

ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ
ДУБНА

553

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S.Yu.Shmakov, V.V.Uzhinskii, A.M.Zadorozhny

**DIAGEN - GENERATOR
OF INELASTIC NUCLEUS-NUCLEUS
INTERACTION DIAGRAMS**

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PROGRAM SUMMARY

Title of program: DIAGEN

Catalogue number:

Program obtainable from:

Computer: CDC 6500, IBM, EC

Operating system: NOS/BE (CDC), OC(EC)

Programming language used: FORTRAN IV, also compatible
with FORTRAN 77

High speed storage required: 48 Kwords

No. of bits in a word: 32

Peripherals used: line printer

No. of lines in combined program and test deck: 568

Card image code: EBCDIC

Keywords: Glauber approximation, nucleus-nucleus interactions
at high energies, Monte-Carlo calculation, diagram
generator.

Nature of physical problem:

Calculation of different characteristics of inelastic
nucleus-nucleus collisions within the framework of
the Glauber approximation.

Method of solution:

Monte-Carlo evaluation of multiple integrals and
probability interpretation of the Glauber approximation
is used.

Typical running time:

It depends on the mass numbers of colliding nuclei.



In the test example of collision of ^{238}U and ^{16}O the calculation of the cross section and the profile function takes 103 sec, and 0.5 sec for one diagram generation is required.

Unusual features of the program:-

A random number generator is required.

LONG WRITE-UP

1. Introduction

Now hadron-nucleus and nucleus-nucleus interactions are widely studied in high energy experimental physics. Their results are usually interpreted using the Glauber approximation [1] which allows obtaining values of total, elastic, inelastic cross sections and so on. However, the calculation of Glauber expressions is a rather hard computational problem. In concrete calculations one have to do numerous approximations and simplifications requiring, as a rule, participation of a Glauber theory expert.

The main part of such calculations, however, can be standardized on the basis of the approach suggested in [2]. This problem is solved with the aid of the code DIAGEN (Glauber's DIAGram GENerator).

The plan of the paper is as follows. The next section contains a brief introduction to the Glauber theory. In section 3 the diagram representation of different scattering processes is given. In section 4 the algorithm is described. Finally, section 5 contains a description of the code DIAGEN and an example of how to use it.

2. The main formulas of the Glauber theory

As is well known, the scattering amplitude of two nuclei with the mass numbers A and B in the impact parameter representation is given by [3-6]

$$F(\vec{b}) \Big|_{\substack{A(i \rightarrow f) \\ B(i \rightarrow f)}} = \langle \Psi_A^f; \Psi_B^f | 1 - \prod_{j=1}^A \prod_{k=1}^B [1 - \gamma(\vec{b} - \vec{s}_j + \vec{t}_k)] | \Psi_A^i; \Psi_B^i \rangle, \quad (1)$$

where \vec{b} is the impact parameter vector. The broken brackets mean the average over the initial Ψ_A^i, Ψ_B^i and final Ψ_A^f, Ψ_B^f state wave functions of nuclei A and B. $\gamma(\vec{b})$ is the amplitude of elastic nucleon-nucleon (NN) scattering in the impact parameter representation

$$\gamma(\vec{b}) = \frac{1}{2\pi i p} \int e^{i\vec{q}\vec{b}} f(\vec{q}) d^2q. \quad (2)$$

p is the momentum of nucleus A per nucleon in a system, where target nucleus B is at rest. $f(\vec{q})$ is the NN-elastic scattering amplitude in the momentum representation.

$\{\vec{s}_A\}$ and $\{\vec{t}_B\}$ are the coordinates of the nucleons with regard to the centers of mass of nuclei A and B, respectively, in the plane of the impact parameter (i.e. in the plane perpendicular to the momentum p).

Using (1) one can find different nucleus-nucleus interaction characteristics. For example, on the simple assumption*) that

$$|\Psi_A^i|^2 = \prod_{j=1}^A \rho_A(\vec{s}_j, \vec{z}_j), \quad |\Psi_B^i|^2 = \prod_{j=1}^B \rho_B(\vec{t}_j, \vec{z}_j). \quad (3)$$

(ρ_A and ρ_B are the one-particle density of nuclei A and B) one can obtain

*) The centre-of-mass correlations are ignored, but they can be easily taken into account (see for example [4]).

$$\sigma_{AB}^{tot} = 2 \operatorname{Re} \int d^2\vec{\rho} F(\vec{\rho}) \Big|_{\substack{A(i \rightarrow i) \\ B(i \rightarrow i)}} = 2 \operatorname{Re} \int d^2\vec{\rho}. \quad (4)$$

$$\left\{ 1 - \prod_{i=1}^A \prod_{j=1}^B [1 - \gamma(\vec{\rho} - \vec{s}_i + \vec{c}_j)] \right\} \cdot \left\{ \prod_{i=1}^A \rho_A(\vec{s}_i, z_i) d^3z_i \right\} \left\{ \prod_{i=1}^B \rho_B(\vec{c}_i, \xi_i) d^3t_i \right\}$$

$$\frac{d\sigma_{AB}^{el}}{d\Omega} = \left(\frac{p_A}{2\pi} \right)^2 \left| \int d^2\vec{\rho} e^{i\vec{q}\vec{\rho}} F(\vec{\rho}) \Big|_{\substack{A(i \rightarrow i) \\ B(i \rightarrow i)}} \right|^2 \quad (5)$$

$$\sum_{\vec{\ell}_1, \vec{\ell}_2} \frac{d\sigma}{d\Omega} \Big|_{\substack{A(i \rightarrow \ell_1) \\ B(i \rightarrow i)}} = \left(\frac{p_A}{2\pi} \right)^2 \int d^2\vec{\rho}_1 d^2\vec{\rho}_2 \exp(i\vec{q}(\vec{\rho}_1 - \vec{\rho}_2)).$$

$$\left\{ 1 - \prod_{i=1}^A \prod_{j=1}^B [1 - \gamma(\vec{\rho}_1 - \vec{s}_i + \vec{c}_j)] \right\} \left\{ 1 - \prod_{i=1}^A \prod_{j=1}^B [1 - \gamma^*(\vec{\rho}_2 - \vec{s}_i + \vec{c}_j)] \right\} \cdot (6)$$

$$\left\{ \prod_{i=1}^A \rho_A(\vec{s}_i, z_i) d^3z_i \right\} \left\{ \prod_{i=1}^B \rho_B(\vec{c}_i, \xi_i) d^3t_i \right\} \left\{ \prod_{i=1}^B \rho_B(\vec{c}_i', \xi_i') d^3t_i' \right\}$$

$$\sum_{\vec{\ell}_1, \vec{\ell}_2} \frac{d\sigma}{d\Omega} \Big|_{\substack{A(i \rightarrow \ell_1) \\ B(i \rightarrow \ell_2)}} = \left(\frac{p_A}{2\pi} \right)^2 \int d^2\vec{\rho}_1 d^2\vec{\rho}_2 \exp(i\vec{q}(\vec{\rho}_1 - \vec{\rho}_2)). \quad (7)$$

$$\left\{ 1 - \prod_{i=1}^A \prod_{j=1}^B [1 - \gamma(\vec{\rho}_1 - \vec{s}_i + \vec{c}_j)] \right\} \left\{ 1 - \prod_{i=1}^A \prod_{j=1}^B [1 - \gamma^*(\vec{\rho}_2 - \vec{s}_i + \vec{c}_j)] \right\} \cdot$$

$$\cdot \left\{ \prod_{i=1}^A \rho_A(\vec{s}_i, z_i) d^3z_i \right\} \left\{ \prod_{i=1}^B \rho_B(\vec{c}_i, \xi_i) d^3t_i \right\}$$

$$\sigma_{AB}^{in} = \int d^2\vec{\rho} \left\{ 1 - \prod_{i=1}^A \prod_{j=1}^B [1 - \gamma(\vec{\rho} - \vec{s}_i + \vec{c}_j) - \gamma^*(\vec{\rho} - \vec{s}_i + \vec{c}_j) + \gamma(\vec{\rho} - \vec{s}_i + \vec{c}_j) \cdot \gamma^*(\vec{\rho} - \vec{s}_i + \vec{c}_j)] \right\} \cdot (8)$$

$$\cdot \left\{ \prod_{i=1}^A \rho_A(\vec{s}_i, z_i) d^3z_i \right\} \left\{ \prod_{i=1}^B \rho_B(\vec{c}_i, \xi_i) d^3t_i \right\}.$$

Here σ_{AB}^{tot} is the total cross section, $d\sigma^{el}/d\Omega$ is the differential elastic cross section. Expression (6) gives the differential quasi-elastic cross section for scattering of nucleus B summed over all final states of nucleus A. Formula (7) gives the double quasi-elastic differential cross section summed over all final states of nuclei A and B (including elastic scattering). Finally σ_{AB}^{in} is the inelastic cross section.

The main problem of the calculation of all these expressions is the calculation of the profile function

$$\Gamma(\vec{\rho}) = \int \left\{ 1 - \prod_{i=1}^A \prod_{j=1}^B (1 - p_{ij}) \right\} \cdot \left\{ \prod_{i=1}^A \rho_A(\vec{z}_i) d^3z_i \right\} \cdot \left\{ \prod_{i=1}^B \rho_B(\vec{t}_i) d^3t_i \right\}, \quad (9)$$

where $p_{ij} = \gamma(\vec{\rho} - \vec{s}_i + \vec{c}_j)$ for expressions (4), (5), or $p_{ij} = \gamma(\vec{\rho} - \vec{s}_i + \vec{c}_j) + \gamma^*(\vec{\rho} - \vec{s}_i + \vec{c}_j) - \gamma(\vec{\rho} - \vec{s}_i + \vec{c}_j) \cdot \gamma^*(\vec{\rho} - \vec{s}_i + \vec{c}_j)$ for expression (8). Thus for interpretation of the experimental data within the framework of the Glauber approach one needs an effective procedure of evaluation of expressions like (9). It was suggested in paper [2] that the Monte-Carlo method should be used for this purpose.

3. Diagram representation of scattering processes

It is convenient to introduce a diagram representation for various terms of Glauber expressions. For this purpose we rewrite the part of integrand (9) containing NN amplitudes in the form:

$$1 - \prod_{i=1}^A \prod_{j=1}^B (1 - p_{ij}) = \sum_{i=1}^A \sum_{j=1}^B p_{ij} \prod_{\substack{k=1 \\ k \neq i}}^A \prod_{\substack{\ell=1 \\ \ell \neq j}}^B (1 - p_{k\ell}) + \frac{1}{2} \sum_{i=1}^A \sum_{\substack{j, k=1 \\ j \neq k}}^B p_{ij} p_{ik} \prod_{\substack{\ell=1 \\ \ell \neq i, m \neq j, k}}^B (1 - p_{\ell m}) + \frac{1}{2} \sum_{i=1}^A \sum_{\substack{k=1 \\ k \neq i}}^B p_{ik} p_{jk} \prod_{\substack{\ell=1 \\ \ell \neq i, j, m \neq k}}^B (1 - p_{\ell m}) + \dots = \sum_M \left\{ \prod_{(i,j) \in M} p_{ij} \right\} \left\{ \prod_{(i,j) \notin M} (1 - p_{ij}) \right\} \quad (10)$$

Here M is the set of ordered pairs (i, j) of numbers of interacting nucleons of nuclei A and B; a pair (i, j) belongs to M if and only if nucleon i of nucleus A interacts with nucleon j of nucleus B. Representing nucleons of nuclei A and B by two rows of labelled points (see fig. 1) one can represent the elements of the set M by the lines connecting nucleons i and j . Each term of (10) can be put into one-to-one correspondence with some diagrams of such type. For example, the first three terms of (10) correspond to the diagrams of fig. 1. These diagrams are called the bipartite graphs in the graph theory [7].

In physical literature different representations of graphs are used (see e.g. [6,8-11]). Recently, the so-called "net diagrams" have been most popular. Nucleons of nuclei A and B in them are represented by vertical and horizontal lines, respectively, and interactions between the nucleons are designated by black points at the intersection of the

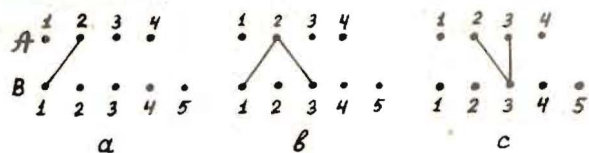


Fig. 1

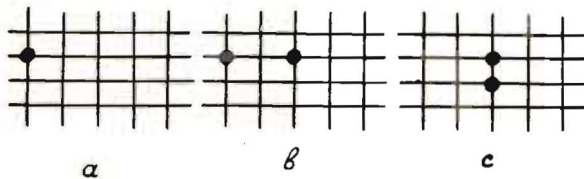


Fig. 2

corresponding lines. For example, the net diagrams of graphs of fig. 1 are given in fig. 2.

4. Description of the algorithm

Considering the part of integrand (9) containing nuclear densities as a probabilistic measure, one can easily construct the Monte-Carlo estimation of multiple integral (9) in the form

$$G(\vec{\ell}, \{\vec{z}_A\}, \{\vec{t}_B\}) = 1 - \prod_{i=1}^A \prod_{j=1}^B (1 - p_{ij}). \quad (11)$$

The mean value of $G(\vec{\ell}, \{\vec{z}_A\}, \{\vec{t}_B\})$ evaluates the profile function (9) - $\Gamma(\vec{\ell})$

$$\Gamma(\vec{\ell}) \approx \frac{1}{N} \sum_{k=1}^N G(\vec{\ell}, \{\vec{z}_A\}, \{\vec{t}_B\}). \quad (12)$$

Here N is the number of ensembles of nucleon coordinates of nuclei A and B sampled from the distribution defined by the probabilistic measure *)

$$d^M[\rho_A, \rho_B] = \left(\prod_{i=1}^A \rho_A(\vec{z}_i) d^3z_i \right) \left(\prod_{j=1}^B \rho_B(\vec{t}_j) d^3t_j \right). \quad (13)$$

Practically N of the order of one hundred is sufficient to obtain the value of an inelastic cross-section with the accuracy about some per cent.

Note also that in the case of inelastic scattering expression (10) admits of a simple probabilistic interpretation.

*) It is possible in this approach to take into account multinucleon correlations using nonfactorized expressions for nuclear densities.

The left-hand side of (10) is the probability that at least one interaction of nucleons takes place. Each term of the right-hand side is the probability of collisions with the given number of nucleon interactions: it has a simple structure of probability of simultaneous realization of independent elementary events, - whose probabilities are P_{ij} or $1 - P_{ij}$ depending on whether interaction between the nucleons i and j takes place or not. This structure of Glauber expressions allows one to generate the diagrams of nucleus-nucleus scattering in a simple way. Thus, the algorithm of diagram generation consists of the following steps:

1. Estimation of multiple integral (9) using nuclear densities as a probabilistic measure and tabulation of the function $\Gamma(\vec{b})$;
2. Sampling of \vec{b} according to the distribution of $\Gamma(\vec{b})$;
3. Sampling of transverse coordinates of nucleons according to the nuclear densities;
4. Determination of interacting pairs of nucleons, which requires generation of A·B random numbers $\{\xi_{ij}\}_{i,j=1}^{A,B}$ uniformly distributed in the interval $[0, 1]$. An inelastic interaction of a pair of nucleons i and j takes place if $\xi_{ij} \leq P_{ij}$.

One has to perform step 1 only once for a given projectile-target combination steps 2-4 should be repeated until the required number of diagrams is reached.

5. Description of the code DIAGEN

1. The code DIAGEN includes subroutines PREVIO, DIAGEN, CONUCL, RANNOR.
- 1.1. The subroutine PREVIO (NA, NCA, RA, NB, NCB, RB, NSITEB, NSTAT, SIG, RO, A)

calculates the profile-function $\Gamma(\vec{b})$ (see (9)) in the impact parameter interval $(0, 4 \cdot (RA + RB))$.

Input values: NA, NCA, RA are the mass number, charge and radius (in Fm) of nucleus A; NB, NCB, RB are the mass number, charge and radius of nucleus B. NSITEB is the number of nodes over b for tabulation of the function $\Gamma(\vec{b})$. NSTAT is the number of coordinate configurations over which the averaging $G(\vec{b}, \{z_A, \{t_A\})$ (see (12)) is performed, SIG is the total cross section (in mb) of NN-interactions at the given energy of NN-collisions. RO is the ratio of real to imaginary parts of the NN elastic scattering amplitude at the zero momentum transfer. A is the slope of the differential NN-elastic scattering cross section at the zero momentum transfer (in $(\text{GeV}/c)^{-2}$).

Output values are stored in common-blocks AMPL, DIAPAR and PROF (see below).

In the subroutine we have assumed that at sufficiently high energies the NN-elastic scattering amplitude can be parametrized as

$$\gamma(\vec{b}) = \frac{\sigma_{NN}^{tot}}{4\sqrt{\pi}\alpha} (1 - i \text{Re} f_{NN}(0) / \text{Im} f_{NN}(0)) \cdot e^{-\vec{b}^2/2\alpha} \quad (14)$$

At energies about 1-2 GeV one can use an effective value of

$$\alpha = \sigma_{NN}^{tot} / 4\sqrt{\pi}.$$

- 1.2. Subroutine DIAGEN (NA, RA, NB, RB, NEDGS, NEDMAX, ISEQ1, ISEQ2, JS, JT)

Input values: NA is the mass number of nucleus A, RA is its radius (in Fm); NB is the mass number of nucleus B, RB is its radius (in Fm). NEDMAX is the maximum number of

edges *) (inelastic NN-interactions) in a graph (diagram). Besides, see in COMMON /DIAPAR/ parameters IBIM, BMIN, BMAX.

Output values: NEDGS is the number of edges in the generated diagram. ISEQ1, ISEQ2 are two vectors representing the set M. ISEQ1 (ISEQ2) includes the numbers of interacting nucleons of nucleus A(B). Dimensions of ISEQ1 and ISEQ2 must be defined in the calling program as greater than or equal to NEDMAX. JS, JT are the degrees of the points of a graph. JS(I) (JT(I)) is equal to the number of inelastic NN-collisions in which the Ith-nucleon from nucleus A (B) participated. For example, for diagrams of fig. 1 ISEQ1, ISEQ2, JS, JT are

For fig. 1a

ISEQ1 = 2 JS = 0, 1, 0, 0
ISEQ2 = 1 JT = 1, 0, 0, 0

For fig. 1b

ISEQ1 = 2,2 JS = 0, 2, 0, 0
ISEQ2 = 1,3 JT = 1,0, 1, 0

For fig. 1c

ISEQ1 = 2,3 JS = 0, 1, 1,0
ISEQ2 = 3,3 JT = 0, 0, 2, 0

Note that before the first call of DIAGEN the subroutine PREVIO must be called.

1.3. The subroutine CONUCL (S,NA,RA) generates coordinates of nuclear nucleons. It is used in PREVIO and DIAGEN

Input values: NA and RA are the mass number and radius of the nucleus.

*) In principle, NEDMAX must be equal to A·B, but in practical calculation its value of several hundreds is enough.

Output values: S(3,NA) is the set of the coordinates of the nucleons. S(1,I), S(2,I), S(3,I) are the X-, Y-, Z-components of the radius - vector of the Ith-nucleon, respectively (the x, y components are in the impact parameter plane).

Notes:

- (i) If A=1, S(1,1), S(2,1), S(3,1) are equal to zero.
- (ii) If NA=2, we use the parametrization of the squared wave function of the deuteron from [12]. The Z-component of the nucleon coordinates is not defined.
- (iii) If NA=4 (helium nucleus), $\rho_A(\vec{z}) = \exp(-\vec{z}^2/R_A^2)/(4\pi R_A^2)^{3/2}$.

Usually, $R_A = 1.37$ Fm is used.

- (iv) If NA ≥ 12 the Woods-Saxon distribution of nuclear density

$$\rho_A(\vec{z}) = \text{const}/[1 + \exp((|\vec{z}| - R_A)/c)]$$

is used. c = 0.545 Fm

If one wishes to have another forms of nuclear density, he must change the corresponding operators in the subroutine CONUCL.

2. Explanation of COMMON-blocks

2.1. COMMON /AMPI/ CA, CI, GA contains the parameters of the NN-scattering amplitude.

$$CA = C_{NN}^{tot} (1 - i \text{Re} f_{NN}(0) / \text{Im} f_{NN}(0)) / 4\pi a.$$

CI is the imaginary unit. GA = 1/2a. The COMMON-block is filled in by subroutine PREVIO.

2.2. COMMON / PROF / NSTB, BSTEP, BSITE (100) contains the characteristics of the profile function $\Gamma(\beta)$. In

BSITE (I) the value of $\frac{2\pi}{c_{AB}} \int_0^{b_i} \beta \Gamma(\beta) d\beta$ is stored.

$$b_i = i \times \text{BSTEP}.$$

NSTB is the number of steps over the impact parameter.

2.3. COMMON/ DIAPAR /IBIM, BMIN, BMAX, BIMP, SIGMA,
SIGMAB, NSPECT, NSPECP

Here the following parameters are stored:

IBIM, BMIN, BMAX are DIAGEN options. In the case IBIM=1 impact parameter will be sampled from the interval (BMIN, BMAX), otherwise the impact parameter is determined according to profile function.

BIMP the value of the impact parameter, SIGMA the value of the inelastic cross sections.

SIGMAB the value of inelastic cross section at (BMIN, BMAX) if IBIM=1, otherwise SIGMAB=SIGMA
NSPECT, NSPECP are not used in this version of the code.

2.4. COMMON/ COOR /S(3,238), TAU (3,238) contains the coordinates of the nucleons of nuclei A and B (S and TAU, respectively).

3. Additional programs

3.1. The subroutine NUCLCH (NA, NCA, ICS) allows charges to be ascribed to the nuclear nucleons.

Input values: NA and NCA are the mass number and charge of a nucleus.

Output values: Vector ICS (NA). ICS(I) is equal to the charge of the Ith-nucleon (0 or 1 for the neutron or proton, $1 \leq I \leq NA$).

All distributions of the charge over nuclear nucleons are assumed to have an equal probability.

3.2. The subroutine RANNOR (X,Y) returns two normally distributed numbers X and Y. It is used in CONUCL.

3.3. The function RNDM (DULLY) is a random number generator.

4. An example of using the code for generation of $^{16}\text{O} + ^{238}\text{U}$ inelastic interaction diagrams at $\sqrt{s_{NN}} = 20$ GeV.

```
COMMON/DIAPAR/IBIM,BMIN,BMAX,BIMP,SIGMA,SIGMAB,NSPECT,NSPECP
DIMENSION ISEQ1(160), ISEQ2(160)
DIMENSION JS(40), JT(238)
DIMENSION IQ(16,238)
NEVENT=2

C-----
C                               DIAGEN OPTIONS
C-----
                              IBIM=1
                              BMIN=8.0
                              BMAX=9.0
                              NSITEB= 50
                              NSTAT=50
                              NEDMAX=160
C-----
C                               PROJECTILE/TARGET CHARACTERISTICS
C-----
                              NA=16
                              NCA=8
                              RA=1.12*FLOAT(NA)**0.333333
                              NB=238
                              NCB=92
                              RB=1.07*FLOAT(NB)**0.333333
C-----
C                               NUCLEON-NUCLEON ELASTIC AMPLITUDE PARAMETERS
C-----
                              SIG=40.
                              RO=0.
                              A=12.84
C-----
C
C
CALL PREVIO(NA,NCA,RA,NB,NCB,RS,NSITEB,NSTAT,SIG,RO,A)
DO 60 N=1,NEVENT
CALL DIAGEN(NA,RA,NB,RS,NEDGS,NEDMAX,ISEQ1,ISEQ2,JS,JT)
C-----
C
C
NWA=0
NWB=0
DO 10 I=1,NA
IF(JS(I).EQ.0) GO TO 10
NWA=NWA+1
CONTINUE
10 DO 20 I=1,NB
IF(JT(I).EQ.0) GO TO 20
NWB=NWB+1
CONTINUE
20 NSPECA=NA-NWA
NSPECB=NB-NWB
PRINT 1002,BIMP,NEDGS,NSPECA,NSPECB
1002 FORMAT(/' CHARACTERISTICS OF EVENT '/2X,24(1H-)/
*' IMPACT PARAMETER B = ',F6.2/
*' INTERACTION MULTIPLICITY NEDGS = ',I4/
*' NUMBER OF SPECTATORS IN NUCLEUS A = ',I3/
*' NUMBER OF SPECTATORS IN NUCLEUS B = ',I3)
```



```

DO 30 J=1,NA
DO 30 K=1,NB
30 IQ(J,K)=0
DO 40 J=1,NEDGS
NA1=ISEQ1(J)
NB1=ISEQ2(J)
40 IQ(NA1,NB1)=1

```

```

C
PRINT 1003,(JS(J),J=1,NA)
1003 FORMAT(/10X,'ADJACENCY MATRIX OF THE DIAGRAM'/11X,32(1H-)//
      *1X,5H \JS,16I3/
      *1X,5H JT\-,16(3H---))
DO 50 J=1,NB
IF (JT(J).NE.0)PRINT 1004,JT(J),(IQ(K,J),K=1,NA)
50 CONTINUE
1004 FORMAT(2X,12,1X,'I',16I3 )
60 CONTINUE
END

```

Test run output:
=====

GLAUBER'S APPROACH IS USED TO CALCULATE THE CROSS-SECTIONS
OF VARIOUS INELASTIC PROCESSES IN THE COLLISION OF
=====

	PROJECTILE	TARGET	
A	16	238	(MASS NUMBERS)
Z	8	92	(CHARGES)
R	2.822	6.631	(RADII (FM))

AMPLITUDE PARAMETRIZATION

```

=====
      SIG      -B*B/(2*A)  SIG = 40.00 (MB)
F (B) = ----- * (1-I*RD) * E      RD = 0.0
NN      4*PI*A      A = 12.64 (GEV/C)**(-2)

```

THE NUMBER OF POINT OVER B 21 (NSITEB)
STATISTICS PER POINT 50 (NSTAT)
MAX VALUE OF B 16.21 FM

CROSS-SECTION IS 3751.12 +/- 94.26 MB
CROSS SECTION AT B IN INTERVAL (8.0000, 9.0000) IS 535.218 MB

CHARACTERISTICS OF EVENT

IMPACT PARAMETER B = 8.95
INTERACTION MULTIPLICITY NEDGS = 15
NUMBER OF SPECTATORS IN NUCLEUS A = 11
NUMBER OF SPECTATORS IN NUCLEUS B = 226

ADJACENCY MATRIX OF THE DIAGRAM

```

-----
\JS 6 3 0 0 0 1 0 0 0 0 0 0 3 2 0 0
JT\
1 I 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 I 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
2 I 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0
1 I 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0
2 I 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0
1 I 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
1 I 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 I 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 I 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2 I 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0
1 I 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 I 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 I 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

```

CHARACTERISTICS OF EVENT

IMPACT PARAMETER B = 8.46
INTERACTION MULTIPLICITY NEDGS = 13
NUMBER OF SPECTATORS IN NUCLEUS A = 9
NUMBER OF SPECTATORS IN NUCLEUS B = 232

ADJACENCY MATRIX OF THE DIAGRAM

```

-----
\JS 0 0 1 1 0 3 0 1 0 0 0 1 0 0 3 3
JT\
5 I 0 0 0 1 0 1 0 1 0 0 0 0 0 0 1 1
3 I 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 1
2 I 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1
1 I 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
1 I 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
1 I 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0

```

Concluding remark

If it is necessary to calculate other Glauber values (see section 2), one should change the definition of PIJ in the subroutine PREVIO and determine the corresponding expressions in it.

Acknowledgement

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References

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Шмаков С.Ю., Ужинский В.В.,
Задорожный А.М.
DIAGEN - генератор диаграмм неупругих
ядро-ядерных взаимодействий

E2-88-732

Дано описание программы, которая генерирует диаграммы неупругих ядро-ядерных взаимодействий. Вероятности появления различных диаграмм определяются в рамках глауберовского приближения. Программа позволяет определять сечения тех или иных процессов, число спектральных нуклонов и т.д.

Работа выполнена в Лаборатории вычислительной техники и автоматизации ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1988

Shmakov S.Yu., Uzhinskii V.V.,
Zadorozhny A.M.
DIAGEN - Generator of Inelastic Nucleus-Nucleus
Interaction Diagrams

E2-88-732

Description of the program code generating inelastic nucleus-nucleus interaction diagrams is given. Probabilities of various diagram appearance are determined within the framework of Glauber approximation. The code allows one to determine cross sections of any processes, the number of spectator nucleons, etc.

The investigation has been performed at the Laboratory of Computing Techniques and Automation, JINR.

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