which are scattered in and out of a phase space elementary volume. For electrons it is:

$$\left(\frac{\partial f_e}{\partial t}\right)^{\text{el coll}} \equiv \int f'_e f'_n - f_e f_n g \sigma d\vec{v}_n \sin\chi d\chi d\beta \quad (2)$$

or:

$$\left(\frac{\partial f_e}{\partial t}\right)^{\text{el coll}} \rightarrow \sum_{v_n, \xi, \eta, \chi, \beta} (f'_e f'_n - f_e f_n) g \sigma v_n^2 \Delta_5 \quad (3)$$

where:

$$\Delta_5 \equiv \Delta v_n \Delta(-\cos\xi) \Delta\eta \Delta(-\cos\chi) \Delta\beta \quad (4)$$

The continuous functions f'_e, f'_n are identical with the functions f_e, f_n respectively. In the present term f'_e, f'_n are evaluated at the values $\vec{v}'_e, \vec{v}'_n$ which correspond to the discrete set of values of the five collision integral variables and to a fixed value of $\vec{v}_e$, namely $\vec{v}_e^*$, which varies only from one Boltzmann equation to another.

If one assumes a two dimensional grid $\vec{v}_{e,kj} (v_{ek}, \theta_{ej})$ for $\vec{v}_e$, the numerical evaluation of the elastic collision integral may be expressed as follows:

$$\begin{aligned}
 \left(\frac{\partial f_e}{\partial t} \right)^{\text{el coll}} &= \sum_{\vec{v}_n, \chi, \beta} (f_e' f_n' - f_e f_n) g \sigma v_n^2 \Delta_5 = \\
 &= \sum_{kj} \sum_{v_n, \xi, \eta, \chi, \beta}^{\substack{v_{ek} < v_e' < v_{ek} + \Delta v_{ek} \\ \theta_{ej} < \theta_e' < \theta_{ej} + \Delta \theta_{ej}}} (f_e' f_n' - f_e f_n) g \sigma v_n^2 \Delta_5 = \\
 &= \sum_{kj} f_{e, kj} \sum_{\vec{v}_n, \chi, \beta}^{kj=et} \frac{f_e'}{f_{e, kj}} f_n' g \sigma v_n^2 \Delta_5 - \\
 &- \sum_{\vec{v}_n, \chi, \beta} f_e f_n g \sigma v_n^2 \Delta_5 = \\
 &= \sum_{kj} f_{e, kj} M_{kj}(\vec{v}') P_{kj}(\vec{v}', f_n') - f_e(\vec{v}_e^*) G(\vec{v}_e^*, f_n) \quad (5)
 \end{aligned}$$

where:

$f_{e,kj} \rightarrow$ the discrete set of values of $f_e(\vec{v}_e)$ at the
 kj locations of the grid $\vec{v}_{e,kj}$
 $\vec{v}_e^*$ $\rightarrow$ specific value of the $\vec{v}_{e,kj}$ set
 $\vec{v}'$ $\rightarrow$ stands for $\vec{v}'_e, \vec{v}'_n$
 $\vec{v}_n \equiv \vec{v}_n(\vec{v}_n, \xi, \eta)$

$$P_{kj} \vec{v}', f'_n \equiv \frac{1}{M_{kj}} \sum_{\vec{v}_n, \chi, \beta}^{kj=ct} \frac{f'_e}{f_{e,kj}} f'_n g \sigma v_n^2 \Delta_5 \approx$$

$$\approx \frac{1}{M_{kj}} \sum_{\vec{v}_n, \chi, \beta}^{kj=ct} f'_n g \sigma v_n^2 \Delta_5 \quad (6)$$

$$\left(\lim_{f_{e,kj}} \frac{f'_e}{f_{e,kj}} = 1 \text{ at small } kj \text{ grid steps} \right)$$

$M_{kj}(\vec{v}')$ $\sim$ kj multiplicity factor or number of f'_e
 values in the kj cell when v_n, χ, β vary.

$f_e(\vec{v}_e^*) \rightarrow$ identic with one of the $f_{e,kj}$ values

$$G(v_e^*, f_n) \equiv \sum_{\vec{v}_n, \chi, \beta} f_n g \sigma v_n^2 \Delta_5 \quad (7)$$

Expression (5) substitutes the elastic collision integral
 with a linear combination of a discrete set of values $f_{e,kj}$ of

the electron distribution function. Each term of the sum represents the rate of electrons scattered from values around $\vec{v}_{e,kj}$ (within kj cell) to $\vec{v}_e^*$, and the last term represents the rate of electrons scattered from $\vec{v}_e^*$ to any $\vec{v}_e$.

The inelastic collision term has a similar structure with the elastic collision term if each group of particles undergoing a specific bound-bound transition, is considered a different species.

If the quantum states before collision are labeled by the indexes (s,r) , and the ones after collision by the labels (q,l) , and if the states are nondegenerate such that detailed balance equilibrium holds:

$$g_{q\ell} I_{q\ell}^{\Delta r} d\vec{v}_q d\vec{v}_\ell = g_{\Delta r} I_{\Delta r}^{g\ell} d\vec{v}_\Delta d\vec{v}_r$$

then the inelastic collision term is:

$$\left(\frac{\partial f_s}{\partial t} \right)^{\text{in coll}} = \sum_{r,q,\ell} \int (f'_q f'_{\ell} - f_s f_r) g_{\Delta r} I_{\Delta r}^{g\ell} d\vec{v}_r d\vec{\Omega}$$

or, for electrons colliding with neutrals:

$$\begin{aligned} \left(\frac{\partial f_e}{\partial t} \right)^{\text{in coll}} &= \sum_{r,\ell} \int (f'_e f'_{n,\ell} - f_e f_{n,r}) g I_r^\ell d\vec{v}_{n,r} d\vec{\Omega} = \\ &= \sum_{r,\ell} \sum_{k,j} f_{e,kj} M_{kj,r\ell}(\vec{v}') P_{kj,r\ell}(\vec{v}', f'_{n,e}) - \\ &- f_e(\vec{v}_e^*) G_r(\vec{v}_e^*, f_{nr}) \end{aligned}$$

where:

$$P_{kj,rl} \vec{v}', f'_{n,l} \equiv \frac{1}{M_{kj,rl}} \sum_{\vec{v}_n, \chi, \beta}^{kj=ct} \frac{f'_e}{f_{e,kj}} f'_{n,l} g_{\sigma v_n}^2 \Delta_5 \approx$$

$$\approx \frac{1}{M_{kj,rl}} \sum_{\vec{v}_n, \chi, \beta}^{kj=ct} f'_{n,l} g_{\sigma v_n}^2 \Delta_5$$

$$G_r \left(\vec{v}_e^*, f_{nr} \right) \equiv \sum_{\vec{v}_n, \chi, \beta} f_{nr} g_{\sigma v_n}^2 \Delta_5$$

$$\vec{v}_e' = \vec{v}_e' \left(\vec{v}_n', , , \vec{v}_e^*, \epsilon_{rl} \right)$$

The inelastic collision integral differs from the elastic collision integral through the functions $\vec{v}_e'$ which now depend also on the excitation energies of the $r \rightarrow l$ bound-bound transitions, one transition in each term of the rl sum.

The Coulomb interaction term or the Fokker-Planck term represents the phase space particle (electrons) density time rate of change due to multiple long range interaction and is expressed as a truncated series expansion of the distribution function for small angular deflections averaged over the distribution function of a second ionized species:

$$\left(\frac{\partial f_e}{\partial t} \right)^{Coul} \equiv - \sum_{\xi} \frac{\partial}{\partial v_{e\xi}} (\dot{\gamma}_{\xi} f_e) + \sum_{\xi\eta} \frac{1}{2} \frac{\partial^2 \gamma_{\xi\eta} f_e}{\partial v_{e\xi} \partial v_{e\eta}} \quad (14)$$

where the two terms are called the dynamical friction and the diffusion or dispersion respectively. The indexes ξ, η stand for cartesian coordinates and the γ 's have the following significance:

$$\gamma_{\xi} \equiv \sum_i \iint \Delta v_{e\xi} g b d b d \beta f_i d \vec{v}_i \quad (15)$$

$$\gamma_{\xi\eta} \equiv \sum_i \iint \Delta v_{e\xi} \Delta v_{e\eta} g b d b d \beta f_i d \vec{v}_i \quad (16)$$

The Coulomb term (14) conserves particles, momentum, and energy.

Expressions (B1) or B8) of Appendix B represent the Coulomb term in cartesian or polar coordinates respectively, subsequent to the integration over scattering angles, and expression (B17) represents the Coulomb term for a maxwellian distribution of the ions.

The electric field term for electrons is:

$$\left(\frac{\partial f_e}{\partial t} \right)^E \equiv - \frac{q_e \vec{E}}{m_e} \text{grad}_{\vec{v}_e} f_e = \frac{e \vec{E}}{m_e} \text{grad}_{\vec{v}_e} f_e \quad (17)$$

when written for the right side of Boltzmann Equation (1). The effect of the field is to alter the component of the velocity which is along the electric field. For a planar symmetric system the electric term in cartesian or polar coordinates respectively

in the velocity space is:

$$\left(\frac{\partial f_e}{\partial t}\right)^E = \frac{eE_z}{m_e} \frac{\partial f_e}{\partial v_z} = \frac{eE_z}{m_e} \left(\cos \theta_e \frac{\partial f_e}{\partial v_e} - \frac{\sin \theta_e}{v_e} \frac{\partial f_e}{\partial \theta_e} \right)$$

and the effect of the field is to shift the distribution function along the v_z direction or normal to the hyperbolas $v_e \cos \theta_e = \text{constant}$ in the velocity space.

RESULTS

The results presented on Figures 1-11 represent the effect of various physical processes on a standard local electron distribution function presented on Figure 1, which is Maxwellian in speed and slightly anisotropic ($j \sim 12 \text{ A/cm}^2$) in polar angle.

The v_e , θ_e variables of the electron velocity are represented in the base plans of the perspectives (right side of the figures) and the parameter indicated by the title is represented by the height. The zero values of the functions are revealed by the tables of numbers which follow the figures, in which the electron speed v_e varies along lines and the polar angle θ_e of the electron velocity with the direction perpendicular to the electrodes varies along columns.

The left side of the figures represent the contour maps (projection on the base plane of the constant function values curves) of the corresponding functions.

Figure 2 represents the elastic collision integral, therefore the time rate of change of the distribution function due to electron - (neutral cesium) short range interaction. It shows a decrease at larger f_e and an increase at smaller f_e , at small speeds, thus a randomization effect of electron motion directions.

Figure 3 describes the time rate of change of f_e due to one excitational transition of the neutral cesium atom. A larger relative variation of f_e is obtained at the speed for which the inelastic cross section has a maximum as shown on Figure 3 . The electron distribution function for inelastic collisions is

defined for a larger range of v_e values and is represented on Figure 1 (bottom).

Figures 4 and 5 describe the effect of the electron-ion and electron-electron interactions respectively. The rate of change of f_e is larger at smaller speeds and the electron-electron interactions have a larger contribution than the electron-ion.

Figure 6 shows the perturbing effect of the electric field on the electron angular distribution. The retarding (decelerating) electric field depletes velocity space regions of small speed and forward (emitter $\rightarrow$ collector) directed electrons and feeds regions with backward directed electrons. Two maxima are formed close to $\theta_e = \pi/2$.

Figures 7-9 reproduce the elastic, coulomb (electron-electron) and electric field terms relative to a common arbitrary reference, for a quick evidence of the significant contributions, which are produced in this example by an electric field of intensity $E_z = + 15$ V/cm.

Figure 11 represents the spatial derivative of the electron distribution which would insure a steady state. As observed (from number better than from figures) the large value of $\partial f_e / \partial z$ at small speeds leads to the conclusion that the reference distribution function does not represent a steady state solution for the conditions assumed in present calculations.

The effect of the physical processes considered may be summarized as follows:

While the elastic collisions tend to isotropize the electron distribution, the electric field changes an anisotropic distribution

into another not necessarily more isotropic. This result is due to the fact that the elastic collisions act more on electron directions, but the electric field acts on electron speed for electrons moving along the field lines and on electron directions for electrons moving perpendicular to the field lines.

The inelastic collisions produce resonant rate of change at the speeds at which the cross sections have maxima and have simultaneously some randomization effect.

Finally the coulomb interactions thermalize the electrons, more rapidly the small speed ones.

Concerning the thermionic diode performance the above observations are equivalent to the statement: the elastic collisions produce a loss in electron current; the inelastic collisions produce a small loss in electron current and a loss in electron energy converted into cesium excitational energy and subsequently into radiative energy which is partly if not totally (depending on the optical transparency of the plasma and electrode and wall reflectivity) lost; the coulomb interactions enhance or decrease the electron energy loss depending on the state of departure from maxwellian of the electron distribution, therefore on the repopulation rate of those speed regions at which excitational collisions are most probable; finally, the electric field may increase or decrease the electric current according to its direction and intensity.

The results presented above, completed with the entire spectrum of the excitational collisions, with the ionization-recombination collisions and charge exchange collisions, are used for an interelectrode spatial solution.

APPENDIX A

Binary Collisions

The binary collision between two particles represented on Figures (0a)-(0c) is described by the momentum (A25) and energy conservation equation (A40) and by their consequences (A26) - (A39) and (A41) - (A66).

Equations (A25) and (A40) solve four of the six components of the particle velocities $\vec{v}'_1$ and $\vec{v}'_2$ after collision as function of the velocities $\vec{v}_1$ and $\vec{v}_2$ before collision and of particle masses. The two arbitrary parameters are chosen to be the angle χ between the relative velocities $\vec{g}$ and $\vec{g}'$ before and after collision, and the angle β which measures the right hand rotation of $\vec{g}'$ around $\vec{g}$ with respect to the collisional plane $(\vec{v}_1, \vec{v}_2)$.

Following consequences of equations (A25) and (A40) are used for expressing the solution $\vec{v}'_1, \vec{v}'_2$.

The center of mass velocity remains unchanged during a collision, elastic or inelastic (A26).

The two colliding particles have equal momenta with respect to the center of mass (A27).

They also have equal momenta after collision, with respect to the center of mass (A28), though different to the one before collision (A27).

If the collision is elastic the relative velocity $\vec{g}'$ and the momentum of a particle with respect to the center of mass P_{ci} vary in direction but not in magnitude (A27), (A28) and (A41) - (A43).

The particle velocities after collision are expressed by the relations (A34) and (A35).

The inverse collision leading to (A39) is described by similar equations (A34), (A35), with the substitutions (A36) - (A38).

For a set of polar variables v_1 , θ_1 , ϕ_1 of $\vec{v}_1$ with respect to the polar axis $\vec{z}$ and a set of polar variables v_2 , ξ , η for $\vec{v}_2$ with respect to a polar axis along $\vec{v}_2$, the velocities after collision are expressed by (A34), (A35) with the substitutions (A53), (A54) and (A56).

The polar variables after collision with respect to the polar axis z are expressed in (A59) - (A66).

BINARY COLLISION RELATIONS

$$\vec{p}_i \equiv m_i \vec{v}_i \quad (i = 1, 2) \quad (A1)$$

$$\vec{p}'_i \equiv m_i \vec{v}'_i \quad (A2)$$

$$\vec{v}_c \equiv \frac{1}{m_1 + m_2} (\vec{p}_1 + \vec{p}_2) \quad (A3)$$

$$\vec{v}'_c \equiv \frac{1}{m_1 + m_2} (\vec{p}'_1 + \vec{p}'_2) \quad (A4)$$

$$\vec{v}_{ci} \equiv \vec{v}_i - \vec{v}_c \quad (A5)$$

$$\vec{v}'_{ci} \equiv \vec{v}'_i - \vec{v}'_c \quad (A6)$$

$$\vec{g} \equiv \vec{v}_1 - \vec{v}_2 \quad (A7)$$

$$\vec{g}' \equiv \vec{v}'_1 - \vec{v}'_2 \quad (A8)$$

$$\vec{g}_\perp \equiv g \hat{i}_\perp \quad (A9)$$

$$\hat{i}_\perp \times \hat{i}_g \parallel \hat{i}_{g'} \times \hat{i}_g \quad (\hat{i}_\perp \text{ contained in plane } (\vec{g}, \vec{g}')) \quad (A10)$$

$$\chi \equiv (\vec{g}, \vec{g}') \quad (A11)$$

$$\beta \equiv [(\vec{v}_1, \vec{g}), (\vec{g}, \vec{g}')] \equiv [(\vec{v}_1, \vec{g}), \hat{i}_\perp] \quad (A12)$$

$$\beta' \equiv [(\vec{v}'_1, \vec{g}'), (\vec{g}', \vec{g}'')] \equiv [(\vec{v}'_1, \vec{g}'), \hat{i}'_\perp] \quad (A13)$$

$$\eta \equiv [(\vec{v}_1, \vec{z}), (\vec{v}_1, \vec{v}_2)] \quad (A14)$$

$$\eta' \equiv [(\vec{v}'_1, \vec{z}), (\vec{v}'_1, \vec{v}'_2)] \quad (A15)$$

$$\xi \equiv [(\vec{g}, \vec{z}), (\vec{g}, \vec{g}')] \quad (A16)$$

$$\xi \equiv (\vec{v}_1, \vec{v}_2) \quad (A17)$$

$$\xi_i \equiv (\vec{v}_c, \vec{v}_i) \quad (A18)$$

$$\gamma_i \equiv (\vec{g} , \vec{v}_i) \quad (A19)$$

$$\alpha \equiv (\vec{g} , \vec{v}_c) \quad (A20)$$

$$\alpha' \equiv (\vec{g}' , \vec{v}_c) \quad (A21)$$

$$\delta \equiv [(\vec{v}_1 , \vec{v}_2) , (\vec{v}'_1 , \vec{v}'_2)] \quad (A22)$$

$$\epsilon_i \equiv (\epsilon'_{int,i} - \epsilon_{int,i}) \quad (A23)$$

$$\epsilon \equiv \epsilon_1 + \epsilon_2 \quad (A24)$$

$$\vec{p}_1 + \vec{p}_2 = \vec{p}'_1 + \vec{p}'_2 \quad (A25)$$

$$\vec{v}_c = \vec{v}'_c \quad (A26)$$

$$\vec{p}_{c1} = - \vec{p}_{c2} = \mu \vec{g} \quad (A27)$$

$$\vec{p}'_{c1} = - \vec{p}'_{c2} = \mu \vec{g}' \quad (A28)$$

$$\vec{p}_i = m_i \vec{v}_c + \vec{p}_{ci} \quad (A29)$$

$$\vec{p}'_i = m_i \vec{v}_c + \vec{p}'_{ci} \quad (A30)$$

$$\vec{p}'_1 = \frac{\mu}{m_2} (\vec{p}_1 + \vec{p}_2) + \mu \vec{g}' \quad (A31)$$

$$\vec{p}'_2 = \frac{\mu}{m_1} (\vec{p}_1 + \vec{p}_2) - \mu \vec{g}' \quad (A32)$$

$$\vec{g}' = \frac{g'}{g} (\cos \chi \vec{g} + \sin \chi \vec{g}_\perp) \quad (A33)$$

$$\vec{v}'_1 = (M_1 + M_2 \sqrt{1+R} \cos \chi) \vec{v}_1 + M_2 (1 - \sqrt{1+R} \cos \chi) \vec{v}_2 + M_2 \sqrt{1+R} \sin \chi \vec{g}_\perp \quad (A34)$$

$$\vec{v}'_2 = M_1(1-\sqrt{1+R} \cos \chi) \vec{v}_1 + (M_2+M_1\sqrt{1+R} \cos \chi) \vec{v}_2 - M_1\sqrt{1+R} \sin \chi \vec{g}_\perp \quad (\text{A35})$$

$$\vec{g}'_\perp = \sin \chi \vec{g} - \cos \chi \vec{g}_\perp \quad (\text{for inverse collision}) \quad (\text{A36})$$

$$\chi' = \chi \quad (\text{for inverse collision}) \quad (\text{A37})$$

$$R' = -R \quad (\text{for inverse collision}) \quad (\text{A38})$$

$$\vec{v}''_i = \vec{v}_i \quad (\text{for inverse collision}) \quad (\text{A39})$$

$$\frac{1}{2m_1} p_1^2 + \frac{1}{2m_2} p_2^2 = \frac{1}{2m_1} p_1'^2 + \frac{1}{2m_2} p_2'^2 + \epsilon \quad (\text{A40})$$

$$\frac{\mu}{2} g^2 = \frac{\mu}{2} g'^2 + \epsilon \quad (\text{A41})$$

$$|\vec{g}| = |\vec{g}'| \quad \text{if} \quad \epsilon = 0 \quad (\text{A42})$$

$$|p_{ci}| = |p_{ci}'| \quad \text{if} \quad \epsilon = 0 \quad (\text{A43})$$

$$\cos \xi_1 = \frac{1}{2v_1 v_c} \left(v_1^2 + v_c^2 - \frac{\mu^2}{m_1^2} g^2 \right) \quad (\text{A44})$$

$$\cos \gamma_1 = \frac{m_1}{2\mu g v_1} \left(v_1^2 + \frac{\mu^2}{m_1^2} g^2 - v_c^2 \right) \quad (\text{A45})$$

$$\cos \alpha = \frac{m_1}{2\mu g v_c} \left(v_1^2 - \frac{\mu^2}{m_1^2} g^2 - v_c^2 \right) \quad (\text{A46})$$

$$\cos \alpha' = (\cos^2 \alpha \cos^2 \chi + \sin^2 \alpha \sin^2 \chi \cos^2 \zeta + \frac{1}{2} \sin 2\alpha \sin 2\chi \cos \zeta) \quad (\text{A47})$$

$$\text{tg } \delta = \frac{\sin \zeta}{\sin \alpha \text{ ctg } \chi - \cos \alpha \cos \zeta} \quad (\text{A48})$$

$$v_c^2 = \frac{\mu^2}{m_2^2} v_1^2 + \frac{\mu^2}{m_1^2} v_2^2 + \frac{2\mu}{m_1+m_2} v_1 v_2 \cos \xi \quad (\text{A49})$$

$$g^2 = v_1^2 + v_2^2 - 2v_1v_2 \cos \xi = \quad (A50)$$

$$= v_1^2 + v_2^2 - 2v_1v_2 [\cos\theta_1 \cos\theta_2 + \sin\theta_1 \sin\theta_2 \cos(\phi_1 - \phi_2)]$$

$$g'^2 = v_1^2 + v_2^2 - 2v_1v_2 \cos\xi - \frac{2}{\mu} \epsilon \quad (A51)$$

$$\begin{aligned} \cos(\beta - \zeta) &= \cos\gamma_1 \cos\theta_g \sin\eta \sin(\phi_g - \phi_e) + \\ &+ \cos\theta_g \cos(\phi_g - \phi_e) (\cos\gamma_1 \cos\theta_e \cos\eta - \sin\gamma_1 \sin\theta_e) + \\ &+ \sin\theta_g (\sin\gamma_1 \cos\theta_e + \cos\gamma_1 \sin\theta_e \cos\eta) \end{aligned} \quad (A52)$$

$$\vec{v}_1 = \begin{pmatrix} v_1 \sin\theta_1 \cos\phi_1 \\ v_1 \sin\theta_1 \sin\phi_1 \\ v_1 \cos\theta_1 \end{pmatrix} \quad (A53)$$

$$\begin{aligned} &- v_2 \sin\xi \cos\eta \cos\theta_1 \cos\phi_1 + v_2 \cos\xi \sin\theta_1 \cos\phi_1 + \\ &\quad + v_2 \sin\xi \sin\eta \sin\phi_1 \\ \vec{v}_2 &= \begin{pmatrix} - v_2 \sin\xi \cos\eta \cos\theta_1 \sin\phi_1 + v_2 \cos\xi \sin\theta_1 \sin\phi_1 - \\ - v_2 \sin\xi \sin\eta \cos\phi_1 \\ v_2 \sin\xi \cos\eta \sin\theta_1 + v_2 \cos\xi \cos\theta_1 \end{pmatrix} \end{aligned} \quad (A54)$$

$$\vec{g} = \begin{pmatrix} v_{1x} - v_{2x} \\ v_{1y} - v_{2y} \\ v_{1z} - v_{2z} \end{pmatrix} \quad (A55)$$

$$\begin{aligned}
 \vec{g}_1 = & \left(\begin{aligned}
 & g \sin\beta \cos\eta \sin\phi_1 + (v_1 - v_2 \cos\xi) \cos\beta \sin\eta \sin\phi_1 + \\
 & + v_2 \sin\xi \cos\beta \sin\theta_1 \cos\phi_1 + g \sin\beta \sin\eta \cos\theta_1 \cos\phi_1 - \\
 & - (v_1 - v_2 \cos\xi) \cos\beta \cos\eta \cos\theta_1 \cos\phi_1 \\
 & - g \sin\beta \cos\eta \cos\phi_1 - (v_1 - v_2 \cos\xi) \cos\beta \sin\eta \cos\phi_1 + \\
 & + v_2 \sin\xi \cos\beta \sin\theta_1 \sin\phi_1 + g \sin\beta \sin\eta \cos\theta_1 \sin\phi_1 - \\
 & - (v_1 - v_2 \cos\xi) \cos\beta \cos\eta \cos\theta_1 \sin\phi_1 \\
 & v_2 \sin\xi \cos\beta \cos\theta_1 - g \sin\beta \sin\eta \sin\theta_1 + \\
 & + (v_1 - v_2 \cos\xi) \cos\beta \cos\eta \sin\theta_1
 \end{aligned} \right) \quad (A56)
 \end{aligned}$$

$$p_1'^2 = \left(\frac{\mu}{m_2} \right)^2 (\vec{p}_1 + \vec{p}_2)^2 + \mu^2 g'^2 + \frac{2\mu^2}{m_2} (\vec{p}_1 + \vec{p}_2) \cdot \vec{g}' \quad (A57)$$

$$p_2'^2 = \left(\frac{\mu}{m_1} \right)^2 (\vec{p}_1 + \vec{p}_2)^2 + \mu^2 g'^2 + \frac{2\mu^2}{m_1} (\vec{p}_1 + \vec{p}_2) \cdot \vec{g}' \quad (A58)$$

$$\begin{aligned}
 v_1'^2 = & (1 + M_2^2 R + 2M_1 M_2 (\sqrt{1+R} \cos\chi - 1)) v_1^2 + \\
 & M_2^2 [R - 2 (\sqrt{1+R} \cos\chi - 1)] v_2^2 + \\
 & + 2M_2 [(M_2 - M_1) (\sqrt{1+R} \cos\chi - 1) - M_2 R] v_1 v_2 \cos\xi + \\
 & + 2M_2 \sqrt{1+R} \sin\chi v_1 v_2 \sin\xi \cos\beta \quad (A59)
 \end{aligned}$$

where

$$M_1 \equiv \frac{m_1}{m_1+m_2} \quad , \quad M_2 \equiv \frac{m_2}{m_1+m_2} \quad (A60)$$

$$R \equiv \frac{-2\varepsilon}{\mu g^2} \quad (A61)$$

$$\begin{aligned} \cos\theta_1' &= \frac{1}{v_1'} (M_1+M_2 \sqrt{1+R} \cos\chi) v_1 \cos\theta_1 + \\ &+ M_2 (1 - \sqrt{1+R} \cos\chi) v_2 (\sin\xi \cos\eta \sin\theta_1 + \cos\xi \cos\theta_1) + \\ &+ M_2 \sqrt{1+R} \sin\chi (v_2 \sin\xi \cos\beta \cos\theta_1 - g \sin\beta \sin\eta \sin\theta_1 + \\ &+ (v_1 - v_2 \cos\xi) \cos\beta \cos\eta \sin\theta_1) \end{aligned} \quad (A62)$$

$$t_g \phi_1' = \frac{v_1' l_y}{v_1' l_x} \quad (A63)$$

$$v_2'^2 = \frac{m_1}{m_2} (v_1^2 - v_1'^2) + v_2^2 - \frac{2\varepsilon}{m_2} \quad (A64)$$

$$m_1 v_1 \cos\theta_1 + m_2 v_2 \cos\theta_2 = m_1 v_1' \cos\theta_1' + m_2 v_2' \cos\theta_2' \quad (A65)$$

$$t_g \phi_2' = \frac{v_2' l_y}{v_2' l_x} \quad (A66)$$

APPENDIX B
Coulomb interactions

The time rate of change of a specified velocity number of electrons due to electron-ion Coulomb collisions is expressed by the truncated expansion (B1), completed with the expressions (B2)-(B4).

If the ion velocity distribution function is isotropic, the functions h_{ei} and p_{ei} are functions of the electron speed [equations (B5) and (B6)], and if the electron distribution function is axially symmetric in the velocity space [equation (B7)], the Coulomb term has the expression (B8).

For a maxwellian ion velocity distribution equation [(B9)] the functions h_{ei} and p_{ei} are expressed in (B12) and (B13) respectively, where the "erf" is defined in (B14). For this specific case the two terms in the cartesian coordinates expansion of relation (B1) are expressed in relations (B15) and their sum in (B17).

COULOMB INTERACTION RELATIONS

$$\begin{aligned} \left(\frac{\partial f_e}{\partial t} \right)^{\text{Coul}} &= \Gamma_{ei} \left[- \sum_{\xi} \frac{\partial}{\partial \mathbf{v}_{e\xi}} \left(f_e \frac{\partial h_{ei}}{\partial \mathbf{v}_{e\xi}} \right) + \frac{1}{2} \sum_{\xi, \eta} \frac{\partial^2}{\partial \mathbf{v}_{e\xi} \partial \mathbf{v}_{e\eta}} \left(f_e \frac{\partial^2 p_{ei}}{\partial \mathbf{v}_{e\xi} \partial \mathbf{v}_{e\eta}} \right) \right] \\ &\equiv \Gamma_{ei} \{ -\nabla \cdot (f_e \nabla h_{ei}) + \frac{1}{2} f_e \nabla^2 (\nabla^2 p_{ei}) + \\ &\quad + \frac{1}{2} \nabla f_e \cdot \nabla (\nabla^2 p_{ei}) + \frac{1}{2} \nabla \cdot [(\nabla f_e \cdot \nabla) (\nabla p_{ei})] \} \end{aligned} \quad (\text{B1})$$

$$\Gamma_{ei} \equiv \frac{\mu_{ei}^2 e^4 z_i^2}{m_e^4 4\pi K_o^2} \ln \Delta \quad (\text{B2})$$

$$h_{ei} \equiv \left(\frac{m_e}{\mu} \right)^2 \int \frac{f_i}{|\vec{v}_e - \vec{v}_i|} d\vec{v}_i \equiv \int \frac{f_i}{g} d\vec{v}_i \quad (\text{B3})$$

$$p_{ei} \equiv \int f_i (|\vec{v}_e - \vec{v}_i|) d\vec{v}_i \equiv \int f_i g d\vec{v}_i \quad (\text{B4})$$

$$f_i \equiv f_i(v_i) \begin{cases} \nearrow h_{ei} \equiv h_{ei}(v_e) \equiv h(v) \\ \searrow p_{ei} \equiv p_{ei}(v_e) \equiv p(v) \end{cases} \quad (\text{B5})$$

$$p_{ei} \equiv p_{ei}(v_e) \equiv p(v) \quad (\text{B6})$$

$$f_e \equiv f_e(v_e, \theta) \equiv f(v, \theta) \quad (\text{B7})$$

$$\begin{aligned}
 \left(\frac{\partial f_e}{\partial t} \right)^{\text{Coul}} = & -\Gamma_{ei} \frac{1}{v^2} \frac{\partial}{\partial v} (v^2 f \frac{\partial h}{\partial v}) + \frac{1}{2} \Gamma_{ei} f \left(\frac{\partial^4 p}{\partial v^4} + \frac{4}{v} \frac{\partial^3 p}{\partial v^3} \right) + \\
 & + \frac{1}{2} \Gamma_{ei} \frac{\partial f}{\partial v} \frac{\partial^3 p}{\partial v^3} + \frac{2}{v} \frac{\partial^2 p}{\partial v^2} - \frac{2}{v^2} \frac{\partial p}{\partial v} + \\
 & + \frac{1}{2} \Gamma_{ei} \left(\frac{\partial^2 f}{\partial v^2} \frac{\partial^2 p}{\partial v^2} + \frac{\partial f}{\partial v} \frac{\partial^3 p}{\partial v^3} + \frac{2}{v} \frac{\partial f}{\partial v} \frac{\partial^2 p}{\partial v^2} \right)
 \end{aligned} \tag{B8}$$

$$f_i \equiv n_i \left(\frac{m_i}{2\pi kT_i} \right)^{3/2} \exp \left(- \frac{m_i v_i^2}{2kT_i} \right) \equiv \frac{1}{2\pi} \alpha \beta^3 e^{-\beta^2 v_i^2} \tag{B9}$$

$$\alpha \equiv \frac{2n_i}{\sqrt{\pi}} \tag{B10}$$

$$\beta \equiv \sqrt{\frac{m_i}{2kT_i}} \tag{B11}$$

$$h_{ei} \equiv \left(\frac{m_e}{\mu_{ei}} \right)^2 \frac{\alpha}{v_e} \frac{\sqrt{\pi}}{2} \text{erf}(\beta v_e) \quad (\text{for B9}) \tag{B12}$$

$$p_{ei} \equiv \frac{\alpha}{2\beta} [e^{-\beta^2 v_e^2} + \left(\frac{1}{\beta v_e} + 2\beta v_e \right) \frac{\sqrt{\pi}}{2} \text{erf}(\beta v_e)] \quad (\text{for B9}) \tag{B13}$$

$$\text{erf}(x) \equiv \frac{2}{\sqrt{\pi}} \int_0^x e^{-x'^2} dx' \tag{B14}$$

$$\begin{aligned}
 \left(\frac{\partial f_e}{\partial t} \right)_I^{\text{Coul}} = & \Gamma_{ei} \left\{ f 2 \left(\frac{m_e}{\mu_{ei}} \right)^2 \alpha \beta^3 e^{-\beta^2 v^2} - \right. \\
 & \left. - \frac{\partial f}{\partial v} \left(\frac{m_e}{\mu_{ei}} \right)^2 \frac{\alpha \beta}{v} [e^{-\beta^2 v^2} - \frac{\sqrt{\pi}}{2\beta v} \text{erf}(\beta v)] \right\}
 \end{aligned} \tag{B15}$$

$$\begin{aligned}
 \left(\frac{\partial f_e}{\partial t} \right)_{II}^{\text{Coul}} = & \Gamma_{ei} \{ -f 2\alpha\beta^3 e^{-\beta^2 v^2} + \frac{\partial f}{\partial v} \frac{\alpha\beta}{v} [e^{-\beta^2 v^2} - \frac{\sqrt{\pi}}{2\beta v} \text{erf}(\beta v)] + \\
 & + \frac{\partial f}{\partial v} \frac{1}{2} \frac{\alpha}{\beta v^3} [(1+2\beta^2 v^2) e^{-\beta^2 v^2} - \frac{\sqrt{\pi}}{2\beta v} \text{erf}(\beta v)] + \\
 & + \frac{\partial^2 f}{\partial v^2} \frac{1}{2} \frac{\alpha}{\beta v^2} [-e^{-\beta^2 v^2} + \frac{\sqrt{\pi}}{2\beta v} \text{erf}(\beta v)] \} \quad (B16)
 \end{aligned}$$

$$\begin{aligned}
 \left(\frac{\partial f_e}{\partial t} \right)^{\text{Coul}} = & \Gamma_{ei} \left\{ \frac{m_e}{m_i} \left(2 + \frac{m_e}{m_i} \right) f 2\alpha\beta^3 e^{-\beta^2 v^2} + \right. \\
 & + \frac{\partial f}{\partial v} \frac{\alpha\beta}{v} \left[1 + \frac{1}{2\beta^2 v^2} - \frac{m_e}{m_i} \left(2 + \frac{m_e}{m_i} \right) \right] e^{-\beta^2 v^2} - \\
 & - \frac{\partial f}{\partial v} \frac{\alpha}{v^2} \frac{\sqrt{\pi}}{2} \left[\frac{1}{2\beta^2 v^2} - \frac{m_e}{m_i} \left(2 + \frac{m_e}{m_i} \right) \right] \text{erf}(\beta v) + \\
 & \left. - \frac{\partial^2 f}{\partial v^2} \frac{1}{2} \frac{\alpha}{\beta v^2} [e^{-\beta^2 v^2} - \frac{\sqrt{\pi}}{2\beta v} \text{erf}(\beta v)] \right\} \quad (B17)
 \end{aligned}$$

FIGURE 0a

FIGURE 0b

FIGURE 0c

FE DISTRIBUTION - UNSCALED

FE DISTRIBUTION - UNSCALED

ELECTRON DISTRIBUTION FUNCTION

ELECTRON DISTRIBUTION FUNCTION

FIGURE 1

COLLISION INTEGRAL - UNSCALED

COLLISION INTEGRAL - UNSCALED

$$\left(\frac{\partial f_e}{\partial t} \right)^{el \text{ coll}}$$

COLLISION INTEGRAL - UNSCALED

COLLISION INTEGRAL - UNSCALED

$$\left(\frac{1}{f_e} \frac{\partial f_e}{\partial t} \right)^{el \text{ coll}}$$

FIGURE 2

INELASTIC COLLISION INTEGRAL

INELASTIC COLLISION INTEGRAL

$$\left(\frac{\partial f_e}{\partial t} \right)^{\text{in coll}}$$

RELATIVE INELASTIC COLLISION INTEGRAL

RELATIVE INELASTIC COLLISION INTEGRAL

$$\frac{1}{f_e} \left(\frac{\partial f_e}{\partial t} \right)^{\text{in coll}}$$

FIGURE 3

E-I COULOMB - UNSCALED

E-I COULOMB - UNSCALED

$$\left(\frac{\partial f_e}{\partial t} \right)^{\text{Coul, e-i}}$$

E-I COULOMB - UNSCALED

E-I COULOMB - UNSCALED

$$\frac{1}{f_e} \left(\frac{\partial f_e}{\partial t} \right)^{\text{Coul, e-i}}$$

FIGURE 4

E-E COULOMB - UNSCALED

E-E COULOMB - UNSCALED

$$\left(\frac{\partial f_e}{\partial t}\right)^{\text{Coul, e-e}}$$

E-E COULOMB - UNSCALED

E-E COULOMB - UNSCALED

$$\frac{1}{f_e} \left(\frac{\partial f_e}{\partial t}\right)^{\text{Coul, e-e}}$$

FIGURE 5

ELECTRIC FIELD TERM - UNSCALED

ELECTRIC FIELD TERM - UNSCALED

ELECTRIC FIELD TERM - UNSCALED

ELECTRIC FIELD TERM - UNSCALED

FIGURE 6

COLLISION INTEGRAL - SCALED

COLLISION INTEGRAL - SCALED

$$\left(\frac{\partial f_e}{\partial t} \right)^{\text{el coll}}$$

COLLISION INTEGRAL - SCALED

COLLISION INTEGRAL - SCALED

$$\frac{1}{f_e} \left(\frac{\partial f_e}{\partial t} \right)^{\text{el coll}}$$

FIGURE 7

E-E COULOMB TERM - SCALED

E-E COULOMB TERM - SCALED

E-E COULOMB TERM - SCALED

$\left(\frac{\partial f_e}{\partial t} \right)^{\text{Coul, e-e}}$

E-E COULOMB TERM - SCALED

$\frac{1}{f_e} \left(\frac{\partial f_e}{\partial t} \right)^{\text{Coul, e-e}}$

FIGURE 8

ELECTRIC FIELD TERM - SCALED

ELECTRIC FIELD TERM - SCALED

$$\left(\frac{\partial f_e}{\partial t} \right)^E$$

ELECTRIC FIELD TERM - SCALED

ELECTRIC FIELD TERM - SCALED

$$\frac{1}{f_e} \left(\frac{\partial f_e}{\partial t} \right)^E$$

FIGURE 9

COUL + EFT + COLL - UNSCALED

COUL + EFT + COLL - UNSCALED

$$\left(\frac{\partial f_e}{\partial t}\right)^{el \text{ coll}+E+Cou}$$

COUL + EFT + COLL - UNSCALED

COUL + EFT + COLL - UNSCALED

$$\frac{1}{f_e} \left(\frac{\partial f_e}{\partial t}\right)^{el \text{ coll}+E+Cou}$$

FIGURE 10

DFDZ

DFDZ

$$\frac{\partial f_e}{\partial z}$$

DFDZ

DFDZ

$$\frac{1}{f_e} \frac{\partial f_e}{\partial z}$$

FIGURE 11

FIGURE 1 : f_e

```

$ INPUT
NN-          C.NC=      A.NCN=          G.NCG=          E.NB=          C.N'E=          18.NCTE=          18.XME=
0.9109100000000000-27.4FTH = 70000000.00000000 , TE= 1500.000000000000 , TH= 0.2206800000000000D-21, VHHH=
1000000.0000000000 , TH= 1000.000000000000 , HF= 99999999999.999 , P= 0.1000000000000000D 00. TRFS=
600.00000000000000 , OF= 0.4000000000000000D-09, ILL THZ= 0.9932799999999999D 03
, END

```

0.18010D-09	0.18730D-09	0.18770D-09	0.18110D-09	0.09410D-10	0.67700D-10	0.45840D-10	0.28010D-10	0.15950D-10	0.84650D-11
0.41000D-11	0.19310D-11	0.82000D-12	0.33230D-12	0.12410D-12	0.43170D-13	0.14400D-13	0.42320D-14		
0.19890D-09	0.10540D-09	0.16110D-09	0.17040D-09	0.98400D-10	0.69210D-10	0.49370D-10	0.27720D-10	0.15790D-10	0.83790D-11
0.41450D-11	0.19110D-11	0.82130D-12	0.37900D-12	0.12390D-12	0.42730D-13	0.13860D-13	0.41890D-14		
0.19640D-09	0.10350D-09	0.15940D-09	0.17190D-09	0.99340D-10	0.68500D-10	0.44910D-10	0.27440D-10	0.15620D-10	0.82930D-11
0.41050D-11	0.18320D-11	0.81790D-12	0.32500D-12	0.12100D-12	0.42290D-13	0.13720D-13	0.41460D-14		
0.19430D-09	0.10160D-09	0.15700D-09	0.12710D-09	0.96390D-10	0.67790D-10	0.44440D-10	0.27150D-10	0.15460D-10	0.82070D-11
0.40600D-11	0.18120D-11	0.80450D-12	0.32220D-12	0.12030D-12	0.41890D-13	0.13570D-13	0.41030D-14		
0.19390D-09	0.10130D-09	0.15610D-09	0.12640D-09	0.95300D-10	0.67080D-10	0.43700D-10	0.26810D-10	0.15300D-10	0.81210D-11
0.40100D-11	0.18520D-11	0.79610D-12	0.31890D-12	0.11900D-12	0.41420D-13	0.13450D-13	0.40600D-14		
0.19000D-09	0.17800D-09	0.15440D-09	0.12510D-09	0.94370D-10	0.66310D-10	0.43510D-10	0.26580D-10	0.15140D-10	0.80350D-11
0.79750D-11	0.10330D-11	0.78760D-12	0.71550D-12	0.11780D-12	0.40980D-13	0.13290D-13	0.40170D-14		
0.18810D-09	0.17540D-09	0.15300D-09	0.12270D-09	0.93360D-10	0.65600D-10	0.42050D-10	0.26300D-10	0.14980D-10	0.79490D-11
0.54350D-11	0.18130D-11	0.77940D-12	0.71210D-12	0.11650D-12	0.40540D-13	0.13150D-13	0.39740D-14		
0.18670D-09	0.17400D-09	0.15110D-09	0.12240D-09	0.92350D-10	0.64950D-10	0.42500D-10	0.26020D-10	0.14820D-10	0.78640D-11
0.32000D-11	0.17140D-11	0.77000D-12	0.70810D-12	0.11530D-12	0.40100D-13	0.13000D-13	0.39310D-14		
0.18460D-09	0.17110D-09	0.14950D-09	0.12100D-09	0.91340D-10	0.64240D-10	0.42110D-10	0.25730D-10	0.14650D-10	0.77780D-11
0.78880D-11	0.10710D-11	0.76710D-12	0.70500D-12	0.11300D-12	0.39660D-13	0.12860D-13	0.38880D-14		
0.18360D-09	0.17000D-09	0.14680D-09	0.11360D-09	0.90330D-10	0.63930D-10	0.41650D-10	0.25450D-10	0.14490D-10	0.76920D-11
0.32050D-11	0.17150D-11	0.76590D-12	0.70200D-12	0.11170D-12	0.39230D-13	0.12720D-13	0.38450D-14		
0.18000D-09	0.16870D-09	0.14470D-09	0.11240D-09	0.89330D-10	0.62720D-10	0.41180D-10	0.25160D-10	0.14330D-10	0.76060D-11
0.50660D-11	0.17350D-11	0.76450D-12	0.70060D-12	0.11150D-12	0.38790D-13	0.12600D-13	0.38020D-14		
0.17850D-09	0.16640D-09	0.14450D-09	0.11100D-09	0.88310D-10	0.62110D-10	0.40620D-10	0.24880D-10	0.14170D-10	0.75200D-11
0.50700D-11	0.17150D-11	0.76310D-12	0.69590D-12	0.11000D-12	0.38350D-13	0.12440D-13	0.37590D-14		
0.17650D-09	0.16450D-09	0.14390D-09	0.11510D-09	0.87300D-10	0.61400D-10	0.40150D-10	0.24590D-10	0.14010D-10	0.74340D-11
0.50670D-11	0.16900D-11	0.76170D-12	0.69190D-12	0.10900D-12	0.37910D-13	0.12290D-13	0.37160D-14		
0.17440D-09	0.16760D-09	0.14120D-09	0.11440D-09	0.86290D-10	0.60970D-10	0.39790D-10	0.24310D-10	0.13840D-1	

FIGURE 1 : f_e [illegible]

COLLISION INTELPAL - UNSOLVED

-0.2000D-01	-0.5003D-01	-0.8368D-01	-0.9430D-01	-0.9077D-01	-0.7726D-01	-0.5914D-01	-0.3847D-01	-0.2219D-01	-0.1148D-01
-0.5572D-02	-0.1436D-02	-0.1032D-02	-0.4003D-03	-0.1420D-03	-0.4899D-04	-0.1648D-04	-0.5474D-05		
-0.1835D-01	-0.5120D-01	-0.17304D-01	-0.8421D-01	-0.8009D-01	-0.6817D-01	-0.5218D-01	-0.3395D-01	-0.1958D-01	-0.1013D-01
-0.4916D-02	-0.1141D-02	-0.9109D-03	-0.3532D-03	-0.1253D-03	-0.4323D-04	-0.1454D-04	-0.4830D-05		
-0.1590D-01	-0.4437D-01	-0.6399D-01	-0.7311D-01	-0.6942D-01	-0.5908D-01	-0.4523D-01	-0.2942D-01	-0.1697D-01	-0.8775D-02

-0.4261D-07	-0.1855D-02	-0.7594D-03	-0.3061D-03	-0.1086D-03	-0.3746D-04	-0.1260D-04	-0.4186D-05		
-0.1346D-01	-0.3755D-01	-0.5415D-01	-0.6103D-01	-0.5074D-01	-0.4909D-01	-0.3826D-01	-0.2489D-01	-0.1436D-01	-0.7425D-02
-0.7695D-02	-0.1570D-02	-0.5679D-03	-0.2590D-03	-0.9189D-04	-0.3170D-04	-0.1066D-04	-0.3542D-05		
-0.1101D-01	-0.3072D-01	-0.4430D-01	-0.4093D-01	-0.4806D-01	-0.4040D-01	-0.3131D-01	-0.2037D-01	-0.1175D-01	-0.6075D-02
-0.2950D-02	-0.1284D-02	-0.5465D-03	-0.7110D-03	-0.7518D-04	-0.7593D-04	-0.8721D-05	-0.2897D-05		
-0.8963D-02	-0.2384D-01	-0.3446D-01	-0.3003D-01	-0.3738D-01	-0.3101D-01	-0.2435D-01	-0.1584D-01	-0.9135D-02	-0.4725D-02
0.2594D-02	-0.0990D-04	0.4770D-03	0.1648D-03	-0.5840D-04	-0.2017D-04	-0.6782D-05	-0.2253D-05		
-0.6117D-02	-0.1707D-01	-0.2403D-01	-0.2774D-01	-0.2670D-01	-0.2720D-01	-0.1739D-01	-0.1132D-01	-0.6525D-02	-0.3375D-02
-0.1638D-01	-0.7135D-03	-0.3635D-03	-0.1177D-03	-0.4175D-04	-0.1440D-04	-0.4843D-05	-0.1609D-05		
0.3671D-01	-0.1024D-01	-0.1477D-01	0.1664D-01	-0.1602D-01	-0.1364D-01	-0.1044D-01	-0.6789D-02	-0.3915D-02	-0.2025D-02
-0.9829D-03	-0.1980D-03	0.1021D-03	-0.7059D-04	-0.2504D-04	-0.0638D-05	-0.2905D-05	-0.9649D-06		
0.1224D-02	-0.3416D-02	-0.4926D-02	-0.5551D-02	-0.5342D-02	-0.4546D-02	-0.3479D-02	-0.2263D-02	-0.1304D-02	-0.6745D-03
-0.3274D-03	-0.1425D-03	-0.6061D-04	-0.2349D-04	-0.8330D-05	-0.2873D-05	-0.9659D-06	-0.3207D-06		
0.1277D-02	0.3410D-02	0.4918D-02	0.5543D-02	0.5336D-02	0.4543D-02	0.3478D-02	0.2264D-02	0.1306D-02	0.6756D-03
0.3287D-03	0.1430D-03	0.6086D-04	0.2351D-04	0.8382D-05	0.2892D-05	0.9729D-06	0.3234D-06		
0.3669D-02	0.1024D-01	0.1476D-01	0.1664D-01	0.1602D-01	0.1363D-01	0.1044D-01	0.6790D-02	0.3916D-02	0.2026D-02
0.9837D-03	0.4904D-03	0.1023D-03	0.7071D-04	0.2509D-04	0.0657D-05	0.2912D-05	0.9676D-06		
0.6115D-01	0.1706D-01	0.2461D-01	0.2773D-01	0.2670D-01	0.2720D-01	0.1739D-01	0.1132D-01	0.6527D-02	0.3376D-02
0.1630D-02	0.7139D-03	0.3030D-03	0.1170D-03	0.4181D-04	0.1442D-04	0.4850D-05	0.1612D-05		
0.0561D-02	0.2389D-01	0.3445D-01	0.3003D-01	0.3737D-01	0.3181D-01	0.2435D-01	0.1584D-01	0.9137D-02	0.4726D-02
0.2295D-02	0.0991D-03	0.4752D-03	0.1649D-03	0.5852D-04	0.2019D-04	0.6789D-05	0.2256D-05		
0.1161D-01	0.7071D-01	0.4430D-01	0.4093D-01	0.4805D-01	0.4090D-01	0.3131D-01	0.2037D-01	0.1175D-01	0.6076D-02
0.2950D-02	0.1285D-02	0.5467D-03	0.7120D-03	0.7523D-04	0.7595D-04	0.8728D-05	0.2900D-05		
0.1375D-01	0.3074D-01	0.4414D-01	0.6101D-01	0.5073D-01	0.4929D-01	0.3826D-01	0.2490D-01	0.1436D-01	0.7426D-02
0.7695D-02	0.1570D-02	0.5682D-03	0.2591D-03	0.9194D-04	0.3172D-04	0.1067D-04	0.3544D-05		
0.1900D-01	0.1437D-01	0.6099D-01	0.7100D-01	0.6941D-01	0.5966D-01	0.4523D-01	0.2942D-01	0.1697D-01	0.8776D-02
0.4761D-02	0.1025D-02	0.5496D-03	0.3062D-03	0.1087D-03	0.3743D-04	0.1261D-04	0.4186D-05		
0.1835D-01	0.5119D-01	0.7583D-01	0.8590D-01	0.8000D-01	0.6817D-01	0.5218D-01	0.3395D-01	0.1958D-01	0.1013D-01
0.7910D-02	0.2141D-02	0.9111D-03	0.7593D-03	0.1254D-03	0.4325D-04</				

FIGURE 2 : $\frac{1}{f_e} \left(\frac{\partial f_e}{\partial t} \right)^{\text{el coll}}$

COLLISION INTEGRAL - UNSCALED

-0.107500 09	-0.309400 04	-0.514500 09	-0.715800 09	-0.913100 09	-0.110500 10	-0.129000 10	-0.137400 10	-0.139100 10	-0.135600 10
-0.133400 10	-0.125700 10	0.124400 10	-0.120500 10	0.111400 10	-0.113500 10	-0.111700 10	-0.112940 10	-0.123500 10	-0.120800 10
-0.922400 08	-0.376300 04	0.458500 09	-0.638100 09	0.817900 09	-0.984900 09	-0.115000 10	-0.122500 10	-0.124000 10	-0.120800 10
-0.118600 10	-0.112000 10	-0.110900 10	-0.107400 10	-0.102000 10	-0.101200 10	-0.104900 10	-0.115300 10	-0.115300 10	-0.115300 10
0.007700 00	-0.141000 04	-0.401500 09	-0.553700 09	-0.712700 09	-0.862500 09	0.100700 10	-0.107200 10	-0.108600 10	-0.105800 10
-0.101900 10	-0.700800 09	-0.971100 09	-0.940100 09	-0.893400 09	-0.885800 09	-0.918500 09	-0.101000 10	-0.928400 09	-0.904700 09
-0.690600 08	-0.706800 09	-0.734300 09	-0.477700 09	-0.609100 09	0.737400 09	-0.861000 09	-0.916800 09	-0.928400 09	-0.904700 09
-0.887900 04	-0.830600 04	-0.830200 09	-0.803000 09	-0.763900 09	-0.757400 09	-0.785300 09	-0.863200 09	-0.767600 09	-0.748000 09
0.571100 03	0.171000 09	-0.303800 09	-0.395000 04	-0.505300 09	-0.609700 09	-0.711900 09	-0.758100 09	-0.767600 09	-0.748000 09
-0.753400 09	0.079500 04	-0.686500 09	-0.664600 09	-0.631600 09	-0.626200 09	0.649300 09	-0.713700 09	-0.603400 09	-0.588000 09
0.410300 08	-0.151400 04	0.223100 09	0.310500 04	-0.396100 09	0.479300 09	-0.559600 09	-0.595900 09	-0.603400 09	-0.588000 09
0.577100 09	-0.535000 09	0.539600 09	-0.572400 09	0.496400 09	-0.497200 09	-0.510300 09	-0.561000 09	-0.435700 09	-0.424500 09
-0.524100 06	0.290100 08	-0.161100 09	-0.174200 09	-0.206000 09	-0.346100 09	0.404100 09	-0.430200 09	-0.435700 09	-0.424500 09
-0.400300 09	-0.553500 09	-0.389500 09	-0.377100 09	-0.358100 09	-0.355300 09	-0.368400 09	-0.404900 09	-0.264200 09	-0.257500 09
-0.190600 06	-0.500700 09	0.291300 08	-0.130000 09	0.173500 09	0.209300 09	-0.245100 09	-0.261000 09	-0.264200 09	-0.257500 09
-0.291700 09	-0.158000 04	-0.236200 09	-0.223400 09	0.111300 09	-0.215400 09	-0.223300 09	-0.245500 09	-0.890200 08	-0.867200 08
-0.663100 07	-0.198500 08	-0.372500 08	0.450600 08	-0.584900 08	-0.707700 08	-0.826100 08	-0.879300 08	-0.890200 08	-0.867200 08
-0.850300 08	-0.001500 03	0.195000 08	-0.269300 08	-0.130700 08	-0.724300 08	-0.750900 08	-0.825000 08	0.901100 08	0.878400 08
0.667300 07	0.190000 08	0.132100 08	0.465100 08	0.530000 08	0.715000 08	0.835100 08	0.889500 08	0.901100 08	0.878400 08
0.062500 08	0.011400 08	0.800200 08	0.281900 08	0.145500 08	0.737400 08	0.764800 08	0.841200 08	0.269800 09	0.266300 09
0.203200 08	0.000800 08	0.101000 09	0.140600 09	0.179300 09	0.217000 09	0.253400 09	0.269800 09	0.269800 09	0.266300 09
0.264500 09	0.140000 09	0.210600 09	0.236000 09	0.225100 09	0.223200 09	0.231500 09	0.254500 09	0.460700 04	0.448900 09
0.347500 08	0.100500 09	0.170300 09	0.237000 09	0.301300 09	0.365000 09	0.427100 09	0.494900 09	0.460700 04	0.448900 09
0.400100 09	0.100600 09	0.412100 09	0.399100 09	0.379500 09	0.376100 09	0.390000 09	0.428800 09	0.652400 09	0.635700 09
0.405100 08	0.111500 09	0.291100 09	0.335600 09	0.420100 09	0.510000 09	0.604900 09	0.644200 09	0.652400 09	0.635700 09
0.624000 09	0.589900 09	0.583600 09	0.565100 09	0.537100 09	0.532500 09	0.552200 09	0.607100 09	0.848600 04	0.826900 09
0.631000 06	0.130900 09	0.313600 09	0.436500 09	0.556000 09	0.673900 09	0.706800 09	0.837900 09	0.848600 04	0.826900 09
0.811700 09	0.166600 09	0.259100 09	0.275000 09	0.298000 09	0.347600 09	0.718200 09	0.789600 09	0.104900 10	0.102300 10
0.780400 08	0.155000 09	0.382900 09	0.539900 09	0.680000 09	0.833400 09	0.913100 09	0.103600 10	0.104900 10	0.102300 10
0.100300 10	0.090300 09	0.194000 09	0.190000 09	0.186300 09	0.850600 09	0.888100 09	0.976300 09	0.125500 10	0.122300 10
0.295300 08	0.159900 09	0.406300 09	0.645000 09	0.821300 09	0.996700 09	0.116400 10	0.123900 10	0.125500 10	0.122300 10
0.140000 10	0.111300 10	0.112300 10	0.100300 10	0.100300 10	0.100400 10	0.106200 10	0.116800 10	0.146600 10	0.142800 10
0.109000 09	0.100300 09	0.151000 09	0.150000 09	0.150000 09	0.116400 10	0.135900 10	0.144700 10	0.146600 10	0.142800 10
0.130900 10	0.130900 10	0.131100 10	0.130900 10	0.130900 10	0.130900 10	0.130900 10	0.130900 10	0.168100 10	0.163900 10
0.125100 09	0.130400 09	0.131500 09	0.130500 09	0.130300 10	0.130300 10	0.155900 10	0.166000 10	0.168100 10	0.163900 10
0.160800 10	0.150500 10	0.150300 10	0.150500 10	0.150300 10	0.150300 10	0.142300 10	0.156400 10		

-T*-

FIGURE 3 : $\left(\frac{\partial f_e}{\partial t}\right)^{\text{in coll}}$

PREPARED FOR THE COMPTON EFFECT

					$(v_e = 3.09)$ ↓	$(v_e = 3.31)$ ↓	$(v_e = 3.54)$ ↓	$(v_e = 3.77)$ ↓	$(v_e = 4 \text{ eV})$ ↓
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.11730E-10	-0.40190E-11	-0.4E080E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.12730E-10	-0.45720E-11	-0.45610E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.12570E-10	-0.45250E-11	-0.45140E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.11710E-10	-0.44780E-11	-0.44680E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.12510E-10	-0.44320E-11	-0.44210E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.12480E-10	-0.43850E-11	-0.43740E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.12050E-10	-0.43380E-11	-0.43270E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.11920E-10	-0.42910E-11	-0.42810E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.11790E-10	-0.42440E-11	-0.42340E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.11660E-10	-0.41970E-11	-0.41870E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.11530E-10	-0.41500E-11	-0.41400E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.11400E-10	-0.41030E-11	-0.40930E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.11270E-10	-0.40560E-11	-0.40460E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.11140E-10	-0.40090E-11	-0.40000E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.11010E-10	-0.39620E-11	-0.39530E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.10880E-10	-0.39150E-11	-0.39060E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.10750E-10	-0.38680E-11	-0.38590E-12	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	-0.10620E-10	-0.38210E-11	-0.38130E-12	0.0	0.0

FIGURE 3 $\frac{1}{f_e} \left(\frac{\partial f_e}{\partial t} \right)$ in coll

RELATIVE THERMAL COLLISION INTEGRAL (relative to t_e)
$$\begin{array}{cccc} (v_e = 3.31 \text{ eV}) & (v_e = 3.54 \text{ eV}) & (v_e = 3.77) & (v_e = 4 \text{ eV}) \\ \downarrow & \downarrow & \downarrow & \downarrow \end{array}$$
[illegible]

Figure 4 : $\left(\frac{\partial f_e}{\partial t}\right)$ Coul, e-i

E-I COULOMB - UNSCALED

0.3426D-04	-0.3477D-06	0.6361D-07	-0.3093D-07	-0.1742D-07	-0.9096D-08	-0.5461D-08	-0.2885D-08	-0.1440D-08	-0.6872D-09
-0.3075D-09	-0.1294D-09	-0.5115D-10	-0.1097D-10	-0.6592D-11	-0.2146D-11	-0.6576D-12	-0.5415D-12		
0.3391D-04	-0.3442D-06	0.6296D-07	-0.3060D-07	-0.1735D-07	-0.9796D-08	-0.5406D-08	-0.2856D-08	-0.1433D-08	-0.6802D-09
-0.3044D-09	-0.1281D-09	-0.5063D-10	-0.1078D-10	-0.6526D-11	-0.2124D-11	-0.6470D-12	-0.5360D-12		
0.3357D-04	-0.3407D-06	0.6137D-07	-0.3029D-07	-0.1707D-07	-0.9695D-08	-0.5350D-08	-0.2827D-08	-0.1419D-08	-0.6732D-09
-0.3012D-09	-0.1268D-09	-0.5011D-10	-0.1058D-10	-0.6459D-11	-0.2102D-11	-0.6404D-12	-0.5305D-12		
0.3322D-04	-0.3371D-06	0.6167D-07	-0.2998D-07	-0.1689D-07	-0.9595D-08	-0.5295D-08	-0.2797D-08	-0.1404D-08	-0.6662D-09
-0.2981D-09	-0.1255D-09	-0.4959D-10	-0.1039D-10	-0.6392D-11	-0.2080D-11	-0.6337D-12	-0.5250D-12		
0.3287D-04	-0.3336D-06	0.6103D-07	-0.2966D-07	-0.1671D-07	-0.9494D-08	-0.5239D-08	-0.2768D-08	-0.1389D-08	-0.6593D-09
0.2950D-09	-0.1241D-09	-0.4907D-10	-0.1020D-10	-0.6325D-11	-0.2059D-11	-0.6271D-12	-0.5195D-12		
0.3252D-04	-0.3301D-06	0.6038D-07	-0.2935D-07	-0.1654D-07	-0.9394D-08	-0.5184D-08	-0.2739D-08	-0.1374D-08	-0.6523D-09
-0.2918D-09	-0.1228D-09	-0.4856D-10	-0.1001D-10	-0.6258D-11	-0.2037D-11	-0.6205D-12	-0.5140D-12		
0.3217D-04	-0.3266D-06	0.5973D-07	-0.2903D-07	-0.1636D-07	-0.9293D-08	-0.5129D-08	-0.2709D-08	-0.1360D-08	-0.6453D-09
-0.2887D-09	-0.1215D-09	-0.4804D-10	-0.1781D-10	-0.6191D-11	-0.2015D-11	-0.6138D-12	-0.5085D-12		
0.3183D-04	-0.3230D-06	0.5909D-07	-0.2872D-07	-0.1618D-07	-0.9193D-08	-0.5073D-08	-0.2680D-08	-0.1345D-08	-0.6383D-09
-0.2856D-09	-0.1202D-09	-0.4752D-10	-0.1762D-10	-0.6124D-11	-0.1993D-11	-0.6077D-12	-0.5030D-12		
0.3148D-04	-0.3195D-06	0.5884D-07	-0.2841D-07	-0.1601D-07	-0.9092D-08	-0.5018D-08	-0.2651D-08	-0.1330D-08	-0.6314D-09
-0.2825D-09	-0.1189D-09	-0.4700D-10	-0.1743D-10	-0.6057D-11	-0.1971D-11	-0.6006D-12	-0.4975D-12		
0.3113D-04	-0.3160D-06	0.5780D-07	-0.2809D-07	-0.1583D-07	-0.8992D-08	-0.4962D-08	-0.2621D-08	-0.1316D-08	-0.6244D-09
-0.2794D-09	-0.1175D-09	-0.4648D-10	-0.1724D-10	-0.5940D-11	-0.1950D-11	-0.5939D-12	-0.4920D-12		
0.3078D-04	-0.3124D-06	0.5715D-07	-0.2778D-07	-0.1565D-07	-0.8891D-08	-0.4907D-08	-0.2592D-08	-0.1301D-08	-0.6174D-09
-0.2767D-09	-0.1163D-09	-0.4596D-10	-0.1704D-10	-0.5923D-11	-0.1928D-11	-0.5873D-12	-0.4865D-12		
0.3041D-04	-0.3089D-06	0.5651D-07	-0.2747D-07	-0.1548D-07	-0.8791D-08	-0.4851D-08	-0.2563D-08	-0.1286D-08	-0.6104D-09
-0.2731D-09	-0.1149D-09	-0.4544D-10	-0.1685D-10	-0.5856D-11	-0.1906D-11	-0.5807D-12	-0.4810D-12		
0.3009D-04	-0.3054D-06	0.5586D-07	-0.2715D-07	-0.1530D-07	-0.8691D-08	-0.4796D-08	-0.2534D-08	-0.1272D-08	-0.6035D-09
-0.2700D-09	-0.1136D-09	-0.4492D-10	-0.1666D-10	-0.5709D-11	-0.1884D-11	-0.5740D-12	-0.4755D-12		
0.2973D-04	-0.3018D-06	0.5521D-07	-0.2684D-07	-0.1512D-07	-0.8598D-08	-0.4740D-08	-0.2504D-08	-0.1257D-08	-0.5965D-09
-0.2669D-09	-0.1123D-09	-0.4440D-10	-0.1647D-10	-0.5622D-11	-0.1863D-11	-0.5674D-12	-0.4700D-12		
0.2939D-04	-0.2983D-06	0.5457D-07	-0.2652D-07	-0.1495D-07	-0.8490D-08	-0.4685D-08	-0.2475D-08	-0.1242D-08	-0.5895D-09
-0.2638D-09	-0.1110D-09	-0.4388D-10	-0.1627D-10	-0.5655D-11	-0.1841D-11	-0.5607D-12	-0.4645D-12		
0.2904D-04	-0.2948D-06	0.5392D-07	-0.2621D-07	-0.1477D-07	-0.8389D-08	-0.4630D-08	-0.2446D-08	-0.1227D-08	-0.5825D-09
-0.2606D-09	-0.1097D-09	-0.4336D-10	-0.1603D-10	-0.5589D-11	-0.1819D-11	-0.5541D-12	-0.4590D-12		
0.2869D-04	-0.2912D-06	0.5328D-07	-0.2590D-07	-0.1459D-07	-0.8289D-08	-0.4574D-08	-0.2416D-08	-0.1213D-08	-0.5756D-09
-0.2575D-09	-0.1084D-09	-0.4284D-10	-0.1582D-10	-0.5542D-11	-0.1797D-11	-0.5477D-12	-0.4535D-12		
0.2834D-04	-0.2877D-06	0.5263D-07	-0.2558D-07	-0.1442D-07	-0.8188D-08	-0.4519D-08	-0.2387D-08	-0.1198D-08	-0.5686D-09
-0.2544D-09	-0.1071D-09	-0.4237D-10	-0.1569D-10	-0.5455D-11	-0.1775D-11	-0.5408D-12	-0.4480D-12		

FIGURE 4 : $\frac{1}{f_e} \left(\frac{f_e}{t} \right)^{\text{Coul, e-e}}$

E-I COLUMBIA UNCLASSIFIED

[illegible]

FIGURE 5 : $\left(\frac{\partial f_c}{\partial t}\right)^{\text{Coul, e-e}}$

E-E COULOMB - UNSHIELD

0.6836D-02	0.4664D-02	0.3206D-02	0.1650D-02	0.5100D-03	-0.9538D-04	-0.2902D-03	-0.2693D-03	-0.1820D-03	-0.1023D-03
-0.5041D-04	-0.2236D-04	-0.9082D-05	-0.3412D-05	-0.1193D-05	-0.3893D-06	-0.1187D-06	-0.4997D-07		
0.6767D-02	0.4617D-02	0.3174D-02	0.1633D-02	0.5048D-03	-0.9441D-04	-0.2872D-03	-0.2666D-03	-0.1802D-03	-0.1013D-03
-0.4900D-04	-0.2217D-04	-0.8990D-05	-0.3378D-05	-0.1101D-05	-0.3853D-06	-0.1175D-06	-0.4946D-07		
0.6698D-02	0.4570D-02	0.3141D-02	0.1616D-02	0.4996D-03	-0.9344D-04	-0.2843D-03	-0.2639D-03	-0.1783D-03	-0.1003D-03
-0.4938D-04	-0.2190D-04	-0.8897D-05	-0.3343D-05	-0.1109D-05	-0.3814D-06	-0.1163D-06	-0.4896D-07		
0.6628D-02	0.4522D-02	0.3109D-02	0.1600D-02	0.4944D-03	-0.9247D-04	-0.2814D-03	-0.2611D-03	-0.1765D-03	-0.9922D-04
-0.4887D-04	-0.2160D-04	-0.8805D-05	-0.3308D-05	-0.1157D-05	-0.3774D-06	-0.1151D-06	-0.4845D-07		
0.6559D-02	0.4475D-02	0.3076D-02	0.1583D-02	0.4893D-03	-0.9151D-04	-0.2784D-03	-0.2584D-03	-0.1746D-03	-0.9818D-04
-0.4836D-04	-0.2145D-04	-0.8713D-05	-0.3274D-05	-0.1145D-05	-0.3735D-06	-0.1139D-06	-0.4794D-07		
0.6489D-02	0.4428D-02	0.3044D-02	0.1566D-02	0.4841D-03	-0.9054D-04	-0.2755D-03	-0.2556D-03	-0.1728D-03	-0.9715D-04
-0.4789D-04	-0.2122D-04	-0.8621D-05	-0.3239D-05	-0.1133D-05	-0.3695D-06	-0.1127D-06	-0.4744D-07		
0.6420D-02	0.4380D-02	0.3011D-02	0.1549D-02	0.4789D-03	-0.8957D-04	-0.2725D-03	-0.2529D-03	-0.1709D-03	-0.9611D-04
-0.4734D-04	-0.2100D-04	-0.8529D-05	-0.3205D-05	-0.1120D-05	-0.3656D-06	-0.1115D-06	-0.4693D-07		
0.6350D-02	0.4333D-02	0.2979D-02	0.1533D-02	0.4737D-03	-0.8860D-04	-0.2696D-03	-0.2502D-03	-0.1691D-03	-0.9507D-04
-0.4682D-04	-0.2077D-04	-0.8436D-05	-0.3170D-05	-0.1108D-05	-0.3616D-06	-0.1103D-06	-0.4642D-07		
0.6281D-02	0.4286D-02	0.2946D-02	0.1516D-02	0.4686D-03	-0.8763D-04	-0.2666D-03	-0.2474D-03	-0.1672D-03	-0.9403D-04
-0.4631D-04	-0.2054D-04	-0.8344D-05	-0.3135D-05	-0.1096D-05	-0.3570D-06	-0.1091D-06	-0.4591D-07		
0.6217D-02	0.4238D-02	0.2914D-02	0.1499D-02	0.4634D-03	-0.8666D-04	-0.2637D-03	-0.2447D-03	-0.1654D-03	-0.9299D-04
-0.4580D-04	-0.2032D-04	-0.8252D-05	-0.3101D-05	-0.1084D-05	-0.3537D-06	-0.1079D-06	-0.4541D-07		
0.6142D-02	0.4191D-02	0.2881D-02	0.1482D-02	0.4582D-03	-0.8570D-04	-0.2607D-03	-0.2420D-03	-0.1636D-03	-0.9195D-04
-0.4529D-04	-0.2009D-04	-0.8160D-05	-0.3066D-05	-0.1072D-05	-0.3497D-06	-0.1066D-06	-0.4490D-07		
0.6073D-02	0.4144D-02	0.2848D-02	0.1466D-02	0.4530D-03	-0.8473D-04	-0.2578D-03	-0.2392D-03	-0.1617D-03	-0.9091D-04
-0.4478D-04	-0.1986D-04	-0.8060D-05	-0.3031D-05	-0.1060D-05	-0.3458D-06	-0.1054D-06	-0.4439D-07		
0.6003D-02	0.4096D-02	0.2816D-02	0.1449D-02	0.4478D-03	-0.8376D-04	-0.2548D-03	-0.2365D-03	-0.1599D-03	-0.8987D-04
0.4117D-04	-0.1943D-04	-0.7975D-05	-0.2997D-05	-0.1040D-05	-0.3418D-06	-0.1042D-06	-0.4388D-07		
0.5934D-02	0.4049D-02	0.2783D-02	0.1432D-02	0.4427D-03	-0.8279D-04	-0.2519D-03	-0.2338D-03	-0.1580D-03	-0.8883D-04
-0.4375D-04	-0.1941D-04	-0.7883D-05	-0.2967D-05	-0.1036D-05	-0.3379D-06	-0.1030D-06	-0.4338D-07		
0.5865D-02	0.4002D-02	0.2751D-02	0.1415D-02	0.4375D-03	-0.8182D-04	-0.2489D-03	-0.2310D-03	-0.1562D-03	-0.8779D-04
-0.4324D-04	-0.1941D-04	-0.7791D-05	-0.2947D-05	-0.1023D-05	-0.3339D-06	-0.1018D-06	-0.4287D-07		
0.5796D-02	0.3954D-02	0.2718D-02	0.1399D-02	0.4323D-03	-0.8085D-04	-0.2460D-03	-0.2283D-03	-0.1543D-03	-0.8676D-04
-0.4277D-04	-0.1899D-04	-0.7699D-05	-0.2893D-05	-0.1011D-05	-0.3300D-06	-0.1006D-06	-0.4236D-07		
0.5726D-02	0.3906D-02	0.2686D-02	0.1382D-02	0.4271D-03	-0.7989D-04	-0.2431D-03	-0.2256D-03	-0.1525D-03	-0.8572D-04
-0.4229D-04	-0.1893D-04	-0.7607D-05	-0.2870D-05	-0.1000D-05	-0.3260D-06	-0.9942D-07	-0.4185D-07		
0.5656D-02	0.3859D-02	0.2654D-02	0.1365D-02	0.4219D-03	-0.7892D-04	-0.2401D-03	-0.2228D-03	-0.1506D-03	-0.8468D-04
-0.4171D-04	-0.1850D-04	-0.7514D-05	-0.2824D-05	-0.9871D-06	-0.3221D-06	-0.9821D-07	-0.4135D-07		

FIGURE 5 : $\frac{1}{f_e} \left(\frac{\partial f_e}{\partial t} \right)^{\text{Coul, e-e}}$

E-F FOULING - UNCHANGED

[illegible][illegible]

FIGURE 6 : $\left(\frac{\partial f_e}{\partial t} \right)^F$

ELECTRIC FIELD TERM - UNSCALED

0.1786D-01	-0.1149D 00	0.1734D 00	-0.1924D 00	-0.1944D 00	-0.1676D 00	-0.1300D 00	-0.9172D-01	-0.5923D-01	-0.3515D-01
-0.1973D 01	-0.9711D-02	-0.4537D-02	-0.1964D-02	-0.7871D-03	-0.2928D-03	-0.1011D-03	-0.3241D-04		
0.3541D 01	-0.8447D-01	-0.1436D 00	0.1691D 00	-0.1670D 00	-0.1447D 00	-0.1126D 00	-0.7964D-01	-0.5149D-01	-0.3059D-01
0.1671D 01	-0.0460D-02	-0.3351D 02	0.1711D 02	-0.4864D 03	-0.2554D-03	-0.8816D-04	-0.2827D-04		
0.5766D 01	-0.5620D 01	-0.1147D 00	-0.1404D 00	-0.1404D 00	-0.1225D 00	-0.9570D-01	-0.6782D-01	-0.4393D-01	-0.2612D-01
-0.1431D-01	-0.7235D-07	-0.3383D-02	-0.1465D-02	-0.5076D-03	-0.2187D-03	-0.7553D-01	-0.2422D-01		
0.1210D 00	-0.3009D 01	-0.0719D 01	-0.1175D 00	-0.1145D 00	-0.1008D 00	-0.7918D-01	-0.5629D-01	-0.3653D-01	-0.2175D-01
-0.1197D 01	-0.6036D-02	-0.2024D-07	-0.1223D-02	-0.4909D-03	-0.1827D 03	-0.6313D-04	-0.2025D-04		
0.1591D 00	-0.6115D 02	0.0100D-01	-0.0555D-01	-0.8951D-01	0.7970D-01	-0.6307D-01	-0.4502D 01	-0.2930D 01	-0.1748D-01
0.4510D 07	-0.4062D-02	-0.2517D-02	-0.2066D 03	-0.3007D-03	-0.1475D-03	-0.5099D-01	-0.1636D-04		
0.1601D 00	0.1571D 01	-0.3637D-01	0.5960D-01	-0.6527D-01	-0.5932D-01	0.4730D-01	-0.3404D-01	-0.2224D-01	-0.1331D-01
-0.7521D 07	-0.3714D-02	-0.1741D-02	-0.7552D-03	-0.3035D-03	-0.1131D-03	-0.3910D-04	-0.1255D-04		
0.7111D 00	0.3738D-01	-0.1301D-01	-0.3485D 01	-0.4103D-01	-0.3945D-01	0.3211D-01	-0.2333D-01	-0.1535D-01	-0.9230D-02
0.5094D-02	-0.2592D 02	-0.1211D-02	-0.5094D-03	-0.2128D-03	-0.7937D-04	-0.2746D-04	-0.8821D-05		
0.2280D 00	0.5790D-01	0.8886D-02	-0.1107D-01	-0.1918D-01	-0.2016D-01	-0.1726D-01	-0.1289D-01	-0.8632D-02	-0.5251D-02
0.7923D-01	0.1445D-02	-0.7056D-03	-0.3076D-03	-0.1241D-03	-0.4640D-04	-0.1608D-04	-0.5173D-05		
0.7388D 00	0.6027D-01	0.2942D 01	0.1167D-01	0.7669D-02	-0.1472D-02	-0.7819D-02	-0.2730D-02	-0.2082D-02	-0.1368D-02
-0.0012D-04	0.1247D 03	0.2056D 03	-0.9140D-04	-0.5744D-04	0.1416D-04	0.4957D-05	-0.1607D-05		
0.7445D 00	0.01149D-01	0.4657D-01	0.3377D 01	0.2372D-01	0.1667D-01	0.1120D-01	0.7156D-02	0.4290D-02	0.2417D-02
0.1263D 02	0.6704D 03	0.2025D-03	0.1190D 03	0.4723D 04	0.1753D-04	0.5915D-05	0.1878D 05		
0.7471D 00	0.4257D-01	0.6632D-01	0.5403D 01	0.4790D-01	0.3414D 01	0.7491D 01	0.1677D 01	0.1051D-01	0.6104D-02
0.3266D 07	0.1610D 02	0.7509D-03	0.3253D 03	0.1099D-03	0.4008D-04	0.1653D-04	0.5282D-05		
0.7341D 00	0.1015D 00	0.8268D 01	0.7357D-01	0.6341D-01	0.5105D 01	0.3300D-01	0.2610D-01	0.1655D 01	0.9694D-02
0.5251D 02	0.2633D 02	0.1233D-02	0.5769D-03	0.2105D-03	0.7009D-04	0.2690D-04	0.8605D-05		
0.2212D 00	0.1008D 00	0.9765D-01	0.9223D-01	0.6211D-01	0.7735D-01	0.5077D-01	0.3516D-01	0.2242D-01	0.1319D-01
0.7165D 07	0.0001D 02	0.1676D-02	0.7727D-03	0.692D-03	0.1074D-07	0.3700D 04	0.1185D-04		
0.2016D 00	0.1173D 00	0.1112D 00	0.1098D 00	0.9098D-01	0.8311D 01	0.6313D 01	0.4395D-01	0.2612D-01	0.1658D-01
0.4015D 07	0.4511D 02	0.2111D-02	0.9138D 07	0.3656D 03	0.1359D-03	0.4686D-04	0.1501D-04		
0.1760D 00	0.1154D 00	0.1274D 00	0.1263D 00	0.1171D 00	0.9826D-01	0.7507D 01	0.5246D 01	0.3365D-01	0.1988D-01
0.1031D 01	0.5000D-07	0.2546D-07	0.1100D-07	0.1405D 03	0.1073D 03	0.5046D 04	0.1809D 04		
0.1147D 00	0.1175D 00	0.1547D 00	0.1111D 00	0.1053D 00	0.1128D 00	0.0697D-01	0.6069D-01	0.3902D-01	0.2708D-01
0.1759D-01	0.0551D-07	0.7063D-02	0.1731D 07	0.5131D-03	0.1907D-03	0.6521D-04	0.2109D-04		
0.1004D 00	0.1137D 00	0.1456D 00	0.1561D 00	0.1407D 00	0.1268D 00	0.5770D 01	0.6865D-01	0.4421D-01	0.2618D-01
0.1430D 01	0.7711D 07	0.5008D-02	0.1756D 02	0.5837D 03	0.2170D 02	0.7490D 04	0.7401D-04		
0.0754D 01	0.1094D 00	0.1510D 00	0.1074D 00	0.1055D 00	0.1401D 00	0.1008D 00	0.7634D-01	0.4923D-01	0.2919D-01
0.1546D 01	0.0095D 07	0.5007D-02	0.1627D 02	0.6573D-03	0.2426D-03	0.8374D-01	0.2684D-04		

FIGURE 6 : $\frac{1}{f_e} \left(\frac{\partial f_e}{\partial t} \right)^E$

ELF ELECTRIC FIELD TERM - UNSCALED

-0.8009D 08	-0.6174D 09	-0.1009D 10	0.1514D 10	-0.1950D 10	-0.2396D 10	-0.2836D 10	-0.3275D 10	-0.3714D 10	-0.4153D 10
-0.4701D 10	0.5029D 10	-0.5468D 10	0.5906D 10	-0.6344D 10	-0.6782D 10	-0.7220D 10	-0.7658D 10		
0.1781D 09	-0.4566D 09	-0.0915D 09	-0.1299D 10	-0.1697D 10	-0.2091D 10	-0.2483D 10	-0.2873D 10	-0.3262D 10	-0.3651D 10
-0.4039D 10	-0.4427D 10	-0.4814D 10	-0.5202D 10	-0.5589D 10	-0.5976D 10	-0.6363D 10	-0.6750D 10		
0.4201D 09	-0.3063D 09	-0.7195D 09	0.1088D 10	-0.1441D 10	-0.1788D 10	-0.2131D 10	-0.2472D 10	-0.2811D 10	-0.3150D 10
0.3480D 10	0.3045D 10	-0.4162D 10	0.4490D 10	-0.4835D 10	-0.5171D 10	-0.5507D 10	-0.5842D 10		
0.2362D 09	-0.1677D 09	-0.5527D 09	-0.8804D 09	-0.1188D 10	-0.1487D 10	-0.1782D 10	-0.2073D 10	-0.2362D 10	-0.2650D 10
-0.2938D 10	-0.3741D 10	-0.3510D 10	-0.3796D 10	-0.4081D 10	-0.4366D 10	-0.4651D 10	-0.4936D 10		
0.8451D 09	-0.3403D 08	-0.3213D 09	-0.6709D 09	-0.9385D 09	-0.1189D 10	-0.1434D 10	-0.1676D 10	-0.1915D 10	-0.2153D 10
-0.2309D 10	0.2645D 10	-0.2060D 10	-0.3094D 10	-0.3739D 10	-0.3562D 10	-0.3796D 10	-0.4029D 10		
0.2061D 09	0.8083D 08	-0.2355D 09	0.4772D 09	-0.6917D 09	-0.8937D 09	-0.1009D 10	-0.1280D 10	-0.1469D 10	-0.1656D 10
-0.1811D 10	-0.2096D 10	-0.2210D 10	-0.2394D 10	-0.2577D 10	-0.2760D 10	-0.2942D 10	-0.3124D 10		
0.1118D 10	0.2011D 09	-0.8536D 08	-0.2811D 09	-0.4401D 09	-0.6007D 09	-0.7400D 09	-0.8869D 09	-0.1025D 10	-0.1161D 10
-0.1706D 10	0.1479D 10	-0.1562D 10	0.1695D 10	-0.1837D 10	-0.1950D 10	-0.2089D 10	-0.2220D 10		
0.1724D 10	0.3040D 09	0.5879D 08	-0.9046D 08	-0.2071D 09	-0.3104D 09	-0.4053D 09	-0.4955D 09	-0.5826D 09	-0.6677D 09
-0.2911D 09	-0.0733D 09	-0.9154D 09	-0.9961D 09	-0.1017D 10	-0.1157D 10	-0.1237D 10	-0.1316D 10		
0.1293D 10	0.3961D 09	0.1460D 09	0.2644D 08	0.2022D 08	-0.2292D 08	-0.6694D 08	-0.1061D 09	-0.1421D 09	-0.1759D 09
0.2002D 09	-0.2591D 09	-0.2697D 09	0.2993D 09	-0.3201D 09	-0.3571D 09	-0.3854D 09	-0.4134D 09		
0.1383D 10	0.4089D 09	0.3285D 09	0.2780D 09	0.2676D 09	0.2617D 09	0.2690D 09	0.2812D 09	0.2966D 09	0.3142D 09
0.2337D 09	0.3036D 09	0.3748D 09	0.3266D 09	0.4190D 09	0.4418D 09	0.4650D 09	0.4884D 09		
0.1341D 10	0.5701D 09	0.4537D 09	0.4565D 09	0.4924D 09	0.5434D 09	0.6024D 09	0.6663D 09	0.7334D 09	0.8026D 09
0.0335D 09	0.9452D 09	0.1013D 10	0.1091D 10	0.1165D 10	0.1240D 10	0.1314D 10	0.1389D 10		
0.1815D 10	0.6100D 09	0.5720D 09	0.6293D 09	0.7184D 09	0.8219D 09	0.9332D 09	0.1044D 10	0.1168D 10	0.1209D 10
0.1417D 10	0.1575D 10	0.1660D 10	0.1785D 10	0.1910D 10	0.2036D 10	0.2167D 10	0.2289D 10		
0.1251D 10	0.6562D 09	0.6034D 09	0.7077D 09	0.9405D 09	0.1097D 10	0.1261D 10	0.1430D 10	0.1601D 10	0.1774D 10
0.1930D 10	0.2174D 10	0.2480D 10	0.2477D 10	0.2654D 10	0.2832D 10	0.3010D 10	0.3188D 10		
0.1159D 10	0.6714D 09	0.7075D 09	0.7959D 09	0.1159D 10	0.1369D 10	0.1587D 10	0.1808D 10	0.2031D 10	0.2257D 10
0.2403D 10	0.2711D 10	0.2958D 10	0.3160D 10	0.3397D 10	0.3626D 10	0.3856D 10	0.4086D 10		
0.1071D 10	0.2710D 09	0.2841D 09	0.1111D 10	0.1373D 10	0.1630D 10	0.1909D 10	0.2183D 10	0.2460D 10	0.2738D 10
0.2011D 10	0.3796D 10	0.3576D 10	0.3857D 10	0.4138D 10	0.4420D 10	0.4701D 10	0.4983D 10		
0.0467D 09	0.2900D 09	0.2729D 09	0.1769D 10	0.1581D 10	0.1403D 10	0.2279D 10	0.2556D 10	0.2886D 10	0.3216D 10
0.3510D 10	0.3800D 10	0.4412D 10	0.4549D 10	0.4070D 10	0.5212D 10	0.5545D 10	0.5879D 10		
0.6523D 09	0.2750D 09	0.1054D 10	0.1415D 10	0.1787D 10	0.2165D 10	0.2545D 10	0.2927D 10	0.3310D 10	0.3693D 10
0.4071D 10	0.4167D 10	0.4347D 10	0.5132D 10	0.5611D 10	0.6002D 10	0.6300D 10	0.6773D 10		
0.3761D 09	0.2701D 09	0.1126D 10	0.1555D 10	0.1988D 10	0.2417D 10	0.2850D 10	0.3294D 10	0.3731D 10	0.4168D 10
0.4005D 10	0.5019D 10	0.5409D 10	0.5917D 10	0.6351D 10	0.6791D 10	0.7229D 10	0.7667D 10		

FIGURE 10 : $\left(\frac{\partial f_e}{\partial t} \right)^{el \text{ coll}, E, Coul}$

COUL + EFT + COLL - UNSPLIT

-0.3179D-01	-0.1683D-00	0.5544D-00	0.1110D-00	-0.2847D-00	-0.2449D-00	-0.1894D-00	-0.1305D-00	-0.8160D-01	-0.4673D-01
-0.2485D-01	-0.1216D-01	0.5575D-00	0.1160D-00	-0.9303D-03	-0.3422D-03	-0.1177D-03	-0.3793D-04		
0.2394D-01	-0.1311D-00	-0.2142D-00	0.5570D-00	0.2466D-00	-0.2130D-00	-0.1651D-00	-0.1138D-00	-0.7125D-01	-0.4081D-01
-0.2171D-01	-0.1062D-01	-0.4874D-01	0.5570D-00	0.00179D-03	-0.2990D-03	-0.1028D-03	-0.3315D-04		
0.7359D-01	-0.9601D-01	-0.1755D-00	0.5570D-00	-0.1817D-00	-0.1817D-00	-0.1412D-00	-0.9751D-01	-0.6107D-01	-0.3500D-01
-0.1862D-01	-0.9112D-02	-0.4181D-02	-0.1770D-01	0.1691D-01	-0.2565D-03	-0.8824D-04	-0.2846D-04		
0.1172D-00	-0.6311D-01	-0.1382D-00	-0.1710D-00	0.1159D-00	-0.1509D-00	-0.1177D-00	-0.8144D-01	-0.5106D-01	-0.2928D-01
-0.1558D-01	-0.7627D-02	-0.3501D-02	-0.1485D-02	0.5880D-04	-0.2148D-03	-0.7390D-04	-0.2384D-04		
0.1547D-00	-0.3236D-01	-0.1023D-00	-0.1339D-00	-0.1570D-00	0.1200D-00	-0.9466D-01	-0.6565D-01	-0.4122D-01	-0.2365D-01
-0.1260D-00	-0.6168D-02	-0.7832D-02	-0.1202D-02	-0.4725D-03	-0.1739D-03	-0.5982D-04	-0.1930D-04		
0.1861D-00	-0.3762D-02	-0.6778D-01	-0.9694D-01	-0.1022D-00	-0.9120D-01	-0.7701D-01	-0.5014D-01	-0.3155D-01	-0.1813D-01
-0.9663D-02	-0.4734D-02	-0.2175D-02	-0.9233D-03	-0.3631D-03	-0.1336D-03	0.1500D-01	-0.1485D-04		
0.2114D-00	0.2269D-01	-0.3465D-01	-0.6104D-01	-0.6805D-01	-0.6226D-01	-0.4060D-01	-0.7490D-01	-0.2205D-01	-0.1270D-01
-0.6782D-02	-0.3326D-02	-0.1529D-02	-0.6498D-03	-0.2557D-03	-0.9414D-04	-0.7640D-04	0.1017D-04		
0.2307D-00	0.4699D-01	-0.2906D-02	0.2618D-01	-0.3473D-01	-0.3389D-01	-0.2570D-01	-0.1991D-01	-0.1272D-01	-0.7370D-02

-0.3952D-02	-0.1944D-02	-0.8961D-03	-0.3814D-03	-0.1503D-03	-0.5540D-04	-0.1910D-04	-0.6185D-05		
0.2439D-00	0.6914D-01	0.2744D-01	0.7638D-02	-0.2205D-02	-0.6106D-02	-0.6565D-02	-0.5240D-02	-0.3510D-02	-0.2137D-02
-0.1175D-02	-0.5878D-03	-0.2746D-03	-0.1180D-03	-0.1606D-04	-0.1739D-04	-0.6032D-05	-0.1974D-05		
0.2510D-00	0.8914D-01	0.5640D-01	0.4042D-01	0.2952D-01	0.2108D-01	0.1442D-01	0.9175D-02	0.5439D-02	0.2999D-02
0.1551D-02	0.7430D-03	0.3352D-03	0.1403D-03	0.5453D-04	0.1987D-04	0.6780D-05	0.2156D-05		
0.2520D-00	0.1070D-00	0.8396D-01	0.7215D-01	0.6046D-01	0.4768D-01	0.3498D-01	0.2331D-01	0.1426D-01	0.8038D-02
0.4224D-02	0.2048D-02	0.9330D-03	0.3935D-03	0.1539D-03	0.5639D-04	0.1934D-04	0.6205D-05		
0.2469D-00	0.1227D-00	0.1101D-00	0.1028D-00	0.9059D-01	0.7369D-01	0.5513D-01	0.3718D-01	0.2291D-01	0.1298D-01
0.6046D-02	0.3327D-02	0.1519D-02	0.6417D-03	0.2513D-03	0.9217D-04	0.3164D-04	0.1017D-04		
0.2358D-00	0.1362D-00	0.1349D-00	0.1325D-00	0.1190D-00	0.9911D-01	0.7487D-01	0.5077D-01	0.3140D-01	0.1782D-01
0.9116D-02	0.4581D-02	0.2093D-02	0.8848D-03	0.3467D-03	0.1272D-03	0.4369D-04	0.1406D-04		
0.2186D-00	0.1477D-00	0.1583D-00	0.1611D-00	0.1485D-00	0.1239D-00	0.9418D-01	0.6408D-01	0.3971D-01	0.2257D-01
0.1193D-01	0.5809D-02	0.2656D-02	0.1123D-02	0.4400D-03	0.1615D-03	0.5548D-04	0.1787D-04		
0.1953D-00	0.1569D-00	0.1803D-00	0.1887D-00	0.1762D-00	0.1482D-00	0.1131D-00	0.7712D-01	0.4786D-01	0.2722D-01
0.1440D-01	0.7011D-02	0.3206D-02	0.1350D-02	0.5314D-03	0.1951D-03	0.6703D-04	0.2159D-04		
0.1660D-00	0.1640D-00	0.2009D-00	0.2152D-00	0.2032D-00	0.1718D-00	0.1316D-00	0.8989D-01	0.5583D-01	0.3177D-01
0.1681D-01	0.8107D-02	0.3745D-02	0.1584D-02	0.6207D-03	0.2279D-03	0.7831D-04	0.2523D-04		
0.1305D-00	0.1690D-00	0.2201D-00	0.7407D-00	0.2743D-00	0.1949D-00	0.1496D-00	0.1024D-00	0.6364D-01	0.3623D-01
0.1918D-01	0.9338D-02	0.4272D-02	0.1001D-02	0.7080D-03	0.2599D-03	0.8934D-04	0.2880D-04		
0.8901D-01	0.1718D-00	0.2379D-00	0.2651D-00	0.2547D-00	0.2173D-00	0.1673D-00	0.1146D-00	0.7127D-01	0.4058D-01
0.2149D-01	0.1046D-01	0.4787D-02	0.2025D-02	0.7934D-03	0.2913D-03	0.1001D-03	0.3228D-04		

FIGURE 10 : $\frac{1}{f_e} \left(\frac{\partial f_e}{\partial t} \right)^{\text{el coll, E, Coul}}$

COUL + CFT + COLL - UNSCALFD

-0.1582D 09	-0.00083D 09	-0.1563D 10	-0.2217D 10	0.2864D 10	-0.3503D 10	-0.4132D 10	-0.4658D 10	-0.5116D 10	-0.5520D 10
-0.5934D 10	0.6299D 10	-0.6723D 10	0.7121D 10	-0.7490D 10	-0.7926D 10	-0.8406D 10	-0.8964D 10	-0.9513D 10	-0.4871D 10
0.1203D 09	-0.7069D 09	-0.1738D 10	-0.1925D 10	-0.2506D 10	-0.3077D 10	-0.3639D 10	-0.4107D 10	-0.4513D 10	-0.4871D 10
-0.5231D 10	-0.5558D 10	-0.5934D 10	-0.6286D 10	-0.6619D 10	-0.6937D 10	-0.7421D 10	-0.7915D 10	-0.8390D 10	-0.4220D 10
0.3730D 09	-0.5232D 09	0.1101D 10	-0.1634D 10	-0.2149D 10	-0.2652D 10	-0.3144D 10	-0.3554D 10	-0.3909D 10	-0.4220D 10
0.1538D 10	-0.4017D 10	0.5144D 10	-0.5449D 10	-0.5738D 10	-0.6065D 10	-0.6434D 10	-0.6864D 10	-0.7302D 10	-0.3567D 10
0.6013D 09	-0.3175D 09	-0.0162D 09	0.1346D 10	0.1793D 10	-0.2236D 10	-0.2649D 10	-0.2999D 10	-0.3302D 10	-0.3567D 10
-0.3834D 10	-0.4014D 10	-0.4351D 10	-0.4610D 10	-0.4855D 10	-0.5132D 10	-0.5445D 10	-0.5811D 10	-0.6294D 10	-0.2913D 10
0.8017D 09	-0.1801D 09	-0.6554D 09	-0.1059D 10	-0.1457D 10	-0.1800D 10	-0.2153D 10	-0.2443D 10	-0.2694D 10	-0.2913D 10
-0.3137D 10	-0.3730D 10	-0.3957D 10	0.3769D 10	-0.3970D 10	-0.4198D 10	-0.4454D 10	-0.4755D 10	-0.5084D 10	-0.2256D 10
0.2754D 09	0.2116D 08	-0.4389D 09	-0.7752D 09	-0.1083D 10	-0.1374D 10	-0.1655D 10	-0.1836D 10	-0.2084D 10	-0.2256D 10
0.2451D 10	-0.2503D 10	-0.2761D 10	-0.2927D 10	-0.3033D 10	-0.3261D 10	-0.3461D 10	-0.3697D 10	-0.3927D 10	-0.1598D 10
0.1170D 10	0.1790D 09	0.2260D 09	-0.4934D 09	-0.7289D 09	-0.9482D 09	-0.1156D 10	-0.1327D 10	-0.1472D 10	-0.1598D 10
-0.1774D 10	-0.1035D 10	0.1913D 10	-0.2002D 10	-0.2194D 10	-0.2322D 10	-0.2466D 10	-0.2636D 10	-0.2836D 10	-0.9373D 09
0.1236D 10	0.7701D 09	-0.1923D 08	-0.2139D 09	-0.3761D 09	-0.5217D 09	-0.6567D 09	-0.7661D 09	-0.8583D 09	-0.9373D 09

-0.1016D 10	0.1081D 10	0.1163D 10	-0.1235D 10	-0.1304D 10	-0.1381D 10	-0.1469D 10	-0.1573D 10	-0.2425D 09	-0.2747D 09
0.1321D 10	0.4018D 09	0.1836D 09	0.6310D 08	-0.2414D 09	-0.9505D 08	-0.1559D 09	-0.2036D 09	-0.2425D 09	-0.2747D 09
-0.7051D 09	-0.3317D 09	0.3601D 09	-0.7365D 09	-0.1111D 09	-0.4385D 09	-0.4689D 09	-0.5077D 09	-0.5489D 09	-0.5999D 09
0.1374D 10	0.5230D 09	0.3015D 09	0.3376D 09	0.3268D 09	0.3318D 09	0.3462D 09	0.3605D 09	0.3753D 09	0.3899D 09
0.1015D 09	0.4235D 09	0.4445D 09	0.4015D 09	0.4837D 09	0.5065D 09	0.5350D 09	0.5608D 09	0.5952D 09	0.1057D 10
0.1390D 10	0.6750D 09	0.5743D 09	0.6096D 09	0.6768D 09	0.7590D 09	0.8495D 09	0.9265D 09	0.9952D 09	0.1057D 10
0.1173D 10	0.1131D 10	0.1254D 10	0.1310D 10	0.1781D 10	0.1454D 10	0.1537D 10	0.1632D 10	0.1632D 10	0.1726D 10
0.1335D 10	0.1770D 09	0.7670D 09	0.8700D 09	0.1020D 10	0.1186D 10	0.1354D 10	0.1494D 10	0.1617D 10	0.1726D 10
0.1840D 10	0.1740D 10	0.2061D 10	0.2174D 10	0.2289D 10	0.2403D 10	0.2544D 10	0.2706D 10	0.2898D 10	0.2398D 10
0.1336D 10	0.3790D 09	0.2442D 09	0.1145D 10	0.1374D 10	0.1614D 10	0.1860D 10	0.2064D 10	0.2242D 10	0.2398D 10
0.2560D 10	0.7502D 10	0.2873D 10	0.3032D 10	0.3182D 10	0.3355D 10	0.3554D 10	0.3783D 10	0.4069D 10	0.3072D 10
0.1753D 10	0.9002D 09	0.1121D 10	0.1409D 10	0.1721D 10	0.2042D 10	0.2367D 10	0.2636D 10	0.2869D 10	0.3072D 10
0.1753D 10	0.7502D 10	0.3667D 10	0.3897D 10	0.4086D 10	0.4310D 10	0.4566D 10	0.4864D 10	0.5208D 10	0.5594D 10
0.1173D 10	0.9775D 09	0.1297D 10	0.1670D 10	0.2066D 10	0.2470D 10	0.2876D 10	0.3210D 10	0.3408D 10	0.3748D 10
0.1006D 10	0.4735D 10	0.4504D 10	0.4750D 10	0.4990D 10	0.5267D 10	0.5581D 10	0.5947D 10	0.6364D 10	0.6834D 10
0.2932D 09	0.1077D 10	0.1456D 10	0.1927D 10	0.2410D 10	0.2899D 10	0.3386D 10	0.3786D 10	0.4129D 10	0.4427D 10
0.1776D 10	0.7502D 10	0.5724D 10	0.5079D 10	0.4400D 10	0.3707D 10	0.3009D 10	0.2304D 10	0.1594D 10	0.0879D 10
0.7755D 09	0.1007D 10	0.1615D 10	0.2181D 10	0.2794D 10	0.3427D 10	0.4080D 10	0.4364D 10	0.4764D 10	0.5109D 10
0.5006D 10	0.5777D 10	0.6115D 10	0.6490D 10	0.6881D 10	0.7189D 10	0.7619D 10	0.8125D 10	0.8704D 10	0.9364D 10
0.5555D 09	0.1106D 10	0.1767D 10	0.2437D 10	0.3070D 10	0.3750D 10	0.4411D 10	0.4945D 10	0.5401D 10	0.5794D 10
0.6201D 10	0.6769D 10	0.6972D 10	0.7362D 10	0.7728D 10	0.8155D 10	0.8643D 10	0.9219D 10	0.9884D 10	1.0649D 10

FIGURE 11 : $\frac{\partial f_e}{\partial z}$

-52-

DFID

-0.1603D-07	0.2469D-07	-0.2697D-07	-0.2209D-07	-0.1675D-07	-0.1179D-07	-0.7714D-08	-0.4605D-08	-0.2541D-08	-0.1302D-08
-0.6264D-09	-0.2799D-09	-0.1181D-09	-0.4640D-10	-0.1698D-10	-0.5843D-11	-0.1088D-11	-0.5737D-12		
0.1436D-07	-0.2621D-07	-0.2571D-07	-0.2151D-07	-0.1644D-07	-0.1162D-07	0.7620D-08	-0.4554D-08	-0.2515D-08	-0.1289D-08
-0.6202D-09	-0.2771D-09	-0.1170D-09	-0.4595D-10	-0.1682D-10	-0.5707D-11	-0.1870D-11	-0.5683D-12		
0.5095D-07	0.2216D-07	-0.2431D-07	-0.2086D-07	-0.1610D-07	-0.1143D-07	-0.7520D-08	-0.4500D-08	-0.2487D-08	-0.1275D-08
-0.6138D-09	-0.2743D-09	-0.1158D-09	-0.4549D-10	-0.1665D-10	-0.5729D-11	-0.1851D-11	-0.5628D-12		
0.4506D-07	-0.1721D-07	-0.2262D-07	-0.2009D-07	-0.1571D-07	-0.1123D-07	-0.7409D-08	-0.4442D-08	-0.2457D-08	-0.1261D-08
-0.6071D-09	-0.2713D-09	-0.1146D-09	-0.4501D-10	-0.1648D-10	-0.5670D-11	-0.1832D-11	-0.5573D-12		
0.1547D-06	-0.1020D-07	-0.2046D-07	-0.1913D-07	-0.1523D-07	-0.1098D-07	-0.7281D-08	-0.4377D-08	-0.2425D-08	-0.1245D-08
-0.5908D-09	-0.2682D-09	-0.1133D-09	-0.4451D-10	-0.1629D-10	-0.5608D-11	-0.1813D-11	-0.5515D-12		
0.2492D-06	-0.1612D-08	-0.1743D-07	-0.1781D-07	-0.1460D-07	-0.1066D-07	-0.7122D-08	-0.4297D-08	-0.2386D-08	-0.1227D-08
-0.5916D-09	-0.2641D-09	-0.1118D-09	-0.4397D-10	-0.1610D-10	-0.5542D-11	-0.1792D-11	-0.5455D-12		
0.3807D-06	0.1361D-07	-0.1247D-07	-0.1570D-07	-0.1361D-07	-0.1019D-07	-0.6893D-08	-0.4187D-08	-0.2334D-08	-0.1203D-08
-0.5813D-09	-0.2603D-09	-0.1101D-09	-0.4352D-10	-0.1507D-10	-0.5406D-11	-0.1700D-11	-0.5388D-12		
0.6920D-06	0.4699D-07	-0.1744D-08	-0.1122D-07	-0.1158D-07	-0.9242D-08	-0.6453D-08	-0.3986D-08	-0.2244D-08	-0.1164D-08
-0.5646D-09	-0.2536D-09	-0.1075D-09	-0.4230D-10	-0.1554D-10	-0.5361D-11	-0.1736D-11	-0.5301D-12		
0.2195D-05	0.2074D-06	0.4940D-07	0.9020D-08	-0.2205D-08	-0.4096D-08	-0.4545D-08	-0.3144D-08	-0.1881D-08	-0.1012D-08
-0.5635D-09	-0.2300D-09	-0.9484D-10	-0.3934D-10	-0.1454D-10	-0.5050D-11	-0.1645D-11	-0.5076D-12		
-0.2255D-05	-0.2674D-06	-0.1015D-06	-0.5196D-07	-0.2952D-07	-0.1725D-07	-0.9981D-08	-0.5505D-08	-0.2879D-08	-0.1421D-08
-0.6616D-09	-0.2407D-09	-0.1207D-09	-0.4676D-10	-0.1632D-10	-0.5768D-11	-0.1849D-11	-0.5544D-12		
-0.7500D-06	-0.1070D-06	-0.5038D-07	0.3092D-07	-0.2015D-07	-0.1300D-07	-0.8073D-08	-0.4663D-08	-0.2517D-08	-0.1260D-08
-0.6035D-09	-0.2671D-09	-0.1120D-09	-0.4572D-10	-0.1592D-10	-0.5457D-11	0.1758D-11	-0.5318D-12		
-0.4145D-06	0.2762D-07	-0.3965D-07	-0.2645D-07	-0.1812D-07	-0.1206D-07	0.7634D-08	-0.4461D-08	-0.2426D-08	-0.1230D-08
-0.5868D-09	-0.2604D-09	-0.1094D-09	-0.4278D-10	-0.1560D-10	-0.5352D-11	-0.1726D-11	-0.5232D-12		
0.3072D-06	0.5823D-07	-0.3469D-07	-0.2434D-07	-0.1713D-07	-0.1158D-07	-0.7404D-08	-0.4352D-08	-0.2375D-08	-0.1206D-08
-0.5765D-09	-0.2561D-09	-0.1077D-09	-0.4214D-10	-0.1537D-10	-0.5276D-11	-0.1702D-11	-0.5165D-12		
-0.2186D-06	-0.2421D-07	-0.3166D-07	-0.2302D-07	-0.1650D-07	-0.1127D-07	-0.7245D-08	-0.4272D-08	-0.2336D-08	-0.1188D-08
-0.5683D-09	-0.2526D-09	-0.1062D-09	0.4159D-10	-0.1517D-10	-0.5210D-11	-0.1681D-11	-0.5104D-12		
-0.1590D-06	0.4279D-07	-0.2450D-07	0.2095D-07	0.1602D-07	-0.1102D-07	-0.7117D-08	-0.4207D-08	-0.2303D-08	-0.1172D-08
-0.5610D-09	-0.2494D-09	-0.1049D-09	-0.4109D-10	-0.1499D-10	-0.5143D-11	-0.1662D-11	-0.5047D-12		
-0.1149D-06	0.3785D-07	-0.2762D-07	-0.2178D-07	-0.1563D-07	-0.1081D-07	-0.7007D-08	-0.4149D-08	-0.2274D-08	-0.1158D-08
-0.5543D-09	-0.2464D-09	-0.1037D-09	-0.4061D-10	-0.1402D-10	-0.5009D-11	-0.1643D-11	-0.4991D-12		
0.2031D-07	-0.2790D-07	-0.2641D-07	-0.2063D-07	-0.1529D-07	-0.1063D-07	-0.6906D-08	-0.4095D-08	-0.2246D-08	-0.1144D-08
0.5479D-09	-0.2436D-09	-0.1025D-09	-0.4015D-10	-0.1465D-10	-0.5031D-11	-0.1624D-11	-0.4936D-12		
0.4121D-07	-0.3051D-07	-0.2519D-07	-0.2005D-07	-0.1498D-07	-0.1016D-07	-0.6813D-08	-0.4044D-08	-0.2220D-08	-0.1131D-08
-0.5417D-09	-0.2408D-09	-0.1014D-09	-0.3970D-10	-0.1448D-10	-0.4974D-11	-0.1606D-11	-0.4882D-12		

FIGURE 11 : $\frac{1}{f_e} \frac{\partial f_e}{\partial z}$

DFDZ

-0.18440 02	-0.15050 03	-0.10550 03	-0.16710 03	-0.16650 03	-0.16060 03	-0.16830 03	-0.16440 03	-0.15930 03	-0.15380 03
-0.14060 03	-0.14500 03	-0.14240 03	0.13960 03	-0.13690 03	-0.13540 03	-0.13480 03	-0.13560 03		
0.17210 02	-0.14140 03	-0.15460 03	-0.10500 03	-0.16710 03	0.16790 03	0.16790 03	-0.16430 03	-0.15930 03	-0.15380 03
-0.14960 03	0.14500 03	-0.14240 03	-0.13910 03	-0.13630 03	-0.13540 03	-0.13490 03	-0.13570 03		
0.25000 03	0.12070 03	-0.15250 03	-0.16160 03	-0.10530 03	0.16090 03	-0.16750 03	-0.16400 03	-0.15920 03	-0.15380 03
-0.11900 03	0.14500 03	-0.14140 03	-0.13970 03	-0.13700 03	-0.13550 03	-0.13500 03	-0.13480 03		
0.49200 03	-0.14700 02	0.14340 03	-0.15730 03	0.16300 03	-0.16560 03	0.16670 03	-0.16360 03	-0.15890 03	-0.15360 03
-0.14050 03	0.14410 03	0.14240 03	-0.13770 03	-0.13700 03	-0.13550 03	-0.13500 03	-0.13480 03		
0.00110 03	-0.16000 02	-0.13110 03	0.15130 03	-0.15970 03	0.16370 03	-0.16560 03	-0.16290 03	-0.15050 03	-0.15330 03
-0.14010 03	-0.14100 03	0.14230 03	-0.13960 03	-0.13690 03	-0.13540 03	-0.13480 03	-0.13590 03		
0.12510 01	-0.09090 01	-0.11290 03	-0.14210 03	-0.15470 03	-0.10060 03	-0.16370 03	-0.16160 03	-0.15760 03	-0.15270 03
-0.11600 03	-0.14140 03	-0.11200 03	-0.13940 03	-0.13670 03	-0.13520 03	-0.13480 03	-0.13580 03		
0.20160 01	0.11140 02	0.01630 02	0.11690 03	-0.14580 03	0.15520 03	-0.16010 03	-0.15920 03	-0.15590 03	-0.15140 03
-0.11700 03	0.14560 03	0.14130 03	-0.13800 03	-0.13620 03	-0.13480 03	-0.13450 03	-0.13560 03		
0.18000 04	0.27010 03	0.11540 02	-0.01690 02	-0.12540 03	-0.14230 03	-0.15160 03	-0.15320 03	-0.15150 03	-0.14800 03
-0.14510 03	0.14110 03	0.13950 03	-0.13770 03	-0.13490 03	-0.13370 03	-0.13350 03	-0.13490 03		
0.11090 03	0.12050 04	0.13040 03	0.01130 01	-0.24140 02	-0.07770 02	-0.10790 03	-0.12220 03	-0.12840 03	-0.13010 03
0.11090 03	-0.12960 03	0.12960 03	-0.12630 03	-0.13760 03	-0.12730 03	-0.12790 03	-0.13060 03		
0.11090 03	-0.15710 04	0.068670 03	0.43410 03	-0.32600 03	-0.27150 03	-0.23970 02	0.21630 03	-0.19070 03	-0.18470 03
-0.17410 03	-0.10510 03	-0.16000 03	-0.15480 03	0.15010 03	0.14710 03	-0.14510 03	-0.14420 03		
0.41630 01	-0.16580 03	-0.13400 03	-0.13610 03	-0.12560 03	0.20700 03	-0.19600 03	-0.18530 03	-0.17560 03	-0.16690 03
-0.10040 03	0.15460 03	0.15020 03	-0.14640 03	-0.14280 03	0.11070 03	-0.13980 03	-0.13990 03		
0.21000 04	0.41150 03	0.21430 03	-0.22400 03	-0.20520 03	0.19410 03	-0.18750 03	-0.17930 03	-0.17130 03	0.16350 03
-0.14770 03	0.15100 03	0.14610 03	0.11490 03	0.14170 03	-0.13960 03	-0.13880 03	-0.13920 03		
0.17100 01	0.15000 03	-0.24100 03	-0.21040 03	-0.19630 03	-0.18360 03	-0.18390 03	-0.17690 03	-0.16950 03	-0.16220 03
0.15660 03	0.15100 03	0.14770 03	-0.14140 03	0.14110 03	-0.13110 03	-0.13850 03	-0.13900 03		
0.11530 04	-0.10710 03	0.12420 03	0.10130 02	-0.13120 03	-0.16560 03	-0.18210 03	-0.17570 03	-0.16870 03	-0.16170 03
0.15030 03	-0.15010 03	0.11750 03	0.11420 03	-0.14090 03	-0.13900 03	-0.13840 03	-0.13900 03		
0.15000 03	0.10170 03	0.11140 03	-0.19510 03	-0.18700 03	-0.18370 03	-0.18100 03	-0.17510 03	-0.16030 03	-0.16140 03
0.15020 03	0.15000 03	-0.14140 03	-0.14110 03	-0.14090 03	0.13900 03	-0.13840 03	-0.13900 03		
-0.10750 03	0.15010 03	0.10170 03	-0.19060 03	-0.18550 03	-0.18240 03	-0.18030 03	-0.17470 03	-0.16020 03	-0.16130 03
-0.15010 03	-0.15010 03	0.14740 03	0.14410 03	-0.14090 03	-0.13910 03	-0.13840 03	-0.13910 03		
0.16010 03	0.15010 03	0.14300 03	0.13700 03	0.16360 03	-0.18150 03	-0.17990 03	-0.17460 03	-0.16810 03	-0.16130 03

-0.15070 03	-0.15060 03	0.14750 03	-0.14420 03	0.14100 03	-0.13910 03	0.13850 03	-0.13030 03		
-0.15040 03	-0.15060 03	-0.14410 03	-0.14400 03	-0.18210 03	-0.13080 03	-0.17960 03	-0.17450 03	-0.16820 03	-0.16140 03
-0.15030 03	0.15000 03	0.14760 03	-0.14440 03	0.14110 03	-0.13930 03	-0.13870 03	-0.13940 03		