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SOTRM: A PROGRAM TO GENERATE
FIRST AND SECOND ORDER MATRIX ELEMENTS BY
TRACKING CHARGED PARTICLES IN A
SPECIFIED MAGNETIC FIELD

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SOTRM: A PROGRAM TO GENERATE FIRST AND SECOND ORDER
MATRIX ELEMENTS BY TRACKING CHARGED PARTICLES IN A
SPECIFIED MAGNETIC FIELD

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ABSTRACT

A CDC 6600, FORTRAN IV program SOTRM is described. SOTRM generates first and second order transformation elements by integrating numerically through a specified magnetic field. It can also be used for ray tracing. Data input is described and an illustrative example is presented. The results obtained can be used in a matrix beam transport program.

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I. INTRODUCTION

Program SOTRM is a CDC 6600, FORTRAN IV program that generates first and second order transformation elements by integrating numerically through a specified magnetic field a specific set of rays which are then used in an appropriate elimination scheme [1]. It can also ray trace up to 30 nearby rays while integrating for the central orbit. For the purpose of evaluating the significance of the generated elements, it has the ability to apply a previously generated set of elements to the initial conditions of the nearby rays currently being obtained by integration and thus compare the integrated values of the solution with those obtained by applying the transformation.

This program consists of a number of subroutines and should be easily adaptable to various physical problems. We shall give in the following sections brief descriptions of these routines that should help in understanding the program and its subroutines, an explanation of the necessary data input, and a simple test example. It is assumed that the reader is familiar with the development given in [1]; however, the program is easy to use and if the 'black box' approach is taken, it should be possible to set up problems and run the program without consulting [1].

The necessary data input is given in Table III, sample test data is given in Table IV, the resultant output in Table V, and the program listing in Table VI.

II. PROGRAM AND SUBPROGRAM DESCRIPTIONS

The main program is

```
PROGRAM SOTRM(INPUT,OUTPUT,TAPE1)
```

and it is a driving program for subroutine SOTRM1 which actually generates the desired quantities. The sole purpose of SOTRM is to input data that is used in SOTRM1 and to call and execute that subroutine under user control. If it is desired to incorporate SOTRM1 into some user written program, then SOTRM may be discarded.

The main program is built in the style:

```
control:= read; if control= -1 then STOP else
if control=1 then
  begin comment whatever happens when control=1. See the input section;
end else
  if control=2 then
    begin whatever happens when control=2;
    .
    .
  end else
    .
    .
    .
```

The main program is, essentially, described by the data input so we shall describe it no further here.

```
SUBROUTINE SOTRM1(S01,Z1,P1,V,W,PR,PI)
  REAL S01,Z1(1),P1(1),V(5,5),W(5,5,5),PR(1)
  INTEGER PI(1)
```

This subroutine generates a first order matrix V, and a second order matrix W.

It can also ray trace one reference ray and up to 30 nearby rays. All necessary values are supplied and returned in the argument list; the variables appearing there are described in Table I.

There are a number of labeled commons in SOTRM1 that are used for communicating with the subprograms and their names and associated variables are given in Table II.

Once it sets all the initial conditions, SOTRM1 is basically a calling routine for the integration routines. Presently, the Lawrence Radiation Laboratory library routine ZAM [2] is used to carry out this integration. The integration loop will be executed until the program is shut off. The three variables in the common block LIMIT allow the user to control this shut off. The integration loop is exited from and the final values calculated whenever $S_0 \geq S_0\text{MAX}$ or the number of passes through the loop is greater than MAX. Thus, any criteria can be used to delimit the integration range and then one of the variables in LIMIT may be used to actually exit from the loop.

The action taken with regard to matrix generation and printout while integrating will depend on the values of the variables appearing in the integer parameter vector PI. These are explained in the section giving the data input to the driving program SOTRM.

SOTRM1 is built so that upon entry, the values in S_0 , Z1, P1 are the initial values and upon exit, all arguments have their final value. In general, successive calls to SOTRM1 will generate cumulative results valid over the range of a particular call. The exact effect can be ascertained by consulting Table I.

Subroutines ZINIT and ZFINAL are used to establish respectively the

initial values of the solution vector upon entry into SOTRMI and the current, or final, values of the solution vector corresponding to S_0 , or to S_01 upon exit from SOTRMI. It should be remembered that the nearby rays have coordinates $(\delta x_1, \delta \theta_1, \delta x_2, \delta \theta_2, \delta P/P)$ external to SOTRMI, but we are integrating $(\delta x_1, \delta P_1, \delta x_2, \delta P_2)$, thus these two routines perform the necessary transformations.

Subroutine SF generates second order elements using either equation (20) or equation (21) of [1]. The initial values chosen for this elimination are as given in subroutine SETZ which actually sets the initial conditions when generating matrix elements. This subroutine uses the values $(A(1), \dots, A(5))$ located in common YAFS. If we use the dimensionless coordinates $(\delta x_1/\rho, \delta \theta_1, \delta x_2/\rho, \delta \theta_2, \delta P/P_0)$ where ρ is the radius of curvature of the reference particle, then for a uniform field, we have an optimum choice of $(.01, .1, .01, .1, .0001)$ for the value of the vector A.

Subroutine FIELD is expected to set the magnetic field values in the common block FIELD corresponding to the current value of the integration variable S_0 . The units are MKS.

Subroutine GAUSS takes a position vector R corresponding to S_0 and returns the value in gauss of the three field components g_1, g_2, g_3 . For the reference particle, these are in the global coordinate system; for the nearby particle, they are in the local coordinate system; that is, the moving trihedral.

Subroutine FUNC(S_0, Z, F) evaluates the right hand side of the differential equation $DZ = F(Z(s_0))$. See [1], equations (2) and (10).

The purpose of the remaining subroutines used in SOTRMI can be ascertained from the program source listing. In practice, it should be

possible to treat a variety of cases by making appropriate changes to the two field routines FIELD and GAUSS. The integration routines can be changed by substituting another integration package for ZAM [2].

III. PROGRAM CONTROL AND DATA INPUT FOR SOTRM

PROGRAM SOTRM (INPUT,OUTPUT,TAPE1)

This program drives SOTRM1 and can be used to ray trace or to generate transfer matrix elements or a combination of these tasks.

The program is controlled by inputting a quantity S that determines what the program will do. In Table III are given the values of S and the corresponding card, or cards, read and the action taken. S = - 1.0 stops the program and S = 99.0 calls the subroutine SOTRM1.

The program always reads S and after executing the selected section it will again read S. Thus, one can do as many cases as desired. Schematically, we have

```
L1:   S := read;

      execute the appropriate section;

      go to L1;
```

A few comments about SOTRM1 are in order here. The vector Z contains the values of the solution corresponding to S0. Before calling SOTRM1, S = 99, the user must be sure that these values are properly set. Upon exit from SOTRM1, the values in Z will correspond to the value of S0 which existed at the time of exit. Thus, two consecutive calls to SOTRM1 will be cumulative unless the user resets the values in the Z vector. This feature, while possibly annoying in some cases, allows one to have some control when integrating through a series of elements.

However, when generating matrix elements, the subroutine SETZ will store the perturbations in Z upon each entry into SOTRM1. Thus, the

generation of the matrices is not cumulative, but correspond instead to the range of integration within one call to SOTRM1. The final value of the solution vector used to generate the matrix elements does, however, reside in Z upon exit from SOTRM1. The initial values used to start the integration loop in SOTRM1 are stored in the common block ZSAVE, should they be desired. When checking the integrated values against those obtained from the generated transformation elements, subroutine APTRAN applies the transformation to the values in ZSAVE.

IV. SAMPLE DATA INPUT AND CORRESPONDING OUTPUT

To illustrate the program data input and output, we use as an example a 510.72 MeV proton reference particle which moves in a circle in a uniform field of one meter. The data for these examples are given in Table IV.

In Example 1, we generate a transfer matrix corresponding to a 45° bend. Example 2 traces a reference ray and two nearby rays through a 45° bend. Example 3 generates a matrix correspond to a 45° bend, saves the matrix and subsequently applies it to three nearby rays to check against the integrated values. The output of the program SOTRM for these three examples is presented in Table V.

In Example 3, the values ZTRAN represent the values (δx_1 , $\delta \theta_1$, δx_2 , $\delta \theta_2$, $\delta P/P$) obtained by applying the transformation to the initial values. Whereas, ZSOLN gives the values obtained by integration. In the first case, the solution was used to obtain the transformation, thus the two columns are essentially identical. However, the next pass applies the transformation to an arbitrary nearby ray and the results are seen to be somewhat different which is, of course, expected.

Table ISOTRMI Argument List

<u>Variable</u>	<u>Comment</u>
SØ1	The initial value of the independent variable at the time SOTRMI is called. The final value of the independent variable upon exit from SOTRMI.
Z1	This vector contains the values of the coordinates of the reference ray and the nearby rays corresponding to the value of SØ1 upon entry and exit. It is the same as Z in SOTRM and must be set as indicated on the card C4 input to SOTRM. Note: When generating matrix elements, SOTRMI will place the initial conditions in Z1, thus, destroying any previously set values. The matrix is, therefore, not cumulative for successive calls to SOTRMI.
P1	This vector contains the momentum perturbation $\delta P/P_0$ of the nearby particles. It is the same as P in SOTRM and must be set as indicated on the card C2 input to SOTRM. The dimensions of P1 and Z1 must be large enough to hold the required information. Presently P1 has up to 30 elements and Z1 up to $4 \times 31 = 124$ elements.
V(5,5)	Upon exit from SOTRMI, the first order elements of the transfer matrix corresponding to the value of SØ1 are stored here if these values have been asked for.
W(5,5,5)	Upon exit from SOTRMI, the second order elements of the transfer matrix corresponding to the value of SØ1 are stored here if those values have been asked for. The

Table I - contd.

<u>Variable</u>	<u>Comment</u>
	nearby rays are assumed to be a vector $y = (\delta x_1[\text{cm}], \delta\theta_1[\text{mr}], \delta x_2[\text{cm}], \delta\theta_2[\text{mr}], \delta P/P_0)$ and these arrays can be applied directly as $y_i = \sum_j V_{ij} y_j^{(o)} + \sum_{j,k} W_{ijk} y_j^{(o)} y_k^{(o)}.$
PR	This is a real parameter vector the values of which are param (1), ..., param (4) of SOTRM. See the card A2 input to SOTRM.
PI	This is an integer parameter vector the values of which are param (5), ..., param (8) of SOTRM. See the card A2 input of SOTRM.

Table II

SOTRM Tabled Common Blocks

<u>Common Block</u>	<u>Variable</u>	<u>Comment</u>
CASES	NUM	The number of rays, including the reference ray, that are being tracked. Present limit 31.
	L	Global counter
	K	Global counter
CHARGE	Q	Charge [MKS] of the reference particle and of nearby particles.
MOM	P0	Momentum [MKS] of the reference particle.
	P(40)	Momentum, $1 + \delta P/P_0$, of the nearby particles.
FIELD	BB02	Field $B_2(r_1, 0, r_2)$ [Webers] on the reference orbit. It is assumed that the field is only in the two direction [1]. See the figure for the card B input to SOTRM to obtain the axis orientation.
	BB1(40)	The B_1 component of the field on the nearby orbit at the current value of the independent variable S0.
	BB2(40)	The B_2 component of the field on the nearby orbit.
	BB3(40)	The B_3 component of the field on the nearby orbit.
SOLN	Z(164)	The current value of the solution vector. It's value corresponds to equations (3) and (9) of [1]. The units are [MKS].
DER	F(164)	The righthand side of the equation $DZ = F(Z)$. These values are defined by equations (2) and (10) of [1]

Table II - contd.

<u>Common Block</u>	<u>Variable</u>	<u>Comment</u>
PARAM	CONST(8)	Contains the conversion factors from external units to internal [MKS] units.
LIMIT	SØ	Current value of the independent variable.
	SØMAX	The maximum allowed value of SØ.
	MAX	The maximum total number of steps allowed in the integration process.
YAFS	YP(5)	The current $y(+t^{(j)})$ vector for the elimination process [1].
	YM(5)	The current $y(-t^{(j)})$ vector for the elimination process [1].
	A(5)	The perturbation values (δx_1 [cm], $\delta \theta_1$ [mr], δx_2 [cm], $\delta \theta_2$ [mr], $\delta P/P_C$) used when constructing the first and second order matrix elements.
	U(5,5)	The first order matrix correspond to the current value of SØ.
	S(5,5,5)	The second order matrix corresponding to the current value of SØ.
WORK	COUNT	The number of function evaluations used in the integration process to move from SØ1 to the current value of SØ.
	STEP	The current number of maximum step sizes taken.
INIT	ZSAVE(15Ø)	Saves the initial values (δx_1 , $\delta \theta_1$, δx_2 , $\delta \theta_2$, $\delta P/P_O$) if all nearby rays corresponding to SØ1 upon entry into SOTRM1.

Table III

Data Input to SOTRM
May 10, 1970

<u>Value of S</u>	<u>Card</u>	<u>Parameters Read</u>	<u>Format</u>
1	A1	K	E10.0
	A2	(I, PARAM(I), I = 1, K)	(I5, 5X, E15.0)
		param(1) = Q = signed number of charges	
		param(2) = detsin = max. step size [cm]	
		param(3) = s0 max = max. arc length [m]	
		param(4) = S01 = initial arc length [m]	
		param(5) = option	
		0 ray trace.	
		1 first order matrix.	
		- 1 first order matrix, second order trace.	
		2 first order and second order matrices, asymmetric.	
		3 first order and second order matrices, symmetric.	
		param(6) = num = number of rays including the center reference ray. May be set to 1 if generating matrix elements. Value $\leq$ 31.	
		param(7) = max = maximum number of steps that can be taken, includes all step adjustments of the variable step size integrator.	
		param(8) = nprint	
		= 0 No print out of ray trace or of matrix generation.	

Table III - contd.

Value of S	Card	Parameters Read	Format
param(8) = nprint (continued)			
		> 0	Print out every nprint steps, will also print initial and final values.
		< 0	Same as > 0 except that the matrix elements will be stored on Tape 1 if generating elements or will be read from Tape 1 and applied to the initial conditions if ray tracing.
2	B	(low lim(1), uplim(1), I = 1, 3)	(8E10.0)
		low lim (i)	The lower limit of the reference particle [m].
		up lim (i)	The upper limit of the reference particle [m].
3	C		
(3V3.1)	C1	K	(I5)
	C2	(I,P(i),I = 1,K)	(I5,5X,E15.0)
P(i) = momentum of the <u>nearby particle</u> $\delta P/P_0$.			
We have to have read in (num -1) of these at least once.			

Table III -contd.

Value of S	Card	Parameters Read	Format
(3V3.2)	C3	L	I5
	C4	(I, Z(i), i = 1,L)	(I5,5X,E15.0)
		Z(1) = reference ray Pc [mev]	
		Z(2) = angle [deg]	
		Z(3) = starting x ₁ [meters]	
		Z(4) = starting x ₃ [meters]	
		Z(5) = δx_1 [cm]	
		Z(6) = θ_1 [milliradian]	
		Z(7) = δx_2 [cm]	
		Z(8) = θ_2 [milliradian]	
4	D	(A1(I, J), J = 1,10), I = 1,10)	(5E10.0)
		(A2(I, J), J = 1,10), I = 1,10)	
		Input row wise 5 items/ card the matrix A1 and then the matrix A2. These can be used as one wishes, but are presently used with F. Selph field	
5	E		
(5V5.1)	E1	K	(I5)
	E2	(I,J,A1(I,J),L=1,K)	(J5,I5,E15.0)
(5V5.2)	E3	K	(I5)
	E4	(I,J,A2(I,J),L=1,K)	(I5,I5,E15.0)
		Allows one to change values of the individual elements of A1 or A2 or both.	

Table III - contd.

Value of S	Card	Parameters Read	Format
6	F1	K	(I5)
	F2	(I,A(I),L = 1,K)	(I5,5X,E15.0)
		$A(1) = \delta x_1$ [cm] $A(2) = \delta x_1'$ [mr] $A(3) = \delta x_2$ [cm] $A(4) = \delta x_2'$ [mr] $A(5) = \delta p/p$	These are the magnitude of the perturbation for the derivative calculation. They are nominally set by data statements as $\left\{ \begin{array}{l} .01 \text{ [cm]} \\ .1 \text{ [mr]} \\ .01 \text{ [cm]} \\ .1 \text{ [mr]} \\ .0001 \end{array} \right.$

Table IV

SAMPLE INPUT DATA

EXAMPLE 1		EXAMPLE 3	
1.0		1.0	
8		8	
1	1.0	1	1.0
2	1.5707963267949	2	1.5707963267949
3	30.0	3	30.0
4	0.0	4	0.0
5	3.0	5	3.0
6	1.0	6	1.0
7	50.0	7	50.0
8	50.0	8	-50.0
3.2		3.2	
4		4	
1	510.72	1	510.72
2	90.0	2	90.0
3	2.0	3	2.0
4	1.0	4	1.0
99.0		99.0	
-1.		1.0	
		2	
		5	0.0
		6	4.0
1.0		3.1	
8		3	
1	1.0	1	.01
2	1.5707963267949	2	.05
3	30.0	3	.10
4	0.0		
5	0.0	3.2	
6	3.0	16	
7	50.0	1	510.72
8	50.0	2	90.0
3.2		3	2.0
12		4	1.0
1	510.72	5	.5
2	90.0	6	5.0
3	2.0	7	.5
4	1.0	8	5.0
5	1.0	9	1.0
6	0.0	10	10.0
7	0.0	11	1.0
8	0.0	12	10.0
9	0.0	13	5.0
10	0.	14	20.0
11	1.0	15	5.0
12	5.0	16	20.0
3.1		99.0	
2		-1.0	
1	.01		
2	.01		
99.0			
-1.0			

TABLE V

PROGRAM OUTPUT EXAMPLES 1 - 3

1

EXAMPLE 1

CONTROL= 1.000
NUMBER OF PARAMETERS READ = 8

C= 1.0000000
DELSIN= 1.57079633 (CM)
SOMAX= 30.0000000 (M)
SO1= 0.0000000 (M)
OPTICN= 3.0000000
NUM= 1.0000000
MAX= 50.0000000
NPRINT= 50.0000000

CONTROL= 3.200
NUMBER OF PARAMETERS READ = 4

Z(1)= 510.7200000(MEV) Z(2)= 90.0000000(DEG) Z(3)= 2.0000000(M) Z(4)= 1.0000000(M)
Z(

CONTROL= 99.000

START OF SOTRMI

1 THE FOLLOWING HEADINGS ARE TO BE USED FOR CCL. 1-7

K= 0	PX(MEV/C)	PY(MEV/C)	X(M)	Y(M)	THETA(DEG)	FUNC CALLS	CPY/PO
K=(1,NUM-1)	X(CM)	X (MR)	Y(CM)	Y (MR)	DP/PO	DPX/PO	
U(1,J) / J=	1	2	3	4	5		
S(1,J,K) / K=	1	2	3	4	5		

I	SO(METER)	K	1	2	3	4	5	6	7
0	0.00000	0	5.1072000E+02	-8.7594838E-13	2.0000000E+00	1.0000000E+00	9.0000000E+01		1
		U(1,J)	1.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00		
		U(2,J)	0.0000000E+00	1.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00		
		U(3,J)	0.0000000E+00	0.0000000E+00	1.0000000E+00	0.0000000E+00	0.0000000E+00		
		U(4,J)	0.0000000E+00	0.0000000E+00	0.0000000E+00	1.0000000E+00	0.0000000E+00		
		U(5,J)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	1.0000000E+00		
		S(1,1,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00		
		S(1,2,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00		
		S(1,3,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00		
		S(1,4,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00		
		S(1,5,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00		
		S(2,1,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00		
		S(2,2,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00		
		S(2,3,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00		
		S(2,4,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00		
		S(2,5,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00		
		S(3,1,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00		
		S(3,2,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00		

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TABLE V - contd.

Example 1 - contd.

SC .78540
 0 3.6113357E+02 3.6113358E+02 2.7071068E+00 1.2928932E+00 4.5000000E+01
 U(1,J) 7.0710678E-01 7.0710678E-02 0.0000000E+00 0.0000000E+00 2.9289322E+01
 U(2,J) -7.0710678E+00 7.0710678E-01 0.0000000E+00 0.0000000E+00 7.0710679E+02
 U(3,J) 0.0000000E+00 0.0000000E+00 1.0000000E+00 7.8539317E-02 0.0000000E+00
 U(4,J) 0.0000000E+00 0.0000000E+00 0.0000000E+00 1.0000000E+00 0.0000000E+00
 U(5,J) 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 1.0000000E+00

 S(1,1,K) -2.4999997E-03 2.4999999E-04 -8.4703295E-18 -4.3512594E-11 2.4999999E-01
 S(1,2,K) 2.4999999E-04 1.0355356E-05 4.2351647E-19 -2.4701251E-12 1.0355328E-02
 S(1,3,K) -8.4703295E-18 4.2351647E-19 0.0000000E+00 -4.2351647E-19 -8.4703295E-16
 S(1,4,K) -4.3512594E-11 -2.4701251E-12 -4.2351647E-19 -1.4644658E-05 -3.0758907E-09
 S(1,5,K) 2.4999999E-01 1.0355328E-02 -8.4703295E-16 -3.0758907E-09 -2.5000013E+01
 S(2,1,K) 4.6447290E-08 -1.7405893E-09 1.2924697E-22 -8.8496523E-10 3.5355317E+00
 S(2,2,K) -1.7405893E-09 -3.5355301E-04 -1.3552527E-17 -7.5073929E-11 -2.2711833E-07
 S(2,3,K) 1.2924697E-22 -1.3552527E-17 0.0000000E+00 -6.7762636E-18 -2.7105054E-14
 S(2,4,K) -8.8496523E-10 -7.5073929E-11 -6.7762636E-18 -3.5355329E-04 -8.5854197E-08
 S(2,5,K) 3.5355317E+00 -2.2711833E-07 -2.7105054E-14 -8.5854197E-08 -7.0710708E+02
 S(3,1,K) 0.0000000E+00 0.0000000E+00 0.0000000E+00 3.5355339E-04 0.0000000E+00
 S(3,2,K) 0.0000000E+00 0.0000000E+00 0.0000000E+00 1.4644661E-05 0.0000000E+00
 S(3,3,K) 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 S(3,4,K) 3.5355339E-04 1.4644661E-05 0.0000000E+00 0.0000000E+00 3.9145690E-03
 S(3,5,K) 0.0000000E+00 0.0000000E+00 0.0000000E+00 3.9145690E-03 0.0000000E+00
 S(4,1,K) 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 S(4,2,K) 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 S(4,3,K) 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 S(4,4,K) 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 S(4,5,K) 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 S(5,1,K) 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 -1.2621774E-23
 S(5,2,K) 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 -1.2621774E-24
 S(5,3,K) 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 -1.2621774E-23
 S(5,4,K) 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 -1.2621774E-24
 S(5,5,K) -1.2621774E-23 -1.2621774E-24 -1.2621774E-23 -1.2621774E-24 -3.5527137E-07

END OF SOTRM1

CONTROL= -1.000

...END OF COMPUTATIONS...

TABLE V - contd.

EXAMPLE 2

1

CONTROL= 1.000
NUMBER OF PARAMETERS READ = 8

C= 1.0000000
DELSIN= 1.57079633 (CM)
SOMAX= 30.0000000 (M)
SOL= 0.0000000 (M)
OPTICN= 0.0000000
NUM= 3.0000000
MAX= 50.0000000
NPRINT= 50.0000000

CONTROL= 3.200
NUMBER OF PARAMETERS READ = 12

Z(1)= 510.7200000(MEV) Z(2)= 90.0000000(DEG) Z(3)= 2.0000000(M) Z(4)= 1.0000000(M)
Z(5)= 1.0000000(CM) Z(6)= 0.0000000(MR) Z(7)= 0.0000000(CM) Z(8)= 0.0000000(MR)
Z(9)= 0.0000000(CM) Z(10)= 0.0000000(MR) Z(11)= 1.0000000(CM) Z(12)= 5.0000000(MR)

CONTROL= 3.100
NUMBER OF PARAMETERS READ = 2

P(1)= .01000000 DELTA P/PO
P(2)= .01000000 DELTA P/PO

CONTROL= 99.000

START OF SCTRM1

1 THE FOLLOWING HEADINGS ARE TO BE USED FOR CCL. 1-7

		K= 0	PX(MEV/C)	PY(MEV/C)	X(M)	Y(M)	THETA(DEG)	FUNC CALLS	
		K={1,NUM-1}	X(CM)	X (MR)	Y(CM)	Y (MR)	OP/PO	DPX/PO	CPY/PO
		U(I,J) / J=	1	2	3	4	5		
		S(I,J,K) / K=	1	2	3	4	5		
I	SC(METER)	K	1	2	3	4	5	6	7
0	0.00000	0	5.1072000E+02	-3.7594838E-13	2.0000000E+00	1.0000000E+00	9.0000000E+01	1	
		1	1.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	1.0000000E-02	0.0000000E+00	0.0000000E+00
		2	0.0000000E+00	0.0000000E+00	1.0000000E+00	5.0000000E+00	1.0000000E-02	0.0000000E+00	5.0499790E-03
50	.78540	0	3.6113357E+02	3.6113358E+02	2.7071066E+00	1.2928932E+00	4.5000000E+01	110	
		1	1.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	1.0000000E-02	0.0000000E+00	0.0000000E+00
		2	2.9005438E-01	6.9923628E+00	1.3930933E+00	5.0000000E+00	1.0000000E-02	7.0621406E-03	5.0499790E-03

END OF SCTRM1

CONTROL= -1.000

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TABLE V - contd.

...END OF COMPUTATIONS...

1

CONTROL= 1.000
 NUMBER OF PARAMETERS READ = 8

EXAMPLE 3

Q= 1.00000000
 CELSIN= 1.57079633 (CM)
 SOMAX= 30.00000000 (M)
 SOL= 0.00000000 (M)
 OPTION= 3.00000000
 NUM= 1.00000000
 MAX= 50.00000000
 NPRINT= -50.00000000

CONTROL= 3.200
 NUMBER OF PARAMETERS READ = 4

Z(1)= 510.72000000(MEV) Z(2)= 90.00000000(DEG) Z(3)= 2.00000000(M) Z(4)= 1.00000000(M)
 Z1

CONTROL= 99.000

START OF SOTRM1

1 THE FOLLOWING HEADINGS ARE TO BE USED FOR CCL. 1-7

K= 0	PX(MEV/C)	FY(MEV/C)	X(M)	Y(M)	THETA(DEG)	FUNC CALLS			
K=(1,NUM-1)	X(CM)	X (MR)	Y(CM)	Y (MR)	DP/PO	DPX/PO	DPY/PO		
U(1,J) / J=	1	2	3	4	5				
S(1,J,K) / K=	1	2	3	4	5				
I	SO(METER)	K	1	2	3	4	5	6	7
0	0.00000	0	5.1072000E+02	-8.7594838E-13	2.0000000E+00	1.0000000E+00	9.0000000E+01		1
		U(1,J)	1.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
		U(2,J)	0.0000000E+00	1.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
		U(3,J)	0.0000000E+00	0.0000000E+00	1.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
		U(4,J)	0.0000000E+00	0.0000000E+00	0.0000000E+00	1.0000000E+00	0.0000000E+00	0.0000000E+00	
		U(5,J)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	1.0000000E+00	0.0000000E+00	
		S(1,1,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
		S(1,2,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
		S(1,3,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
		S(1,4,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
		S(1,5,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
		S(2,1,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
		S(2,2,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
		S(2,3,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
		S(2,4,K)	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	

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[illegible]

TABLE V - contd.

EXAMPLE 3 - contd.

0	0.000000E+00	0.000000E+00	1.000000E-04	1.000000E-04	0.000000E+00	0.000000E+00
0	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-1.000000E-02	-1.000000E-02
0	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-1.000000E-01	-1.000000E-01
0	0.000000E-02	1.000000E-02	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0	0.000000E+00	0.000000E+00	1.000000E-01	1.000000E-01	0.000000E+00	0.000000E+00
0	1.000000E-04	1.000000E-04	1.000000E-04	1.000000E-04	0.000000E+00	0.000000E+00
0	-1.000000E-02	-1.000000E-02	-1.000000E-02	-1.000000E-02	-1.000000E-02	-1.000000E-02
0	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0	-1.000000E-02	-1.000000E-02	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0	0.000000E+00	0.000000E+00	-1.000000E-01	-1.000000E-01	0.000000E+00	0.000000E+00
0	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-1.000000E-04	-1.000000E-04
0	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0	-1.000000E-01	-1.000000E-01	-1.000000E-01	-1.000000E-01	-1.000000E-01	-1.000000E-01
0	-1.000000E-02	-1.000000E-02	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0	0.000000E+00	0.000000E+00	-1.000000E-01	-1.000000E-01	0.000000E+00	0.000000E+00
0	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-1.000000E-04	-1.000000E-04
0	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
0	-1.000000E-02	-1.000000E-02	-1.000000E-02	-1.000000E-02	0.000000E+00	0.000000E+00
0	-1.000000E-01	-1.000000E-01	0.000000E+00	0.000000E+00	-1.000000E-01	-1.000000E-01
0	0.000000E+00	0.000000E+00	-1.000000E-04	-1.000000E-04	-1.000000E-04	-1.000000E-04
50	.78540	0 3.6113357E+02	3.6113358E+02	2.7071068E+00	1.2928932E+00	4.5000000E+01
	U(1,J)	7.0710678E-01	7.0710678E-02	0.000000E+00	0.000000E+00	2.9289322E+C1
	U(2,J)	-7.0710678E+00	7.0710678E-01	0.000000E+00	0.000000E+00	7.0710679E+C2
	U(3,J)	0.000000E+00	0.000000E+00	1.000000E+00	7.8539817E-02	0.000000E+00
	U(4,J)	0.000000E+00	0.000000E+00	0.000000E+00	1.000000E+00	0.000000E+00
	U(5,J)	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	1.000000E+00
	S(1,1,K)	-2.4999979E-03	2.4999991E-04	-8.4703295E-18	-4.3512594E-11	2.4999991E-01
	S(1,2,K)	2.4999991E-04	1.0355356E-05	4.2351647E-19	-2.4701251E-12	1.0355328E-02
	S(1,3,K)	-8.4703295E-18	4.2351647E-19	0.000000E+00	-4.2351647E-19	-8.4703295E-16
	S(1,4,K)	-4.3512594E-11	-2.4701251E-12	-4.2351647E-19	-1.4644658E-05	-3.0758907E-C9
	S(1,5,K)	2.4999991E-01	1.0355328E-02	-8.4703295E-16	-3.0758907E-09	-2.5000013E+01
	S(2,1,K)	4.6447290E-08	-1.7405893E-09	1.2924697E-22	-8.8496523E-10	3.5355317E+00
	S(2,2,K)	-1.7405893E-09	-3.5355301E-04	-1.3552527E-17	-7.5073929E-11	-2.2711833E-C7
	S(2,3,K)	1.2924697E-22	-1.3552527E-17	0.000000E+00	-6.7762636E-18	-2.7105054E-14
	S(2,4,K)	-8.8496523E-10	-7.5073929E-11	-6.7762636E-18	-3.5355329E-04	-8.5854197E-08
	S(2,5,K)	3.5355317E+00	-2.2711833E-C7	-2.7105054E-14	-8.5854197E-08	-7.0710708E+C2
	S(3,1,K)	0.000000E+00	0.000000E+00	0.000000E+00	3.5355339E-04	0.000000E+00
	S(3,2,K)	0.000000E+00	0.000000E+00	0.000000E+00	1.4644661E-05	0.000000E+00
	S(3,3,K)	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
	S(3,4,K)	3.5355339E-04	1.4644661E-05	0.000000E+00	0.000000E+00	3.9145690E-C3
	S(3,5,K)	0.000000E+00	0.000000E+00	0.000000E+00	3.9145690E-03	0.000000E+00
	S(4,1,K)	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
	S(4,2,K)	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
	S(4,3,K)	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
	S(4,4,K)	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
	S(4,5,K)	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
	S(5,1,K)	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	-1.2621774E-23

TABLE V - contd.

EXAMPLE 3 - contd.

```

S(5,2,K)  0.0000000E+00  0.0000000E+00  0.0000000E+00  0.0000000E+00 -1.2621774E-24
S(5,3,K)  0.0000000E+00  0.0000000E+00  0.0000000E+00  0.0000000E+00 -1.2621774E-23
S(5,4,K)  0.0000000E+00  0.0000000E+00  0.0000000E+00  0.0000000E+00 -1.2621774E-24
S(5,5,K) -1.2621774E-23 -1.2621774E-24 -1.2621774E-23 -1.2621774E-24 -3.5527137E-C7

```

ZTRAN	ZSOLN	ZTRAN	ZSCLN	ZTRAN	ZSCLN
7.0708178E-03	7.0708178E-03	7.0711714E-03	7.0711714E-03	0.0000000E+00	0.0000000E+00
-7.0710678E-02	-7.0710678E-02	7.0707142E-02	7.0707142E-02	0.0000000E+00	0.0000000E+00
0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	1.0000000E-02	1.0000000E-02
0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
-1.4644658E-07	-1.4644658E-07	2.9286822E-03	2.9286822E-03	-7.0713178E-03	-7.0713178E-03
-3.5355329E-06	-3.5355329E-06	7.0703608E-02	7.0703608E-02	7.0710678E-02	7.0710678E-02
7.8539817E-03	7.8539817E-03	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
1.0000000E-01	1.0000000E-01	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
0.0000000E+00	0.0000000E+00	1.0000000E-04	1.0000000E-04	0.0000000E+00	0.0000000E+00
-7.0709643E-03	-7.0709643E-03	0.0000000E+00	0.0000000E+00	-1.4644658E-07	-1.4644658E-07
-7.0714214E-02	-7.0714214E-02	0.0000000E+00	0.0000000E+00	-3.5355329E-06	-3.5355329E-06
0.0000000E+00	0.0000000E+00	-1.0000000E-02	-1.0000000E-02	-7.8539817E-03	-7.8539817E-03
0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	-1.0000000E-01	-1.0000000E-01
0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
-2.9291822E-03	-2.9291822E-03	1.4142489E-02	1.4142489E-02	7.0708178E-03	7.0708178E-03
-7.0717750E-02	-7.0717750E-02	-3.5358064E-06	-3.5358064E-06	-7.0710678E-02	-7.0710678E-02
0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	1.0000000E-02	1.0000000E-02
0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
-1.0000000E-04	-1.0000000E-04	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
7.0706714E-03	7.0706714E-03	1.0000000E-02	1.0000000E-02	7.0711714E-03	7.0711714E-03
-7.0714214E-02	-7.0714214E-02	7.0294368E-10	-5.5800316E-12	7.0707142E-02	7.0707142E-02
7.8546888E-03	7.8546888E-03	0.0000000E+00	0.0000000E+00	1.0000000E-02	1.0000000E-02
1.0000000E-01	1.0000000E-01	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
0.0000000E+00	0.0000000E+00	1.0000000E-04	1.0000000E-04	0.0000000E+00	0.0000000E+00
7.0710249E-03	7.0710249E-03	1.0000000E-02	1.0000000E-02	-1.4644658E-07	-1.4644658E-07
7.0703607E-02	7.0703607E-02	1.4141075E-01	1.4141075E-01	-3.5355329E-06	-3.5355329E-06
7.8542745E-03	7.8542745E-03	0.0000000E+00	0.0000000E+00	1.7853982E-02	1.7853982E-02
1.0000000E-01	1.0000000E-01	0.0000000E+00	0.0000000E+00	1.0000000E-01	1.0000000E-01
0.0000000E+00	0.0000000E+00	1.0000000E-04	1.0000000E-04	0.0000000E+00	0.0000000E+00
2.9286822E-03	2.9286822E-03	2.9285358E-03	2.9285358E-03	-1.4141782E-02	-1.4141782E-02
7.0703608E-02	7.0703608E-02	7.0700072E-02	7.0700073E-02	-3.5352515E-06	-3.5352490E-06
1.0000000E-02	1.0000000E-02	7.8540599E-03	7.8540599E-03	0.0000000E+00	0.0000000E+00
0.0000000E+00	0.0000000E+00	1.0000000E-01	1.0000000E-01	0.0000000E+00	0.0000000E+00
1.0000000E-04	1.0000000E-04	1.0000000E-04	1.0000000E-04	0.0000000E+00	0.0000000E+00
-7.0713178E-03	-7.0713178E-03	-7.0714643E-03	-7.0714642E-03	-1.0000000E-02	-1.0000000E-02
7.0710678E-02	7.0710678E-02	7.0707143E-02	7.0707143E-02	-7.0852371E-10	0.0000000E+00
-1.0000000E-02	-1.0000000E-02	-7.8532745E-03	-7.8532745E-03	0.0000000E+00	0.0000000E+00
0.0000000E+00	0.0000000E+00	-1.0000000E-01	-1.0000000E-01	0.0000000E+00	0.0000000E+00

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TABLE V - contd.

EXAMPLE 3 - contd.

0	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	-1.0000000E-04	-1.0000000E-04
	-7.0709643E-03	-7.0709643E-03	-7.0711107E-03	-7.0711107E-03	-9.9999394E-03	-9.9999394E-03
	-7.0714214E-02	-7.0714214E-02	-7.0717749E-02	-7.0717749E-02	-1.4143196E-01	-1.4143196E-01
	-1.0000000E-02	-1.0000000E-02	-7.8536888E-03	-7.8536888E-03	0.0000000E+00	0.0000000E+00
	0.0000000E+00	0.0000000E+00	-1.0000000E-01	-1.0000000E-01	0.0000000E+00	0.0000000E+00
	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	-1.0000000E-04	-1.0000000E-04
0	-1.4644658E-07	-1.4644658E-07	-2.9291822E-03	-2.9291822E-03	-2.9293287E-03	-2.9293287E-03
	-3.5355329E-06	-3.5355329E-06	-7.0717750E-02	-7.0717750E-02	-7.0721286E-02	-7.0721286E-02
	-1.7853982E-02	-1.7853982E-02	-1.0000000E-02	-1.0000000E-02	-7.8539034E-03	-7.8539034E-03
	-1.0000000E-01	-1.0000000E-01	0.0000000E+00	0.0000000E+00	-1.0000000E-01	-1.0000000E-01
	0.0000000E+00	0.0000000E+00	-1.0000000E-04	-1.0000000E-04	-1.0000000E-04	-1.0000000E-04

END OF SOTRM1

CONTROL= 1.000
NUMBER OF PARAMETERS READ = 2

Q= 1.0000000
DELSIN= 1.57079633 (CM)
SOMAX= 30.0000000 (M)
SOL= .78539816 (M)
OPTICN= 0.0000000
NUM= 4.0000000
MAX= 50.0000000
NPRINT= -50.0000000

CONTROL= 3.100
NUMBER OF PARAMETERS READ = 3

PI 1)= .01000000 DELTA P/PO
PI 2)= .05000000 DELTA P/PO
PI 3)= .10000000 DELTA P/PO

CONTROL= 3.200
NUMBER OF PARAMETERS READ = 16

Z(1)= 510.7200000(MEV)	Z(2)= 90.0000000(DEG)	Z(3)= 2.0000000(M)	Z(4)= 1.0000000(M)
Z(5)= .5000000(CM)	Z(6)= 5.0000000(MR)	Z(7)= .5000000(CM)	Z(8)= 5.0000000(MR)
Z(9)= 1.0000000(CM)	Z(10)= 10.0000000(MR)	Z(11)= 1.0000000(CM)	Z(12)= 10.0000000(MR)
Z(13)= 5.0000000(CM)	Z(14)= 20.0000000(MR)	Z(15)= 5.0000000(CM)	Z(16)= 20.0000000(MR)

CONTROL= 99.000

START OF SOTRM1

1 THE FOLLOWING HEADINGS ARE TO BE USED FOR COL. 1-7

K= 0	PX(MEV/C)	PY(MEV/C)	X(M)	Y(M)	THETA(DEG)	FUNC CALLS

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TABLE V - contd.

EXAMPLE 3 - contd.

K=(1,NUM-1)		X(CM)	X (MR)	Y(CM)	Y (MR)	DP/PO	DPX/PO	DPY/PO	
U(I,J) / J=		1	2	3	4	5			
S(I,J,K) / K=		1	2	3	4	5			
I	SO(METER)	K	1	2	3	4	5	6	7
0	.78540	0	5.1072000E+02	-8.7594838E-13	2.0000000E+00	1.0000000E+00	9.0000000E+01	1	
		1	5.0000000E-01	5.0000000E+00	5.0000000E-01	5.0000000E+00	1.0000000E-02	5.0499158E-C3	5.0499790E-03
01	1.0000000E+C0	1	0.0000000E+010E5	0.0000000E-020E1	0.499300E-02	1.0499825E-02			
		3	5.0000000E+00	2.0000000E+01	5.0000000E+00	2.0000000E+01	1.0000000E-01	2.1994134E-02	2.1998533E-02

ZTRAN		ZSCLN		ZTRAN		ZSCLN		ZTRAN		ZSCLN	
5.0000000E-01	5.0000000E-01	1.0000000E+00	1.0000000E+00	5.0000000E+00	5.0000000E+00	5.0000000E+00	5.0000000E+00				
5.0000000E+00	5.0000000E+00	1.0000000E+01	1.0000000E+01	2.0000000E+01	2.0000000E+01	2.0000000E+01	2.0000000E+01				
5.0000000E-01	5.0000000E-01	1.0000000E+00	1.0000000E+00	5.0000000E+00	5.0000000E+00	5.0000000E+00	5.0000000E+00				
5.0000000E+00	5.0000000E+00	1.0000000E+01	1.0000000E+01	2.0000000E+01	2.0000000E+01	2.0000000E+01	2.0000000E+01				
1.0000000E-02	1.0000000E-02	5.0000000E-02	5.0000000E-02	1.0000000E-01	1.0000000E-01	1.0000000E-01	1.0000000E-01				
0											
50	1.57080	0	3.6113357E+02	3.6113358E+02	2.7071058E+00	1.2928932E+00	4.5000000E+01	110			
		1	1.0015650E+00	7.0184714E+00	8.9560510E-01	5.0000000E+00	1.0000000E-02	7.0885093E-03	5.0499790E-03		
		2	2.8556731E+00	3.3945505E+01	1.7995120E+00	1.0000000E+01	5.0000000E-02	3.5634154E-02	1.0499825E-02		
		3	7.9123449E+00	4.6022222E+01	6.6705157E+00	2.0000000E+01	1.0000000E-01	5.3596455E-02	2.1998533E-02		

ZTRAN		ZSCLN		ZTRAN		ZSCLN		ZTRAN		ZSCLN	
1.0015533E+00	1.0015650E+00	2.8536060E+00	2.8556731E+00	7.9058851E+00	7.9123449E+00						
7.0180346E+00	7.0184714E+00	3.3870414E+01	3.3945505E+01	4.5679093E+01	4.6022222E+01						
8.9559054E-01	8.9560510E-01	1.7993127E+00	1.7995120E+00	6.6688810E+00	6.6705157E+00						
5.0000000E+00	5.0000000E+00	1.0000000E+01	1.0000000E+01	2.0000000E+01	2.0000000E+01						
1.0000000E-02	1.0000000E-02	4.9999999E-02	5.0000000E-02	9.9999996E-02	1.0000000E-01						
0											

END OF SOTRM1

CONTROL= -1.000

...END OF COMPUTATIONS...

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TABLE VI

PROGRAM LISTING

PROGRAM SOTRM(INPUT=300,OUTPUT=1000,TAPE1=1000,TAPE60=INPUT,TAPE61	SOTRM.2
= OUTPUT)	SOTRM.3
* COMMENT THIS IS A CALLING PROGRAM FOR SOTRM1. SEE UCRL 19823.	SOTRM.4
* BEGIN	SOTRM.5
REAL S	SOTRM.6
INTEGER K,L,I,MAXRAY,NUM,N4,NUM1	SOTRM.7
REAL P(40),Z(164),PARAM(10),PR(4),LOW LIM,UP LIM,DUM,A,	SOTRM.8
A1,A2,M1(5,5),M2(5,5,5),U,V	SOTRM.9
INTEGER H1(9),H2(9),PI(5)	SOTRM.10
INTEGER TEXT(13)	SOTRM.11
LOGICAL START	SOTRM.12
COMMON /BOUND/ LOW LIM(3),UP LIM(3)	SOTRM.13
/YAFS/ DUM(10),A(5),U(5,5),V(5,5,5)	SOTRM.14
/TAME/ A1(10,10), A2(10,10)	SOTRM.15
/PARAM/ CONST(8)	SOTRM.16
DATA START/.TRUE./,MAXRAY/31/,(H1(I),I=1,8)/3H Q=,	SOTRM.17
8H DELSIN=,7H SOMAX=,5H S01=,8H OPTION=,5H NUM=,	SOTRM.18
5H MAX=,8H NPRINT=,(H2(I),I=1,8)/1H ,5H (CM),	SOTRM.19
2*4H (M),4*1H /	SOTRM.20
PRINT 2998	SOTRM.21
1 READ 4001, S \$ PRINT 12 ,S \$ IF(S.EQ.-1.) 2,4	SOTRM.22
2 PRINT 5000\$ STOP	SOTRM.23
4 IF(S.EQ.1.) 100,199	SOTRM.24
* BEGIN	SOTRM.25
100 READ 4002, K, (I,PARAM(I),L=1,K)	SOTRM.26
IF(PARAM(8).LT.0.0) REWIND 1	SOTRM.27
IF(START) 102,108	SOTRM.28
* BEGIN	SOTRM.29
102 IF(K.NE.8) 104,106	SOTRM.30
* BEGIN	SOTRM.31
104 PRINT 9000,K \$ STOP	SOTRM.32
9000 FORMAT (///*1 K=*I3* YOU HAVE NOT SET*,	SOTRM.33
* ALL THE INITIAL PARAMETERS*///)	SOTRM.34
106 CONTINUE	SOTRM.35
* END	SOTRM.36
START=.FALSE.	SOTRM.37
108 CONTINUE	SOTRM.38
* END	SOTRM.39
NUM=PARAM(6)	SOTRM.40
NUM1=NUM-1	SOTRM.41
N4=4*NUM	SOTRM.42
PRINT 2999,K	SOTRM.43
PRINT 3000 , ((H1(I),PARAM(I),H2(I)),I=1,8)	SOTRM.44
IF(PARAM(6).GT.MAXRAY) 110,112	SOTRM.45
* BEGIN	SOTRM.46
110 PRINT 9001,PARAM(7)\$ STOP	SOTRM.47
9001 FORMAT(///* TOO MANY RAYS,NUM=*F10.6///)	SOTRM.48
112 CONTINUE	SOTRM.49
* END	SOTRM.50
DO 114 I=1,4,1	SOTRM.51
114 PR(I)= PARAM(I)	SOTRM.52
DO 116 I= 1,4,1	SOTRM.53
116 PI(I)= PARAM(I+4)+SIGN(0.0005,PARAM(I+4))	SOTRM.54
GO TO 1	SOTRM.55

TABLE VI - contd.

199	CONTINUE	SOTRM.56
*	END ELSE	SOTRM.57
	IF(S.EQ.2.) 200,299	SOTRM.58
*	BEGIN	SOTRM.59
200	READ 4001, (LOW LIM(I),UP LIM(I),I=1,3)	SOTRM.60
	PRINT 3004, (I,LOW LIM(I), I,UP LIM(I),I=1,3)	SOTRM.61
	GOTO 1	SOTRM.62
299	CONTINUE	SOTRM.63
*	END ELSE	SOTRM.64
	IF(S.GE.3..AND.S.LT.4.) 300, 399	SOTRM.65
300	IF(S.EQ.3.0.OR.S.EQ.3.1) 302,304	SOTRM.66
*	BEGIN	SOTRM.67
302	READ 4002,K,((I,P(I),I=1,K,1)	SOTRM.68
	PRINT 2999,K	SOTRM.69
	PRINT 3006,((I,P(I),I=1,NUM1,1)	SOTRM.70
*	END	SOTRM.71
304	IF(S.EQ.3.0.OR.S.EQ.3.2) 306,308	SOTRM.72
*	BEGIN	SOTRM.73
306	READ 4002,L,((I,Z(I),I=1,L,1)	SOTRM.74
	PRINT 2999,L	SOTRM.75
	PRINT 3008, ((I,Z(I),I=1,N4,1)	SOTRM.76
*	END	SOTRM.77
308	GOTO1	SOTRM.78
399	CONTINUE	SOTRM.79
*	END ELSE	SOTRM.80
	IF(S.EQ.4.) 400,499	SOTRM.81
*	BEGIN COMMENT INPUT A1 AND A2,F.SELPH FIELD, 5 ITEMS/CARD	SOTRM.82
400	READ 4008,(((A1(I,J),J=1,10),I=1,10),	SOTRM.83
	((A2(I,J),J=1,10),I=1,10)	SOTRM.84
	PRINT 3010,(((A1(I,J),J=1,10),I=1,10)	SOTRM.85
	PRINT 3011,(((A2(I,J),J=1,10),I=1,10)	SOTRM.86
	GOTO 1	SOTRM.87
499	CONTINUE	SOTRM.88
*	END ELSE	SOTRM.89
	IF(S.GE.5..AND.S.LT.6.) 500,599	SOTRM.90
*	BEGIN COMMENT CHANGE A1 OR A2 OR BOTH	SOTRM.91
500	IF(S.EQ.5..OR.S.EQ.5.1)	SOTRM.92
	READ 4010, K,(((I,J,A1(I,J)),L=1,K)\$ PRINT 2999,K	SOTRM.93
	IF(S.EQ.5..OR.S.EQ.5.2)	SOTRM.94
	READ 4010, K,(((I,J,A2(I,J)),L=1,K)\$ PRINT 2999,K	SOTRM.95
	PRINT 3010,(((A1(I,J),J=1,10),I=1,10)	SOTRM.96
	PRINT 3011,(((A2(I,J),J=1,10),I=1,10)	SOTRM.97
	GOTO 1	SOTRM.98
599	CONTINUE	SOTRM.99
*	END ELSE	SOTRM.100
	IF(S.EQ.6.) 600,699	SOTRM.101
*	BEGIN COMMENT INPUT INCREMENTS	SOTRM.102
600	READ 4002, K,(((I,A(I)),L=1,K)\$ PRINT 2999,K	SOTRM.103
	PRINT 3012, ((L,A(L)),L=1,5)	SOTRM.104
	GOTO 1	SOTRM.105
699	CONTINUE	SOTRM.106
*	END ELSE	SOTRM.107
	IF(S.EQ.7) 800,899	SOTRM.108
*	BEGIN COMMENT INPUT TEXT THAT IDENTIFIES THE TABLES AND	SOTRM.109

TABLE VI - contd.

* OUTPUT THE FIRST AND SECOND ORDER ELEMENTS. THIS	SOTRM.110
* SECTION REQUIRES OUTRT A SUBROUTINE TO OUTPUT THE	SOTRM.111
* TABLES.	SOTRM.112
800 READ 4014, TEXT	SOTRM.113
4014 FORMAT(13A10)	SOTRM.114
CALL OUTRT(TEXT,M1,M2)	SOTRM.115
GOTO 1	SOTRM.116
899 CONTINUE	SOTRM.117
* END ELSE	SOTRM.118
IF(S.EQ.99) 700,799	SOTRM.119
* BEGIN COMMENT EXECUTE SOTRM1	SOTRM.120
700 PRINT 4012	SOTRM.121
CALL SOTRM1(PARAM(4),Z,P,M1,M2,PR,PI)	SOTRM.122
PRINT 4011	SOTRM.123
799 CONTINUE	SOTRM.124
* END	SOTRM.125
GOTO 1	SOTRM.126
* COMMENT ALL FORMAT STATEMENTS FOLLOW	SOTRM.127
10 FORMAT(12)	SOTRM.128
12 FORMAT(/* CONTROL=*F7.3)	SOTRM.129
4000 FORMAT(15/(15,(15,E10.0)))	SOTRM.130
4001 FORMAT(8E10.0)	SOTRM.131
4002 FORMAT(15/(15,5X,E15.0))	SOTRM.132
4008 FORMAT(15F10.0)	SOTRM.133
4010 FORMAT(15/(15,15,E15.0))	SOTRM.134
4011 FORMAT(/* END OF SOTRM1 */)	SOTRM.135
4012 FORMAT(/* START OF SOTRM1 */)	SOTRM.136
2998 FORMAT(*1*)	SOTRM.137
2999 FORMAT(* NUMBER OF PARAMETERS READ =*15)	SOTRM.138
3000 FORMAT(/(A10,F15.8,A10/))	SOTRM.139
3004 FORMAT((* LOW LIM(*12*)=*F15.8,* (M) UP LIM(*12*)=*F15.8	SOTRM.140
* (M) */))	SOTRM.141
3006 FORMAT(/(* P(*12*)=*F15.8* DELTA P/PO */))	SOTRM.142
3008 FORMAT(/ * Z(*13*)=*F15.8*(MEV)*, * Z(*13*)=*F15.8*(DEG)*,	SOTRM.143
2(* Z(*13*)=*F15.8*(M) */),	SOTRM.144
2(* Z(*13*)=*F15.8*(CM) *	SOTRM.145
* Z(*13*)=*F15.8*(MR) *)	SOTRM.146
3010 FORMAT(/* A1(I,J)*/(10E12.6))	SOTRM.147
3011 FORMAT(/* A2(I,J)*/(10E12.6))	SOTRM.148
3012 FORMAT(/* DERIVATIVE INCREMENTS*/(* A(*12*)=*E15.6))	SOTRM.149
5000 FORMAT(/*...END OF COMPUTATIONS...*)	SOTRM.150
END	SOTRM.151
	SOTRM.152
	SOTRM.153
	SOTRM.154
SUBROUTINE SOTRM1(SO1,Z1,P1,V,W,PR,PI)\$ REAL SO1\$ REAL Z1(1),P1(1)	SOTRM1.2
,V(5,5),W(5,5,5),PR(1)	SOTRM1.3
INTEGER PI(1)	SOTRM1.4
* BEGIN COMMENT SEE UCRL 19823.	SOTRM1.5
REAL Q,DELSO,SO,SOMAX,PO,SOOUT,BB02	SOTRM1.6
INTEGER NUM,NUM1,N,MAX,NPRINT,I,J,K,L,LOOP,FIN,NXTSTP,COUNT	SOTRM1.7
,I1,STEP,PRTCNT,KK	SOTRM1.8
REAL Z,PO,P,BB1,BB2,BB3,F,CONST,YP,YM,A ,T(992),ZOUT(7)	SOTRM1.9
,ZSAVE,EPS	SOTRM1.10

TABLE VI - contd.

	LOGICAL	BOOL1,BOOL2,LAST,TEXT	SOTRM1.11
	COMMON	/CASES/ NUM,L,K	SOTRM1.12
		/CHARGE/ Q /MOM/ P0,P(40)	SOTRM1.13
		/FIELD/ BBO2,BB1(40),BB2(40),BB3(40)	SOTRM1.14
		/SOLN/ Z(164) /DER/F(164)	SOTRM1.15
		/PARAM/ CONST(8)	SOTRM1.16
		/LIMIT/ SO,SOMAX,MAX	SOTRM1.17
		/YAFS/ YP(5),YM(5),A(5),U(5,5),S(5,5,5)	SOTRM1.18
		/WORK/ COUNT,STEP	SOTRM1.19
	COMMON	/INIT/ ZSAVE(150)	SOTRM1.20
	DATA	(CONST(I),I=1,7) /1.602072E-19,.5343922E-21,1.,1.E-2,	SOTRM1.21
		1.E-3,1.74532925199433E-2,1.E-4/,	SOTRM1.22
		(A(I),I=1,5,1)/ .01,.1,.01,.1,.0001/	SOTRM1.23
	DOUBLE PRECISION	T,DELSO	SOTRM1.24
	EXTERNAL FUNC		SOTRM1.25
	DIMENSION	EPS(6)	SOTRM1.26
	ASSIGN	50 TO LOOP\$ ASSIGN 10000 TO FIN	SOTRM1.27
	ASSIGN	200 TO NXTSTP	SOTRM1.28
		Q=PR(1)*CONST(1)\$ DELSO= PR(2)*CONST(4)\$ SO= SO1*CONST(3)	SOTRM1.29
		SOMAX= PR(3)*CONST(3)\$ COUNT=0	SOTRM1.30
*	COMMENT	SET THE INITIAL CONDITIONS OF THE REFERENCE RAY	SOTRM1.31
*			SOTRM1.32
		PO=Z1(1)*CONST(2)	SOTRM1.33
		Z(1)= SIN(Z1(2)*CONST(6))\$ Z(2)= COS(Z1(2)*CONST(6))	SOTRM1.34
		Z(3)= Z1(3)*CONST(3)\$ Z(4)= Z1(4)*CONST(3)	SOTRM1.35
*			SOTRM1.36
	NPRINT=	IABS(PI(4))	SOTRM1.37
	NUM=PI(2) \$	NUM1=NUM-1 \$ N=4*NUM \$ MAX=PI(3)	SOTRM1.38
4	IF(PI(1).NE.0)	6,10	SOTRM1.39
*	BEGIN	COMMENT SET THE INITIAL CONDITIONS OF THE NEAR BY RAYS	SOTRM1.40
*		FOR GENERATION OF U AND S	SOTRM1.41
6	IF(PI(1).EQ.1.OR.PI(1).EQ.-1)	NUM=11	SOTRM1.42
	IF(PI(1).EQ.2)	NUM= 21	SOTRM1.43
	IF(PI(1).EQ.3)	NUM= 31	SOTRM1.44
	NUM1=NUM-1\$	N=4*NUM\$ MAX=PI(3)	SOTRM1.45
	CALL	SETZ(Z1,P1)	SOTRM1.46
*	END		SOTRM1.47
10	IF(NUM1.GT.0)	CALL ZINIT(P1,Z1)	SOTRM1.48
	CALL	SAVEZP(ZSAVE,Z1,P1,P1)	SOTRM1.49
*	COMMENT	INTEGRATION AND PRINT LOOP	SOTRM1.50
16	STEP= 0\$	PRTCNT= 0\$ LAST= .FALSE.\$ TEXT= .TRUE.	SOTRM1.51
		IF(NPRINT.NE.0) PRINT 4000	SOTRM1.52
	CALL	INTO(4*NUM,SO,FUNC,Z,F,F,DELSO)	SOTRM1.53
*	LOOP..		SOTRM1.54
50	DO 500 I1=	1,MAX	SOTRM1.55
*	BEGIN		SOTRM1.56
	IF(SO.GE.SOMAX)	46,48	SOTRM1.57
*	BEGIN		SOTRM1.58
46	MAX=	I1-1\$ GOTO 500	SOTRM1.59
*	END		SOTRM1.60
48	IF(NPRINT.NE.0.OR.LAST)	52,200	SOTRM1.61
*	BEGIN		SOTRM1.62
52	IF(.NOT.LAST.AND..NOT.TEXT)	GOTO NXTSTP	SOTRM1.63
	SOOUT=	SO/CONST(3)\$ K=0.	SOTRM1.64

TABLE VI - contd.

	IF(TEXT) 54, 60	SOTRM1.65
*	BEGIN COMMENT OUTPUT REFERENCE RAY	SOTRM1.66
54	IF(ABS(Z(1)).GT.1.) 55,56	SOTRM1.67
55	ZOUT(5)= Z(1)+ 1000. \$ GOTO 58	SOTRM1.68
56	ZOUT(5)= ASIN(Z(1))/CONST(6)	SOTRM1.69
58	CONTINUE	SOTRM1.70
	ZOUT(1)= (Z(1)/CONST(2))* P0	SOTRM1.71
	ZOUT(2)=(Z(2)/CONST(2))*P0	SOTRM1.72
	ZOUT(3)= Z(3)/CONST(3)	SOTRM1.73
	ZOUT(4)= Z(4)/CONST(3)	SOTRM1.74
	PRINT 4002, STEP,S0OUT,K,(ZOUT(L),L=1,5),	SOTRM1.75
	COUNT	SOTRM1.76
*	END	SOTRM1.77
60	IF(LAST) 62,64	SOTRM1.78
*	BEGIN COMMENT SET THE FINAL CONDITIONS OF THE	SOTRM1.79
*	REFERENCE RAY	SOTRM1.80
62	Z1(2)=ATAN2(Z(1),Z(2))/CONST(6)	SOTRM1.81
	Z1(3)=Z(3)/CONST(3)	SOTRM1.82
	Z1(4)=Z(4)/CONST(3)	SOTRM1.83
	S01=S0OUT	SOTRM1.84
*	END	SOTRM1.85
64	IF(PI(1).EQ.0.A.NUM1.NE.0) 66,74	SOTRM1.86
*	BEGIN	SOTRM1.87
66	DO 72 K=1,NUM1	SOTRM1.88
*	BEGIN	SOTRM1.89
	L=4*K\$ CALL ZFINAL(ZOUT,0)	SOTRM1.90
	ZOUT(6)= Z(L+2)\$ ZOUT(7)= Z(L+4)	SOTRM1.91
	ZOUT(5)= P(K)-1.	SOTRM1.92
	IF(TEXT) PRINT 4004,K,(ZOUT(I),I=1,7)	SOTRM1.93
	IF(LAST) 68,72	SOTRM1.94
*	COMMENT SET FINAL CONDITIONS OF THE NEARBY	SOTRM1.95
*	RAYS	SOTRM1.96
68	DO 70 I= 1,4	SOTRM1.97
70	Z1(L+1)= ZOUT(I)	SOTRM1.98
72	CONTINUE	SOTRM1.99
*	END	SOTRM1.100
	IF(PI(4).LT.0.AND.TEXT) CALL APTRAN(0)	SOTRM1.101
73	IF(LAST) GO TO FIN	SOTRM1.102
	GO TO NXTSTP	SOTRM1.103
*	END	SOTRM1.104
74	IF(ABS(PI(1)).GT.0) 76,100	SOTRM1.105
*	BEGIN	SOTRM1.106
76	DO 86 KK=1,5	SOTRM1.107
*	BEGIN	SOTRM1.108
	L=4*KK	SOTRM1.109
	K=KK	SOTRM1.110
	CALL ZFINAL(YP,0)	SOTRM1.111
	K=KK+5	SOTRM1.112
	CALL ZFINAL(YM,20)	SOTRM1.113
	CALL YPYM5(KK,5,5)	SOTRM1.114
77	DO 78 I=1,5	SOTRM1.115
78	U(I,KK)=(YP(I)-YM(I))/(2.0*A(KK))	SOTRM1.116
	IF(PI(1).NE.1) 80,84	SOTRM1.117
80	DO 82 I=1,5	SOTRM1.118

TABLE VI - contd.

	S(I,KK,KK)=(YP(I)+YM(I))/(2.0*A(KK	SOTRM1.119
	**2)	SOTRM1.120
82	CONTINUE	SOTRM1.121
84	CONTINUE	SOTRM1.122
86	CONTINUE	SOTRM1.123
*	END	SOTRM1.124
	IF(TEXT.AND.PI(1).NE.0) 88,100	SOTRM1.125
*	BEGIN	SOTRM1.126
88	PRINT 4006,((I,(U(I,K),K=1,5)),I=1,5)	SOTRM1.127
	PRINT 4010	SOTRM1.128
	IF(PI(1).EQ.-1)	SOTRM1.129
	PRINT 4007,	SOTRM1.130
	((I,(S(I,K,K),K=1,5)),I=1,5)	SOTRM1.131
	IF(PI(4).LT.0.A.PI(1).LE.1)	SOTRM1.132
	CALL APTRAN(1,PI(1))	SOTRM1.133
*	END	SOTRM1.134
*	END	SOTRM1.135
100	IF(PI(1).GT.1) 102,104	SOTRM1.136
*	BEGIN	SOTRM1.137
102	CALL SF(4,44,10,1)\$ CALL SF(3,60,14,2)	SOTRM1.138
	CALL SF(2,72,17,3)\$ CALL SF(1,80,19,4)	SOTRM1.139
	IF(TEXT) 103,104	SOTRM1.140
*	BEGIN	SOTRM1.141
103	PRINT 4008,	SOTRM1.142
	((I,J,(S(I,J,K),K=1,5)),J=1,5),I=1,5	SOTRM1.143
	IF(PI(4).LT.0) CALL APTRAN(1,PI(1))	SOTRM1.144
*	END	SOTRM1.145
*	END	SOTRM1.146
104	IF(LAST) GOTO 509	SOTRM1.147
*	END	SOTRM1.148
*	NXTSTP..	SOTRM1.149
200	CALL INT(SO,FUNC,Z,F,T,BOOL1)\$ TEXT= .FALSE.	SOTRM1.150
	IF(BOOL1) 202,204	SOTRM1.151
*	BEGIN	SOTRM1.152
202	STEP= STEP + 1	SOTRM1.153
	PRCNT= PRCNT+1\$ IF(PRCNT.EQ.NPRINT) 203,204	SOTRM1.154
*	BEGIN	SOTRM1.155
203	TEXT= .TRUE.\$ PRCNT= 0	SOTRM1.156
*	END	SOTRM1.157
*	END	SOTRM1.158
204	CONTINUE	SOTRM1.159
500	CONTINUE	SOTRM1.160
*	END OF LOOP	SOTRM1.161
	IF(.NOT.LAST) 501, 508	SOTRM1.162
*	BEGIN	SOTRM1.163
501	IF(NPRINT.EQ.0) 502,504	SOTRM1.164
502	TEXT=.FALSE.\$ GOTO 506	SOTRM1.165
504	TEXT=.TRUE.	SOTRM1.166
506	LAST= .TRUE.\$ MAX=2\$ SOMAX= SOMAX+.05	SOTRM1.167
	GOTO LOOP	SOTRM1.168
508	CONTINUE	SOTRM1.169
*	END	SOTRM1.170
509	IF(PI(1).NE.0) 510,512	SOTRM1.171
		SOTRM1.172

TABLE VI - contd.

```

*      BEGIN
510      DO 511 I=1,5,1
          DO 511 J=1,5,1
          V(I,J)=U(I,J)
511      IF(PI(1).EQ.-1) W(I,J,J)= S(I,J,J)
512      CONTINUE
*      END
          IF(PI(1).GT.1) 514,518
514      DO 516 I=1,5,1
          DO 516 J=1,5,1
          DO 516 K=1,5,1
516      W(I,J,K)= S(I,J,K)
518      CONTINUE
*      FIN..
10000 RETURN
*
4000 FORMAT(*1 THE FOLLOWING HEADINGS ARE TO BE USED FOR COL. 1-7*//
.      19X,*K= 0*,11X,*PX(MEV/C)*,4X,*PY(MEV/C)*,9X,*X(M)*,9X,
.      *Y(M)*,5X,*THETA(DEG)*,4X,*FUNC CALLS*/19X,*K=(1,NUM-1)*,
.      6X,*X(CM)*,10X,*X (MR)*,8X,*Y(CM)*,9X,*Y (MR)*,5X,*DP/PC*,
.      12X,*CPX/PO*,8X,*DPY/PO*/20X,*U(I,J)*,3X,*J=*,4X,*1*,13X,
.      *2*,13X,*3*,13X,*4*,13X,*5*/20X,*S(I,J,K) / K=*,4X,*1*,13X,
.      *2*,13X,*3*,13X,*4*,13X,*5*//5X,*I*,3X,*SO(METER)*
.      2X,*K*,14X,
.      *1*,13X,*2*,13X,*3*,13X,*4*,13X,*5*,13X,*6*,13X,*7*//)
4002 FORMAT(1X,I5,1X,F10.5,2X,I3, 5E15.7,I14)
4004 FORMAT(19X,I3,7E15.7)
4006 FORMAT(20X,*U(*I1*,J)*4X,5E15.7)
4007 FORMAT(20X,*S(*I1*,K,K)*, 2X,5E15.7)
4008 FORMAT(20X,*S(*I1*,*I1*,K)*2X,5E15.7)
4010 FORMAT(/)
      END

      SUBROUTINE ZINIT(P1,Z1)
      REAL P1(1),Z1(1)
*      COMMENT ZINIT ESTABLISHES THE INITIAL VALUES
*      OF THE NEAR BY RAYS. THESE ARE ORIGINALLY FURNISHED
*      AS Z1(L+1) CM, Z1(L+2) MR, Z1(L+3) CM, Z1(L+4) MR.
*      THESE ARE CHANGED TO Z1(L+1) M, Z1(L+2) DELTA P(K)/PO,
*      Z1(L+3) M, Z1(L+4) DELTA P(K)/PC. THE INPUT MOMENTUM
*      P(K) IN UNITS OF DELTA P(K)/PO IS CHANGED TO 1+DELTA P(K)
*      /PO
*      BEGIN
          INTEGER K,L,N,NUM1,NUM
          REAL P,PO,CONST
          COMMON /CASES/NUM,L,K
.          /MOM/ PO,P(40 )
.          /PARAM/ CONST(8)
.          /SOLN/ Z(164)
          NUM1= NUM-1$ N= 4*NUM
          DO 10 K=1,NUM1,1
*      BEGIN
          P(K)= P1(K)+1.0

```

SOTRM1.173
 SOTRM1.174
 SOTRM1.175
 SOTRM1.176
 SOTRM1.177
 SOTRM1.178
 SOTRM1.179
 SOTRM1.180
 SOTRM1.181
 SOTRM1.182
 SOTRM1.183
 SOTRM1.184
 SOTRM1.185
 SOTRM1.186
 SOTRM1.187
 SOTRM1.188
 SOTRM1.189
 SOTRM1.190
 SOTRM1.191
 SOTRM1.192
 SOTRM1.193
 SOTRM1.194
 SOTRM1.195
 SOTRM1.196
 SOTRM1.197
 SOTRM1.198
 SOTRM1.199
 SOTRM1.200
 SOTRM1.201
 SOTRM1.202
 SOTRM1.203
 SOTRM1.204
 SOTRM1.205
 SOTRM1.206
 ZINIT.2
 ZINIT.3
 ZINIT.4
 ZINIT.5
 ZINIT.6
 ZINIT.7
 ZINIT.8
 ZINIT.9
 ZINIT.10
 ZINIT.11
 ZINIT.12
 ZINIT.13
 ZINIT.14
 ZINIT.15
 ZINIT.16
 ZINIT.17
 ZINIT.18
 ZINIT.19
 ZINIT.20
 ZINIT.21

TABLE VI - contd.

```

      L=4*K
      Z(L+2)= Z1(L+2)* CONST(5)
      Z(L+4)= Z1(L+4)* CONST(5)
      Z(L+2)= P(K)*COS(Z(L+4))*SIN(Z(L+2))
      Z(L+4)= P(K)*SIN(Z(L+4))
      Z(L+1)= Z1(L+1)*CONST(4)
      Z(L+3)= Z1(L+3)*CONST(4)
10    CONTINUE
*      END
      RETURN
      END
      ZINIT.22
      ZINIT.23
      ZINIT.24
      ZINIT.25
      ZINIT.26
      ZINIT.27
      ZINIT.28
      ZINIT.29
      ZINIT.30
      ZINIT.31
      ZINIT.32
      ZINIT.33
      ZINIT.34
      ZFINAL.2
      ZFINAL.3
      ZFINAL.4
      ZFINAL.5
      ZFINAL.6
      ZFINAL.7
      ZFINAL.8
      ZFINAL.9
      ZFINAL.10
      ZFINAL.11
      ZFINAL.12
      ZFINAL.13
      ZFINAL.14
      ZFINAL.15
      ZFINAL.16
      ZFINAL.17
      ZFINAL.18
      ZFINAL.19
      ZFINAL.20
      ZFINAL.21
      ZFINAL.22
      SUBROUTINE ZFINAL(Y,M)$ REAL Y(1)$ INTEGER M
      COMMENT ZFINAL ESTABLISHES THE FINAL CONDITIONS OF ANY NEARBY RAY
      IT IS THE INVERSE OF ZINIT EXCEPT THAT IT WORKS ONE
      RAY AT A TIME.
      BEGIN
      INTEGER N,NUM,L,K
      REAL PO,P,Z,CONST
      COMMON /CASES/ NUM,L,K
      /MOM/ PO,P(40)
      /SOLN/ Z(164)
      /PARAM/ CONST(8)
      N=M
      Y(4)=ASIN(Z(L+N+4)/P(K))
      Y(2)=ASIN(Z(L+N+2)/(P(K)*COS(Y(4))))/CONST(5)
      Y(4)=Y(4)/CONST(5)
      Y(1)=Z(L+N+1)/CONST(4)
      Y(3)=Z(L+N+3)/CONST(4)
      RETURN
      END
      SUBROUTINE SF(N1,N2,N3,N4)$ INTEGER N1,N2,N3,N4
      COMMENT SF CBTAINS THE OFF DIAGONAL ELEMENTS OF THE SECOND ORDER
      TRANSFER MATRIX
      BEGIN
      INTEGER M1,M2,M3,M4,K,K1,L,NUM,I,I1,KK
      REAL Z,PO,P,YP,YM,A,U,S
      COMMON /CASES/ NUM,L,K
      /SOLN/ Z(164) /MOM/ PO,P(40)
      /YAFS/ YP(5),YM(5),A(5),U(5,5),S(5,5,5)
      M1=N1$ M2=N2$ M3= N3$ M4=N4
      IF(NUM.EQ.21) 2,20
      COMMENT ASYMMETRIC SOLN
      DO 10 KK=1,M1,1
      BEGIN
      L= 4*KK-4
      K= KK+M3
      CALL ZFINAL(YP,M2)
      CALL YPYM5(KK+M3,10,M1+M3)
      K1= KK+M4
      DO 10 I=1,5,1
      SF.2
      SF.3
      SF.4
      SF.5
      SF.6
      SF.7
      SF.8
      SF.9
      SF.10
      SF.11
      SF.12
      SF.13
      SF.14
      SF.15
      SF.16
      SF.17
      SF.18
      SF.19
      SF.20
      SF.21

```


TABLE VI - contd.

*	BEGIN	SF.22
	S(I,M4,K1)=	SF.23
.	(YP(I)-A(M4)*U(I,M4)- A(K1)*U(I,K1)	SF.24
.	-S(I,M4,M4)*(A(M4)**2)-S(I,K1,K1)*(A(K1)**2))/	SF.25
.	(2.*A(M4)*A(K1))	SF.26
	S(I,K1,M4)=S(I,M4,K1)	SF.27
10	CONTINUE	SF.28
*	END	SF.29
*	RETURN	SF.30
*	COMMENT SYMMETRIC SOLUTION	SF.31
20	DO 30 KK=1,M1,1	SF.32
*	BEGIN	SF.33
	L=4*KK-4	SF.34
	K=KK+M3	SF.35
	CALL ZFINAL(YP,M2)	SF.36
	K= K+10	SF.37
	CALL ZFINAL(YM,M2+40)	SF.38
	K1=KK+M4	SF.39
	CALL YPYM5(KK+M3,10,M1+M3)	SF.40
	DO 30 I=1,5,1	SF.41
*	BEGIN	SF.42
	S(I,M4,K1)=	SF.43
.	(YP(I)+YM(I)-2.0*(S(I,M4,M4)*A(M4)**2	SF.44
.	+S(I,K1,K1)*A(K1)**2))/(4.0*A(M4)*A(K1))	SF.45
	S(I,K1,M4)= S(I,M4,K1)	SF.46
30	CONTINUE	SF.47
*	END	SF.48
*	END	SF.49
	RETURN	SF.50
	END	SF.51
		SF.52
		SF.53
		SF.54
	SUBROUTINE SETZ(Z,P)	SETZ.2
	REAL Z(1),P(1)	SETZ.3
*	COMMENT SETZ SETS THE NEAR BY RAYS FOR GENERATION OF THE FIRST	SETZ.4
*	ORDER MATRIX F AND THE SECOND ORDER MATRIX S	SETZ.5
*	BEGIN	SETZ.6
	INTEGER NUM1,NUM,K,N,L	SETZ.7
	REAL P0,YP,YM,A,U,S,CONST	SETZ.8
	COMMON /CASES/ NUM,L,K	SETZ.9
.	/YAFS/ YP(5),YM(5),A(5),U(5,5),S(5,5,5)	SETZ.10
.	/PARAM/ CONST(8)	SETZ.11
	NUM1= NUM-1\$ N= 4*NUM	SETZ.12
10	DO 10 K=5,N,1	SETZ.13
	Z(K)= 0.	SETZ.14
	DO 12 K=1,NUM1,1	SETZ.15
12	P(K)= 0.0	SETZ.16
	Z(5)=A(1)	SETZ.17
	Z(10)=A(2)	SETZ.18
	Z(15)=A(3)	SETZ.19
	Z(20)=A(4)	SETZ.20
	Z(25)=-Z(5)\$Z(30)=-Z(10)\$Z(35)=-Z(15)\$Z(40)=-Z(20)	SETZ.21
	P(5)=P(5)+A(5)	SETZ.22

TABLE VI - contd.

```

P(10)=P(10)-A(5)
IF(NUM.GT.11) 14, 30
BEGIN
14      DO 16 K=45,57,4
        Z(K)= Z(5)
16      Z(K+40)=-Z(5)
        Z(46)= Z(10)$ Z(86)=-Z(10)
        DO 18 K=62,70,4
        Z(K)= Z(10)
18      Z(K+40)= -Z(10)
        DO 20 K= 51,75,12
        Z(K)= Z(15)
20      Z(K+40)=-Z(15)
        Z(79)= Z(15)$ Z(119)=-Z(15)
        DO 22 K= 68,84,8
        Z(K)= Z(20)
22      Z(K+40)= -Z(20)
        Z(56)=Z(20)$ Z(96)=-Z(20)
        DO 24 K= 14,20,3
        P(K)= P(5)
24      P(K+10)=P(10)
        P(19)= P(5)
        P(29)=P(10)
*      END
30      CONTINUE
RETURN
END

SUBROUTINE FUNC(SO,Z,F)$ REAL SO$ REAL Z(1),F(1)
* COMMENT FUNC COMPUTES THE RIGHT HAND SIDE OF THE DIFFERENTIAL
* EQUATION DZ(SO)=F(Z(SO)) WHERE Z IS IN R**(4*NUM).
* Z(1) TO Z(4) ARE THE REFERENCE RAY AND Z(4*K+1) TO
* Z(4*K+4),K IN (1,...,NUM-1),ARE THE NEARBY RAYS.
* BEGIN
  INTEGER K,K1,NUM,L,COUNT
  REAL QBAR,ABAR,BB3K,WK,DELP3,QBARWK,Q,PO,P,BB02,BB1,BB2,BB3
  COMMON /CASES/ NUM,L,K
  /CHARGE/ Q
  /MCM/ PO,P(40)
  /FIELD/ BB02,BB1(40),BB2(40),BB3(40)
  /WORK/COUNT,STEP
* COMMENT ESTABLISH THE FIELD AT THE CURRENT POSITION IN SPACE
CALL FIELD $ COUNT= COUNT +1
QBAR= Q/PO$ ABAR= QBAR * BB02
* COMMENT REFERENCE RAY
F(1)= -1.*ABAR*Z(2)$ F(2)= ABAR*Z(1)
F(3)= Z(1)$ F(4)= Z(2)$ K1= NUM-1
IF(K1.EQ.0) RETURN
DO 10 K=1,K1,1
* BEGIN
  L=4*K$ DELP3= SQRT(P(K)**2-Z(L+2)**2-Z(L+4)**2)
  WK= DELP3/(1+Z(L+1)*ABAR)$ QBARWK= QBAR/WK
  F(L+2)=(QBARWK) *(Z(L+4)*BB3(K)-DELP3*BB2(K))

```

SETZ.23
 SETZ.24
 SETZ.25
 SETZ.26
 SETZ.27
 SETZ.28
 SETZ.29
 SETZ.30
 SETZ.31
 SETZ.32
 SETZ.33
 SETZ.34
 SETZ.35
 SETZ.36
 SETZ.37
 SETZ.38
 SETZ.39
 SETZ.40
 SETZ.41
 SETZ.42
 SETZ.43
 SETZ.44
 SETZ.45
 SETZ.46
 SETZ.47
 SETZ.48
 SETZ.49
 SETZ.50
 SETZ.51
 FUNC.2
 FUNC.3
 FUNC.4
 FUNC.5
 FUNC.6
 FUNC.7
 FUNC.8
 FUNC.9
 FUNC.10
 FUNC.11
 FUNC.12
 FUNC.13
 FUNC.14
 FUNC.15
 FUNC.16
 FUNC.17
 FUNC.18
 FUNC.19
 FUNC.20
 FUNC.21
 FUNC.22
 FUNC.23
 FUNC.24
 FUNC.25
 FUNC.26

TABLE VI - contd.

		+ABAR*DELP3	FUNC.27
		F(L+4)=(QBARWK) *(DELP3*BB1(K)-Z(L+2)*BB3(K))	FUNC.28
		F(L+1)=Z(L+2)/WK	FUNC.29
		F(L+3)=Z(L+4)/WK	FUNC.30
10		CONTINUE	FUNC.31
*	END		FUNC.32
	RETURN		FUNC.33
	END		FUNC.34
			FUNC.35
			FUNC.36
	SUBROUTINE YPYS(M,N,A5)		YPYM5.2
	INTEGER M,N,A5		YPYM5.3
*	BEGIN COMMENT YP(5) AND YM(5) ARE SET EXACTLY FOR THE FIRST		YPYM5.4
*	STEP. ALL OTHER STEPS ARE SET USING THE CALCULATED		YPYM5.5
*	VALUES OF THE MOMENTUM P.		YPYM5.6
	COMMON /CASES/ NUM,L,K		YPYM5.7
	COMMON /YAFS/ YP(5),YM(5),A(5),U(5,5),S(5,5,5)		YPYM5.8
	COMMON /WORK/ COUNT,STEP /MOM/ PO,P(40)		YPYM5.9
	REAL YP,YM,A,P		YPYM5.10
	INTEGER STEP,NUM		YPYM5.11
	IF(STEP.EQ.0 .A. M.EQ.A5) 2,4		YPYM5.12
*	BEGIN		YPYM5.13
2	YP(5)= A(5)		YPYM5.14
	YM(5)= -A(5)		YPYM5.15
	RETURN		YPYM5.16
*	END ELSE		YPYM5.17
*	BEGIN		YPYM5.18
4	YP(5)= P(M)-1.0		YPYM5.19
	IF(M+N.GT.10 .A. NUM.EQ.21) RETURN		YPYM5.20
	YM(5)=P(M+N)-1.0		YPYM5.21
	RETURN		YPYM5.22
*	END		YPYM5.23
	END		YPYM5.24
			YPYM5.25
			YPYM5.26
	SUBROUTINE SAVEZP(ZSAVE,Z1,P1,PI)		SAVEZP.2
	REAL ZSAVE(1),Z1(1),P1(1),PI(1)		SAVEZP.3
*	BEGIN		SAVEZP.4
*	COMMENT THE INITIAL VALUSE Z1,P1 THAT SOTRM1 WAS CALLED		SAVEZP.5
*	WITH ARE SAVED		SAVEZP.6
	INTEGER NUM,L,K,NUM1		SAVEZP.7
	COMMON /CASES/ NUM,L,K		SAVEZP.8
	NUM1= NUM-1		SAVEZP.9
	DO 20 L= 1,NUM1,1		SAVEZP.10
	DO 18 K= 1,4,1		SAVEZP.11
*	BEGIN		SAVEZP.12
18	ZSAVE(5*L-5+K)= Z1(4*L+K)		SAVEZP.13
20	ZSAVE(5*L)= P1(L)		SAVEZP.14
*	END		SAVEZP.15
	RETURN		SAVEZP.16
	END		SAVEZP.17
			SAVEZP.18
			SAVEZP.19
	SUBROUTINE CUTRT(TEXT,R,T)		CUTRT.2

TABLE VI - contd.

	INTEGER TEXT	OUTRT.3
	REAL R(5,5),T(5,5,5)	OUTRT.4
*	BEGIN COMMENT THIS ROUTINE REQUIRES EXTENDED FORTRAN OUTPUT. SEE	OUTRT.5
*	UCRL 19463. IT OUTPUTS THE FIRST AND SECOND ORDER ELEMENTS	OUTRT.6
*	IN A TABLE LIKE THAT APPEARING IN UCRL 19182. IT CAN BE	OUTRT.7
*	DELETED OR REPLACED. IT IS CALLED FROM PROGRAM SOTRM	OUTRT.8
	INTEGER I,J,K,N	OUTRT.9
	CALL OUTMODE(1HS)	OUTRT.10
	CALL FLIM(10,130)	OUTRT.11
	CALL PAGE	OUTRT.12
	CALL S(1TEXT) & CALL LINES(1)	OUTRT.13
	CALL S(10H(*R(J,K)*)) & CALL LINES(1)	OUTRT.14
	CALL S(14H(* J / K =*))	OUTRT.15
	DO 10 J=1,5,1	OUTRT.16
*	BEGIN	OUTRT.17
	CALL SPACES(8)	OUTRT.18
	CALL OUTI(J,1)	OUTRT.19
10	CALL SPACES(8)	OUTRT.20
*	END	OUTRT.21
	CALL LINES(1)	OUTRT.22
	DO 22 I=1,5,1	OUTRT.23
	DO 20 J=1,5,1	OUTRT.24
	IF(J.EQ.1) CALL SPACES(11)	OUTRT.25
	IF(R(I,J).EQ.0)	OUTRT.26
	CALL S(21H(* 0.0000000E 00*))	OUTRT.27
	IF(R(I,J).NE.0)	OUTRT.28
	CALL OUTR(R(I,J),.FALSE.,17,7)	OUTRT.29
20	CONTINUE	OUTRT.30
22	CALL LINES(1)	OUTRT.31
*	END	OUTRT.32
	CALL LINES(2)	OUTRT.33
	CALL S(12H(*T(I,J,K)*)) & CALL LINES(1)	OUTRT.34
	CALL S(14H(* I/ J/ K =*))	OUTRT.35
	DO 30 I= 1,5,1	OUTRT.36
*	BEGIN	OUTRT.37
	CALL SPACES(8)	OUTRT.38
	CALL OUTI(I,1)	OUTRT.39
30	CALL SPACES(8)	OUTRT.40
*	END	OUTRT.41
	CALL LINES(1)	OUTRT.42
	DO 44 I=1,5,1	OUTRT.43
	DO 42 J= 1,5,1	OUTRT.44
	DO 40 K= J,5,1	OUTRT.45
*	BEGIN	OUTRT.46
	IF(J.EQ.K) 32,38	OUTRT.47
*	BEGIN	OUTRT.48
32	CALL OUTI(I,2)	OUTRT.49
	CALL OUTI(J,3)	OUTRT.50
	CALL SPACES(5)	OUTRT.51
	CALL SPACES(17*(J-1))	OUTRT.52
*	END	OUTRT.53
38	CONTINUE	OUTRT.54
	IF(T(I,J,K).EQ.0.0)	OUTRT.55
	CALL S(21H(* 0.0000000E 00*))	OUTRT.56

TABLE VI - contd.

	IF (T(I,J,K).NE.0.0)	OUTRT.57
	CALL OUTRT(T(I,J,K),.FALSE.,17,7)	OUTRT.58
40	CONTINUE	OUTRT.59
42	CALL LINES(1)	OUTRT.60
44	CONTINUE	OUTRT.61
* *	END	OUTRT.62
	CALL PAGE	OUTRT.63
	CALL S(13H(*END OUTRT*))	OUTRT.64
	CALL LINES(1)	OUTRT.65
	RETURN	OUTRT.66
END		OUTRT.67
		OUTRT.68
		OUTRT.69
	SUBROUTINE APTRAN(I1,KKEY)	APTRAN.2
	INTEGER I1,KKEY,STEP	APTRAN.3
*		APTRAN.4
*	THIS ROUTINE APPLIES THE TRANSFER MATRIX CORRESPONDING TO THE VALUE	APTRAN.5
*	OF KEY TO THE NEARBY RAYS.	APTRAN.6
*		APTRAN.7
	COMMON /INIT/ ZSAVE(150)	APTRAN.8
	COMMON /CASES/ NUM,L,K	APTRAN.9
	COMMON /MOM/ PO,P(40) /YAFS/ YP(5),YM(5),A(5),U(5,5),S(5,5,5)	APTRAN.10
	COMMON /WORK/ COUNT,STEP	APTRAN.11
	DIMENSION ZTRAN(150),ZSOLN(150),V(5)	APTRAN.12
	IF (I1.EQ.0) 4,8	APTRAN.13
4	READ(1) LSTP,KEY,U,S	APTRAN.14
	IF (STEP.NE.LSTP) 720,9	APTRAN.15
720	PRINT 731,STEP,LSTP	APTRAN.16
731	FORMAT(*OWRCNG STEP ON DISK. STEP =*I10,5X*LSTP =*I10)	APTRAN.17
	RETURN	APTRAN.18
8	KEY= KKEY	APTRAN.19
	WRITE(1) STEP,KEY,U,S	APTRAN.20
9	CONTINUE	APTRAN.21
	NUM1=NUM-1	APTRAN.22
	DO 20 L=1,NUM1	APTRAN.23
	M=5*L-5	APTRAN.24
	DO 20 I=1,5	APTRAN.25
	SUM1=0.0	APTRAN.26
	SUM2=0.0	APTRAN.27
	DO 12 J=1,5	APTRAN.28
	SUM1-SUM1+U(I,J)*ZSAVE(M+J)	APTRAN.29
	IF (KEY.EQ.1.OR.KEY.EQ.-1) GO TO 12	APTRAN.30
	DO 10 K=1,5	APTRAN.31
	SUM2=SUM2+S(I,J,K)*ZSAVE(M+J)*ZSAVE(M+K)	APTRAN.32
10	CONTINUE	APTRAN.33
12	CONTINUE	APTRAN.34
	IF (KEY.GT.0) GO TO 17	APTRAN.35
	DO 15 J=1,5	APTRAN.36
15	SUM2=SUM2+S(I,J,J)*ZSAVE(M+J)*ZSAVE(M+J)	APTRAN.37
17	ZTRAN(M+1)=SUM1+SUM2	APTRAN.38
20	CONTINUE	APTRAN.39
	V(5)=0.0	APTRAN.40
	DO 30 KK=1,NUM1	APTRAN.41
	L=4*KK	APTRAN.42

TABLE VI - contd.

K=KK	APTRAN.43
CALL ZFINAL(V,0)	APTRAN.44
DC 30 J=1,5	APTRAN.45
ZSOLN(5*KK+J-5)=V(J)	APTRAN.46
30 CONTINUE	APTRAN.47
DO 40 I=1,NUM1	APTRAN.48
40 ZSOLN(5*I)=P(I)-1.0	APTRAN.49
N=5*NUM1	APTRAN.50
IF(N.EQ.15*(N/15)) GO TO 45	APTRAN.51
NN=15*(N/15)+1	APTRAN.52
GO TO 50	APTRAN.53
45 NN=N-14	APTRAN.54
50 PRINT 55	APTRAN.55
55 FORMAT(///11X5HZTRAN,10X5HZSOLN,15X5HZTRAN,10X5HZSCLN,15X5HZTRAN,	APTRAN.56
110X5HZSOLN)	APTRAN.57
DO 90 I=1,NN,15	APTRAN.58
DO 70 J=1,5	APTRAN.59
K=1-1+J	APTRAN.60
L=K+10	APTRAN.61
PRINT 60,(ZTRAN(M),ZSOLN(M),M=K,L,5)	APTRAN.62
60 FORMAT(5X2E15.7,5X2E15.7,5X2E15.7)	APTRAN.63
70 CONTINUE	APTRAN.64
PRINT 80	APTRAN.65
80 FORMAT(1H0)	APTRAN.66
90 CONTINUE	APTRAN.67
RETURN	APTRAN.68
END	APTRAN.69
	APTRAN.70
	APTRAN.71
FORTRAN IV SUBROUTINE INTO(NC,X,DERI ,Y,F,T,HPRO)	ZAM.2
* COMMENT THIS IS THE LRL INTEGRATOR ZAM. SEE LRL COMPUTER CENTER	ZAM.3
* WRITE UP FOR ZAM D2 BKY ZAM.	ZAM.4
COMMON /INTC/ IPMX,AREF,EMAX,SSSR,HFAC,SWAM,SWEX	ZAM.5
COMMON /INTP/ HPR,XX,N,EUB,ELB,IP,IT,NRKS,SWIN	ZAM.6
DIMENSION Y(1),F(1),T(8,1)	ZAM.7
LOGICAL SWAM,SWEX,SWIN	ZAM.8
INTEGER HFAC	ZAM.9
DOUBLE PRECISION T,HPRO,HPR,XX	ZAM.10
DATA IPMX,AREF,EMAX,SSSR,HFAC,SWAM,SWEX	ZAM.11
\$ /16384,1.0,1.0E-8,100.0,2,.TRUE.,.TRUE./	ZAM.12
* COMMENT NOTE THAT EMAX= 10E-8 IS PROBABLY TOO SMALL FOR EXPERIMEN-	ZAM.13
* TAL DATA, EMAX= 10E-6 IS PROBABLY BETTER.	ZAM.14
C	ZAM.15
HPR=HPRO	ZAM.16
XX=DBLE(X)	ZAM.17
N=NO	ZAM.18
EUB=EMAX	ZAM.19
ELB=EMAX/SSSR	ZAM.20
IP=1	ZAM.21
IT=0	ZAM.22
NRKS=0	ZAM.23
SWIN=SWEX	ZAM.24
CALL DERI (X,Y,F)	ZAM.25
DC 9 I=1,N	ZAM.26

TABLE VI - contd.

	T(5,I)=DBLE(Y(I))	ZAM.27
9	CONTINUE	ZAM.28
	RETURN	ZAM.29
	END	ZAM.30
	SUBROUTINE INT(X,DERI ,Y,F,T,SWPR	ZAM.31
	X)	ZAM.32
	COMMON /INTC/ IPMX,AREF,EMAX,SSSR,HFAC,SWAM,SWEX	ZAM.33
	COMMON /INTP/ HPR,XX,N,EUB,ELB,IP,IT,NRKS,SWIN	ZAM.34
C		ZAM.35
	DIMENSION Y(1),F(1),T(8,1)	ZAM.36
	LOGICAL SWAM,SWEX,SWIN	ZAM.37
	LOGICAL SWPR	ZAM.38
	INTEGER HFAC	ZAM.39
	DOUBLE PRECISION T,HPR,XX	ZAM.40
	DOUBLE PRECISION D,H	ZAM.41
6000	FORMAT (36H0 CANNOT DECREASE H BECAUSE OF HMIN. ,1PE16.8,I20)	ZAM.42
C		ZAM.43
1	CONTINUE	ZAM.44
	SWPR=.FALSE.	ZAM.45
	TEST=0.0	ZAM.46
	H=HPR/DBLE(FLOAT(IP*24))	ZAM.47
	IF ((NRKS .LT. 3) .OR. (.NOT. SWAM)) GO TO 200	ZAM.48
C		ZAM.49
C	ADAMS-MOULTON STEP.	ZAM.50
100	CONTINUE	ZAM.51
	DO 109 I=1,N	ZAM.52
	D=DBLE(F(I))	ZAM.53
	T(4,I)=D	ZAM.54
	Y(I)=SNGL(T(5,I)+H*(	ZAM.55
	X 55.000*D-59.000*T(3,I)+37.000*T(2,I)- 9.000*T(1,I))	ZAM.56
109	CONTINUE	ZAM.57
	X=SNGL(XX+24.CDO*H)	ZAM.58
	CALL DERI (X,Y,F)	ZAM.59
	DO 119 I=1,N	ZAM.60
	D=DBLE(F(I))	ZAM.61
	D=(T(5,I)+H*(	ZAM.62
		ZAM.63
	X 9.000*D+19.000*T(4,I)- 5.000*T(3,I)+ T(2,I))	ZAM.64
	T(6,I)=D	ZAM.65
	E=ABS(SNGL(D)-Y(I))/14.0	ZAM.66
	TEST=AMAX1(E/AMAX1(AREF,ABS(SNGL(D))),TEST)	ZAM.67
119	CONTINUE	ZAM.68
C		ZAM.69
	GO TO 300	ZAM.70
C		ZAM.71
C	ZCNNEVELD STEP.	ZAM.72
200	CONTINUE	ZAM.73
	DO 209 I=1,N	ZAM.74
	D=DBLE(F(I))	ZAM.75
	T(4,I)=D	ZAM.76
C	1	ZAM.77
	Y(I)=SNGL(T(5,I)+H*(	ZAM.78
	X 12.000*D	ZAM.79
209	CONTINUE	ZAM.80

TABLE VI - contd.

	X=SNGL(XX+12.000*H)	ZAM.81
	CALL DERI (X,Y,F)	ZAM.82
	DC 219 I=1,N	ZAM.83
	D=DBLE(F(I))	ZAM.84
	T(6,I)=D	ZAM.85
C	2	ZAM.86
	Y(I)=SNGL(T(5,I)+H*(	ZAM.87
	X 12.000*D	ZAM.88
219	CONTINUE	ZAM.89
	CALL DERI (X,Y,F)	ZAM.90
	DC 229 I=1,N	ZAM.91
	D=DBLE(F(I))	ZAM.92
	T(7,I)=D	ZAM.93
C	3	ZAM.94
	Y(I)=SNGL(T(5,I)+H*(	ZAM.95
	X 24.000*D	ZAM.96
229	CONTINUE	ZAM.97
	X=SNGL(XX+24.000*H)	ZAM.98
	CALL DERI (X,Y,F)	ZAM.99
	DC 239 I=1,N	ZAM.100
	D=DBLE(F(I))	ZAM.101
	T(8,I)=D	ZAM.102
C	4	ZAM.103
	Y(I)=SNGL(T(5,I)+H*(	ZAM.104
	X 3.7500*T(4,I)+5.2500*T(6,I)+9.7500*T(7,I)-0.7500*D	ZAM.105
239	CONTINUE	ZAM.106
	X=SNGL(XX+18.000*H)	ZAM.107
	CALL DERI (X,Y,F)	ZAM.108
	DC 249 I=1,N	ZAM.109
	D=DBLE(F(I))	ZAM.110
	E=ABS(SNGL(H*(	ZAM.111
	X -16.000*T(4,I)+48.000*T(6,I)+48.000*T(7,I)+48.000*T(8,I)	ZAM.112
	X -128.000*D	ZAM.113
C	5	ZAM.114
	D=(T(5,I)+H*(	ZAM.115
	X 4.000*T(4,I)+ 8.000*T(6,I)+ 8.000*T(7,I)+ 4.000*T(8,I)	ZAM.116
	X))	ZAM.117
	T(6,I)=D	ZAM.118
	TEST=AMAX1(E/AMAX1(AREF,ABS(SNGL(D))),TEST)	ZAM.119
249	CONTINUE	ZAM.120
C		ZAM.121
C	BOTH ADAMS-MOULTON AND ZONNEVELD METHODS CONTINUE FROM HERE.	ZAM.122
300	CONTINUE	ZAM.123
	X=SNGL(XX+24.000*H)	ZAM.124
	IF (TEST .LE. EUB) GO TO 310	ZAM.125
	IF (IP*HFAC .GT. IPMX) GO TO 309	ZAM.126
C		ZAM.127
C	REPEAT STEP WITH SMALLER H.	ZAM.128
	NRKS=0	ZAM.129
	IP=IP*HFAC	ZAM.130
	IT=IT*HFAC	ZAM.131
	DO 305 I=1,N	ZAM.132
	Y(I)=SNGL(T(5,I))	ZAM.133
	F(I)=SNGL(T(4,I))	ZAM.134

TABLE VI - contd.

305	CONTINUE	ZAM.135
	GO TO 1	ZAM.136
C		ZAM.137
	CANNOT DECREASE H BECAUSE OF HMIN.	ZAM.138
309	CONTINUE	ZAM.139
	IF (.NOT. SWIN) GO TO 310	ZAM.140
	PRINT 6000, X,IPMX	ZAM.141
	SWIN=.FALSE.	ZAM.142
C		ZAM.143
310	CONTINUE	ZAM.144
C		ZAM.145
C		ZAM.146
C	ACCEPT CURRENT STEP.	ZAM.147
C		ZAM.148
C	XX STILL HAS NOT BEEN CHANGED SINCE ENTRY.	ZAM.149
C	YY(XX) IS STILL IN T(5,).	ZAM.150
C	F(YY) IS IN T(4,).	ZAM.151
C		ZAM.152
	IT=IT+1	ZAM.153
	XX=XX+HPR/CBLE(FLOAT(IP))	ZAM.154
	NRKS=MINO(NRKS+1,4)	ZAM.155
	DO 319 I=1,N	ZAM.156
	D=T(6,I)	ZAM.157
	T(5,I)=D	ZAM.158
	Y(I)=SNGL(D)	ZAM.159
319	CONTINUE	ZAM.160
	X=SNGL(XX)	ZAM.161
	CALL DERI (X,Y,F)	ZAM.162
	IF (IT .LT. IP) GO TO 320	ZAM.163
C		ZAM.164
C	X IS A MULTIPLE OF HPRINT.	ZAM.165
	SWPR=.TRUE.	ZAM.166
	IT=IT-IP	ZAM.167
C		ZAM.168
320	CONTINUE	ZAM.169
	IF (TEST .GE. ELB) GO TO 330	ZAM.170
	IF (MOD(IP,HFAC)+MOD(IT,HFAC) .NE. 0) GO TO 330	ZAM.171
C		ZAM.172
C	PROCEED TO NEXT STEP WITH LARGER H, USING ZONNEVELD METHOD.	ZAM.173
	NRKS=0	ZAM.174
	IP=IP/HFAC	ZAM.175
	IT=IT/HFAC	ZAM.176
	RETURN	ZAM.177
C		ZAM.178
C		ZAM.179
C	PROCEED TO NEXT STEP WITH SAME H.	ZAM.180
330	CONTINUE	ZAM.181
	DO 339 I=1,N	ZAM.182
	T(1,I)=T(2,I)	ZAM.183
	T(2,I)=T(3,I)	ZAM.184
	T(3,I)=T(4,I)	ZAM.185
339	CONTINUE	ZAM.186
	RETURN	ZAM.187
	END	ZAM.188

TABLE VI - contd.

		ZAM.189
		ZAM.190
	SUBROUTINE FIELD	FIELD1.2
*	COMMENT THIS ROUTINE ESTABLISHES THE FIELD AT THE CURRENT	FIELD1.3
*	POSITION OF THE REFERENCE PARTICLE AND THE NEARBY	FIELD1.4
*	PARTICLES. THE ORIGIN IS THE ORIGIN OF THE REFERENCE	FIELD1.5
*	PARTICLE. THE ACTUAL FIELD IN GAUSS IS SUPPLIED BY THE	FIELD1.6
*	SUBROUTINE GAUSS.	FIELD1.7
*	BEGIN	FIELD1.8
	INTEGER K,K1,L,NUM	FIELD1.9
	REAL Z4K,R,PO,P,BB02,BB1,BB2,BB3,Z,G,CONST	FIELD1.10
	DIMENSION R(3),G(3)	FIELD1.11
	COMMON /CASES/ NUM,L,K	FIELD1.12
	/MOM/ PO,P(40)	FIELD1.13
	/FIELD/BB02,BB1(40),BB2(40),BB3(40)	FIELD1.14
	/SOLN/ Z(164)	FIELD1.15
	/PARAM/ CONST(8)	FIELD1.16
	K1=NUM-1	FIELD1.17
*	COMMENT THE POSITION OF THE REFERENCE ORBIT IN THE GLOBAL	FIELD1.18
*	COORDINATE SYSTEM IS R(1),R(2),R(3). SEE FIGURE 1 UCRL	FIELD1.19
*	19182.	FIELD1.20
	R(1)= Z(3)	FIELD1.21
	R(2)= 0.0	FIELD1.22
	R(3)= Z(4)	FIELD1.23
	CALL GAUSS(R,G)	FIELD1.24
	BB02= G(2) * CONST(7)	FIELD1.25
	IF(K1.EQ.0) RETURN	FIELD1.26
	DO 10 K=1,K1,1	FIELD1.27
*	BEGIN	FIELD1.28
	L=4*K\$ Z4K= Z(L+1)	FIELD1.29
*	COMMENT SEE UCRL 19182 FIGURE 1. WE ARE TRANSFORMING	FIELD1.30
*	FROM THE PRIMED TO THE GLOBAL UNPRIMED COORDINATE	FIELD1.31
*	SYSTEM.	FIELD1.32
	R(1)= Z(3)+Z4K * Z(2)	FIELD1.33
	R(2)= Z(L+3)	FIELD1.34
	R(3)= Z(4)- Z4K * Z(1)	FIELD1.35
	CALL GAUSS(R,G)	FIELD1.36
*	COMMENT NOTE THAT THE FIELD HERE, BB1(K)...BB3(K),	FIELD1.37
*	REFERS TO THE FIELD COMPONENTS IN THE PRIMED	FIELD1.38
*	COORDINATE SYSTEM. SEE UCRL 19182 FIGURE 1.	FIELD1.39
	BB1(K)= G(1)* CONST(7)	FIELD1.40
	BB2(K)= G(2)* CONST(7)	FIELD1.41
10	BB3(K)= G(3)* CONST(7)	FIELD1.42
*	END	FIELD1.43
	RETURN	FIELD1.44
	END	FIELD1.45
		FIELD1.46
		FIELD1.47
	SUBROUTINE GAUSS(R,G)\$ REAL R(1),G(1)	GAUSS1.2
*	COMMENT	GAUSS1.3
\$	THIS VERSION OF GAUSS SETS A CONSTANT FIELD = 17.036E4 GAUSS	GAUSS1.4
C	WHICH CORRESPONDS TO A RADIUS OF 1 METER FOR PC= 510.72	GAUSS1.5
*	FOR A PROTON	GAUSS1.6
		GAUSS1.7

TABLE VI - contd.

```

*      BEGIN
      REAL G,PO,P
      COMMON/CHARGE/ G
      /MOM / PO,P(40)
      G(1)=C.
      G(2)=(PO/Q)*1.E4
      G(3)=C.
      RETURN
      END

SUBROUTINE FIELD
COMMENT THIS ROUTINE ESTABLISHES THE FIELD AT THE CURRENT
*      POSITION OF THE REFERENCE PARTICLE AND THE NEARBY
*      PARTICLES. THE ORIGIN IS THE ORIGIN OF THE REFERENCE
*      PARTICLE. THE ACTUAL FIELD IN GAUSS IS SUPPLIED BY THE
*      SUBROUTINE GAUSS.
*      BEGIN COMMENT THIS VERSION OF FIELD CAN BE USED WITH AN IDEAL
*      SEXTUPOLE AND AN IDEAL QUADRUPOLE. IT ASSUMES THAT THE
*      REFERENCE ORBIT HAS FIELD ZERO.
      INTEGER K,K1,L,NUM
      REAL Z4K,R,PO,P,BB02,BB1,BB2,BB3,Z,G,CONST
      DIMENSION R(3),G(3)
      COMMON /CASES/ NUM,L,K
      /MOM/ PO,P(40)
      /FIELD/BB02,BB1(40),BB2(40),BB3(40)
      /SOLN/ Z(164)
      /PARAM/ CONST(8)
      K1=NUM-1
      COMMENT THE REFERENCE ORBIT FIELD IS SET TO ZERO.
      BB02= 0.0
      IF(K1.EQ.0) RETURN
      DO 10 K=1,K1,1
      BEGIN
      L=4*K$ Z4K= Z(L+1)
      COMMENT R(1) AND R(2) GIVE THE DISPLACEMENT IN METERS
      IN THE PRIMED SYSTEM. SEE FIGURE 1 UCRL 19182.
      R(1)=Z(L+1)
      R(2)=Z(L+3)
      CALL GAUSS(R,G)
      BB1(K)= G(1)* CONST(7)
      BB2(K)= G(2)* CONST(7)
      BB3(K)= G(3)* CONST(7)
10      END
      RETURN
      END

SUBROUTINE GAUSS(R,G)$ REAL R(1),G(1)
*      BEGIN
*      COMMENT THIS ROUTINE FURNISHES THE IDEAL QUADRUPOLE FIELD
*      USED AS AN EXAMPLE IN UCRL 19182.
      REAL G,PO,P
      REAL PO

```

GAUSS1.8
 GAUSS1.9
 GAUSS1.10
 GAUSS1.11
 GAUSS1.12
 GAUSS1.13
 GAUSS1.14
 GAUSS1.15
 GAUSS1.16
 GAUSS1.17
 GAUSS1.18
 FIELD2.2
 FIELD2.3
 FIELD2.4
 FIELD2.5
 FIELD2.6
 FIELD2.7
 FIELD2.8
 FIELD2.9
 FIELD2.10
 FIELD2.11
 FIELD2.12
 FIELD2.13
 FIELD2.14
 FIELD2.15
 FIELD2.16
 FIELD2.17
 FIELD2.18
 FIELD2.19
 FIELD2.20
 FIELD2.21
 FIELD2.22
 FIELD2.23
 FIELD2.24
 FIELD2.25
 FIELD2.26
 FIELD2.27
 FIELD2.28
 FIELD2.29
 FIELD2.30
 FIELD2.31
 FIELD2.32
 FIELD2.33
 FIELD2.34
 FIELD2.35
 FIELD2.36
 FIELD2.37
 FIELD2.38
 GAUSS2.2
 GAUSS2.3
 GAUSS2.4
 GAUSS2.5
 GAUSS2.6
 GAUSS2.7

TABLE VI - contd.

```
COMMON/CHARGE/ Q
      /MOM      / P0,P(40)
B0=(PC/Q)*1.E4/2.0
G(1)= B0*R(2)/.0508
G(2)= B0*R(1)/.0508
G(3)=C.0
RETURN
END
```

```
SUBROUTINE GAUSS(R,G)$ REAL R(1),G(1)
      BEGIN
```

```
      COMMENT THIS ROUTINE FURNISHES THE IDEAL SEXTUPOLE FIELD
      USED AS AN EXAMPLE IN UCRL 19182.
```

```
      REAL C,P0,P
```

```
      REAL B0
```

```
COMMON/CHARGE/ Q
```

```
      /MOM      / P0,P(40)
```

```
B0= (P0/Q)*1.0E4/10.0
```

```
G(1)= (2.0*B0*R(1)*R(2))/(.0508**2)
```

```
G(2)= (B0*(R(1)**2-R(2)**2))/(.0508**2)
```

```
G(3)= 0.0
```

```
RETURN
```

```
END
```

GAUSS2.8
GAUSS2.9
GAUSS2.10
GAUSS2.11
GAUSS2.12
GAUSS2.13
GAUSS2.14
GAUSS2.15
GAUSS2.16
GAUSS2.17
GAUSS3.2
GAUSS3.3
GAUSS3.4
GAUSS3.5
GAUSS3.6
GAUSS3.7
GAUSS3.8
GAUSS3.9
GAUSS3.10
GAUSS3.11
GAUSS3.12
GAUSS3.13
GAUSS3.14
GAUSS3.15
GAUSS3.16
GAUSS3.17

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