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MORSE - E
A NEW VERSION OF THE MORSE CODE
ESIS

by

C. PONTI and R. VAN HEUSDEN

1974

Joint Nuclear Research Centre
Ispra Establishment - Italy

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MORSE-E calculates the flux of particles as the sum of the paths travelled within a given volume; the corresponding relative errors are also provided.

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ABSTRACT

This report describes a version of the MORSE code which has been written to facilitate the practical use of this programme. MORSE-E is a ready-to-use version that does not require particular programming efforts to adapt the code to the problem to be solved. It treats source volumes of different geometrical shapes.

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CONTENT

1. INTRODUCTION

The Monte Carlo code MORSE / 1 /, which has been in use since 1970, is well known. Its flexibility leads to adequate solutions to many problems; in particular its ability to deal with 3D irregular geometries, with coupled neutron-gamma-ray problems, with albedo surfaces, and the application of suitable variance reduction techniques, is very useful in shielding applications.

Furthermore the Monte Carlo method offers great accuracy in the description of physical phenomena, and is essentially free from numerical errors. All these qualities should greatly increase the application and the use of Monte Carlo codes within the shielding community.

It appears, however, that these codes are not widely used. In Europe, in particular, only a few people have experience of the Monte Carlo codes available for distribution, and only in three installations has experience of the use of MORSE been developed / 2 /. One of the reasons for the limited use of this code is in the work that one has to do to adapt the code to the particular problem that one needs to solve.Rather than a code in the traditional meaning of the word, MORSE can be considered as a very flexible set of subprograms that can be tailored to solve any particular shielding problem. This work to "tailor" the code is neither trivial nor negligible and requires a detailed knowledge of the code.

The use of the SAMBO package / 3 / may help in doing this work, but does not avoid it, and in general it is rather expensive in terms of machine time.

To make the practical use of the programme more easy, a new version, called MORSE-E, has been developed by ESIS. This version may be applied without any programming effort. It keeps a sufficient flexibility, and has running times that are not substantially greater than those needed to process the particle histories.

The user may choose among several source geometries described in the following section.
MORSE-E calculates particle fluxes and reaction rates averaged over the volume of the zones requested by the user (see section 3); the corresponding standard deviation is also computed.

2. SOURCE GEOMETRY

MORSE-E may consider isotropic sources, uniformely distributed over a volume. The geometry of the source can be one of the three following:

a) Parallelepiped
b) Sphere
c) Cylinder

In the first case, the parallelepiped must have its faces parallel to the coordinate planes; particular cases may be a rectangle (one side is equal zero), or a segment of a straight line (two sides equal zero).

The second case includs spherical shells; these are defined by the coordinates of the centre and by the inner and outer radius of the shell.
The cylinder must have its axis parallel to one of the coordinate axes, x, y or z. The more general case is that of a cylindrical shell with inner radius Ro and outer radius R_1; particular cases may be the disk (height equals zero) or annulus.
Care should be taken that the source volume lies entirely within the system to be treated.
Only one source volume may be specified for each "run" (set of batches); the case of more than one source volume may be dealt with in one job, containing a number of runs (NQIT in card B of MORSE input) equal to the number of source volumes. In this way different sources may be treated in the same job. The results will be given separately for each source volume; at each new run the code reads the data and prints the results for the new source.

3. CALCULATION OF THE FLUX

Fluxes and response functions are calculated in those geometrical media that are requested in input. If the flux is needed in a certain region of space, this region will receive a particular medium number that will be included in the list of the media for which the flux is wanted. A proper input table is used to fix the correspondence (through the subroutine GTMED) between the media and the cross-sections to be applied.

The flux, in a given medium and group, is computed as the weighted sum of the paths travalled within that medium by the particles belonging to that energy group. This provides the integral of the flux over the volume filled by that medium.

The corresponding standard deviation is calculated in the usual way (through the subroutines VAR1, VAR2) from the results of several batches. The normalization of the results to a given value of the total source (EKONST in input) is also provided.

4. INPUT OF MORSE-E

The input of MORSE-E is the same as that of MORSE, as described in appendix C of [1], plus the set of cards listed below that have to be entered after the "mixing cards" XF.

In MORSE-E we can distinguish between "normal" media and "special" media; normal media are those for which a cross-section set is specified, special media are the others, for which a cross-section set need not be specified, such as internal voids (MED-1000), external voids (MED=0), or albedo media. Normal media should be numbered in order from 1 to NN1.

Cross-section sets are numbered from 1 to NMED (card B).

A table of correspondence between normal medium numbers and cross-section sets must be set up for the subroutine GTMED.

The analysis input data read by subroutine SCORIN are the following:

Card TA (I5)

NT Number of media for which the flux is requested

Fluxes may be calculated in normal media and/or in internal voids.

Card TB (I5)

NN1 Number of normal media

Card TC (14I5)

NXT_i Medium numbers for which the flux is requested; NT entries

Card TD (2I5, 2X, I5A4) NN1 cards

M1 Number of normal medium

MX1 corresponding number of cross-section set

LABEL Alphanumeric information to identify the medium

One TD card must be entered for each normal medium; the first with M1 = 1, the others in order up to M1 = NN1.

Card TE (E.10.0)

EKONST Normalization factor

The following input is read in for each new run.

The description of the source is read by subroutine SOURCE.

Card SA (I5)

IND = 0 Point source (the coordinates are entered in card D)

1 Parallelepiped

2 Sphere

3 Cylinder

If IND > 0 card SB is needed.

(IND = 1) Card SB (6E10.0)

X1, X2

Y1, Y2 Source boundaries

Z1, Z2

(IND = 2) Card SB (3E10.0)

X1, Y1, Z1 Coordinates of the centre of the sphere

Card SC (2E10.0)

R0	Inner radius of the sphere
R1	Outer " " " "

(IND = 3) Card SB (6E10.0)

X1, Y1, Z1	Coordinates of the centre of the base of the cylinder
R0	Inner radius of the cylinder
R1	Outer " " " "
H	Height of the cylind r

If IND = 3 card SC is needed.

Card SC (I5)

IAX = 1	cylinder parallel to Z axis
= 2	" " " Y "
= 3	" " " X "

The last part of input is read by subroutine NRUN and provides the calculation of response functions by medium in the following way:

$$R_m = \sum_{g=I1}^{I2} \phi_g^m F_g$$

R_m = response function in medium m

ϕ_g^m = flux of g^{th} group in medium m

F_g = coefficient for the g^{th} group

I1, I2 lower and upper-limit for the sum

Card ZA (I5)

NR Number of response functions to be computed (NR$\geq$0)

NR sets of cards ZB and ZC are entered

Card ZB (2I5A4)

I1, I2 coefficients are given for groups I1 to I2 included

TIT is printed as heading of the response function output

Card ZC (7E10.0)

F_g values for groups I1 to I2

Input for the next run, if any, starts with card SA.

5. COMMENTS ON THE SUBROUTINES WHICH HAVE BEEN ADDED OR CHANGED

MORSE-E uses 9"user routines" and 3 new routines. What follows are some brief comments.

In MORSE-E the storage required for the blank common is increased by the amount

$$3(NG + 1)\ NT + 2 \cdot NN1 + NG$$

NG = number of neutron and/or gamma-ray groups being analysed

NT and NN1 are described with cards TA and TB in section 4.

The amount of blank common actually used is printed by the program.

One new labelled common has been introduced: STAN; it contains 19 variables needed for the new calculations.

Subroutine BANKR

The particular action of BANKR is that of incrementing by the quantity WTBC · ETATH the flux in a given medium and group each time an event of the type real collision, albedo, boundary crossing, or escape occurs in that medium and group.

Subroutine DIREC

When path length biasing is employed, subroutine DIREC determines the main direction of propagation of particles; path stretching will be maximum along this direction.
In MORSE-E the main direction is assumed to be the positive Z direction.
If path length biasing is not applied, DIREC is not used.

Subroutine GTMED

The correspondence between medium numbers and cross-section sets is established by this routine.

Subroutine SCORIN

It reads input cards TA to TE inclusive and prints out their content.

Subroutine SOURCE

This subroutine is called for each source particle from MSOUR. The only change introduced is a call to subroutine SOURGE.

Subroutine SOURGE

This is a new subroutine that provides the coordinates X, Y, Z of a point drawn out from a uniform distribution within a given volume.
It reads input cards SA, SB and SC.

Subroutine STRUN

Called from BANKR at the beginning of each new run it sets to zero the arrays that will be incremented, at the end of each batch, with the fluxes and square of the fluxes of that batch.

Subroutine STBTCH

Called from BANKR at the beginning of each batch it sets to zero the array used to accumulate the flux of the batch.

Subroutine NBATCH

At the end of each batch this subroutine is called from BANKR to add the fluxes and square of the fluxes of the batch into the proper arrays.

Subroutine NRUN

NRUN is called from BANKR at the end of the run. It calculates the fractional standard deviations (via subroutine VAR2), normalizes the flux by dividing by the total number of particles in the run, multiplies by the normalization factor EKONST (card TE), prints these results, reads response function data from cards ZA, ZB and ZC, computes and prints out the responses.
Editing of results is provided by the new subroutines WRIT and WRIT1.

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Alfred Nobel

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