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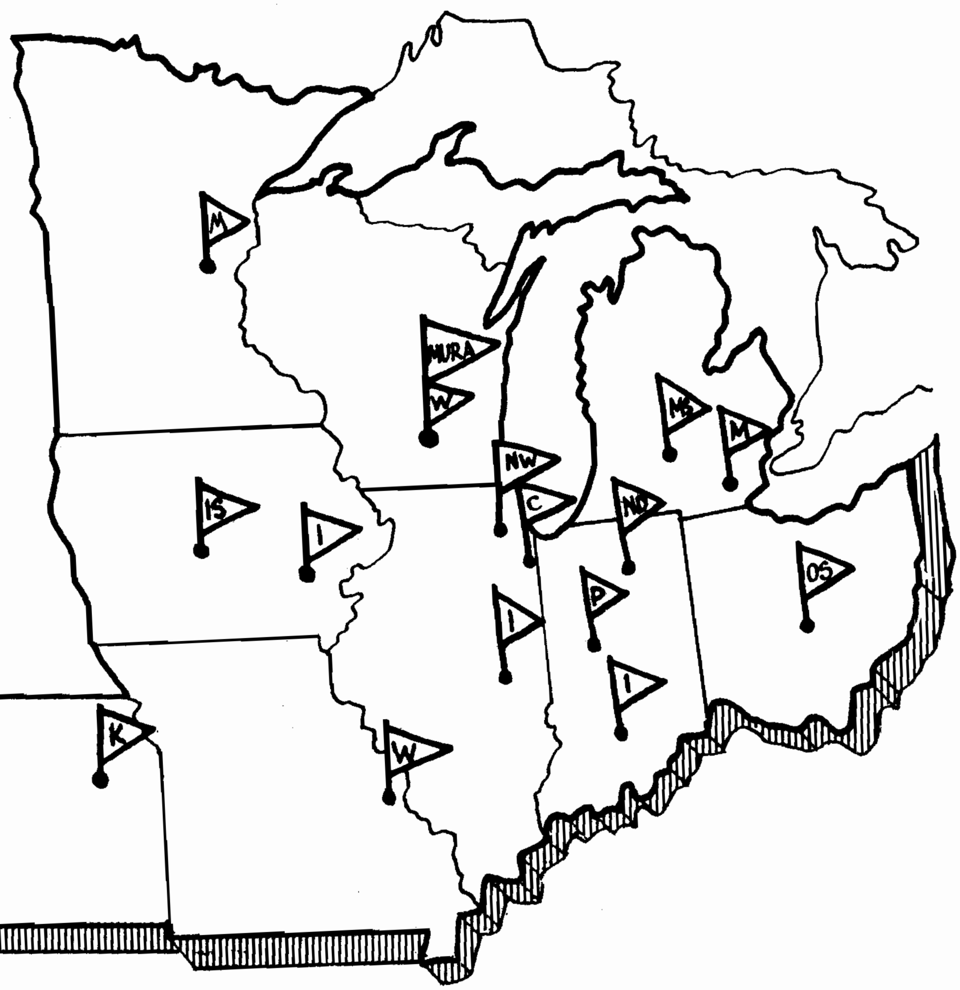
MIDWESTERN UNIVERSITIES RESEARCH ASSOCIATION



NUMBER 566

REPORT

CURSES (Foiled Again)
(Program 287)
March 15, 1960

Computer Program

CURSES (Foiled Again)
(Program 287)

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CURSES, a program for A. Galonsky and S. Rosen, calculates the scattering in an accelerator of a beam of particles, initially on the equilibrium orbit, of any energy and of charge number equal to $\pm$ 1, from a foil of arbitrary material and thickness. The position in betatron phase space after the n^{th} foiling is:

$$Z_n = P_n + iX_n = \sum_{j=1}^{n-1} a_j e^{i2\pi\nu(n-j)} + a_n .$$

The recursion formulae for P_n and X_n are:

$$P_n = P_{n-1} \cos 2\pi\nu - X_{n-1} \sin 2\pi\nu + a_n$$

$$X_n = X_{n-1} \cos 2\pi\nu + P_n \sin 2\pi\nu .$$

a_n is picked randomly from a Molière distribution where the probability of picking a value of a_n (hereafter called t) is given by:

$$P_{(t)} = \frac{2}{\sqrt{\pi}} e^{-t^2} + \frac{1}{B} f^{(1)}_{(t)}$$

where $f^{(1)}_{(t)}$ is a correction factor due to Molière and is computed as follows:

$$f^{(1)}_{(t)} = A_0 + A_1 t + A_2 t^2 + A_3 t^3 + A_4 t^4 + A_5 t^5 + A_6 t^6 + A_7 t^7 \quad \text{for } t \leq 3.5$$

$$= \frac{1}{t^3 \left(1 - \frac{9}{2t^2}\right)^{2/3}} \quad \text{for } t > 3.5$$

$A_0 = 0.0168188$

$A_1 = 0.291854$

$A_2 = -3.35135$

$A_3 = 5.10091$

$A_4 = -3.06547$

$A_5 = 0.863356$

$A_6 = -0.109403$

$A_7 = 0.00450854$

The positions of a particle are calculated until $Z_n \geq A = t_{SL}$ or until n (the number of kicks) $=$ L ,at which time the next particle is started.

Output consists of a print of initial conditions, the number of particles that exceeded A and the number that did not, and a list of the number of particles that exceeded A within brackets of L/100 kicks. Also a plot is made of the number of particles remaining versus the number of foilings undergone. Printing of particle positions every L/100 kicks will be done if required, as will the particle position when it escapes (exceeds A). Plotting may be suppressed. The Molière distribution may be printed if desired.

The Input parameters are the following:

ν	the betatron time
α_{SL}	stability angle = maximum angle of particle with the equilibrium orbit
T	Kinetic Energy of Projectile
E_1	Rest Energy of Projectile
E_2	Rest Energy of Target Nucleus

M_1	Mass Number of Projectile
M_2	Mass Number of Target
Z	Charge Number of Target
x	Target Thickness
$\lambda\!\!\!^{-}_c$	Compton Radian Length of Projectile

These quantities are related to the A, B, and L previously mentioned by the following equations:

$$\beta_1 = \sqrt{1 - \left(\frac{E_1}{T+E_1}\right)^2} \qquad \beta_c = \sqrt{1 + 2E_1/T} \Big/ 1 + \frac{(E_1+E_2)}{T}$$

$$T' = (E_1 + E_2)\left[\sqrt{1 + \frac{2E_2 T}{(E_1+E_2)^2}} - 1\right]$$

$$\lambda\!\!\!^{-} = \lambda\!\!\!^{-}_c \Big/ \sqrt{\left(\frac{T'}{E_1}\right)^2 + 2\left(\frac{T'}{E_1}\right)}$$

$$\Theta_1 = 2.00(10^{10})\frac{\lambda\!\!\!^{-}}{\beta_1}\sqrt{\frac{Z(Z+1)x}{M_2}}$$

$$\Theta_a^2 = 4.55(10^{16})(\lambda\!\!\!^{-} Z^{1/3})^2\left[1.13 + 2.00(10^{-4})\left(\frac{Z}{\beta_1}\right)^2\right]$$

$$\underline{\underline{B}} = 2.53 \log\left(\frac{\Theta_1}{\Theta_a}\right)^2 + 1.07$$

$$\gamma_1 = \sqrt{\beta_c^2 + \left(\frac{E_1}{E_2}\right)^2(1 - \beta_c^2)}$$

$$\alpha'_{SL} = \frac{\alpha_{SL}(1+\gamma_1)}{\sqrt{1-\beta_c^2}} \qquad \text{for small angles}$$

$$\underline{\underline{A}} = t_{SL} = \frac{\alpha'_{SL}}{\theta_1 \sqrt{B}}$$

$$\underline{\underline{L}} = 3A^2$$

L will be computed unless the user wishes to specify it on the agenda sheet. L /100 kicks are taken as the granularity of the final plot (100 points will be plotted along the abscissa).

λ_c will be taken as 2.10(10^{-14}) (for a proton) unless the user specifies something different on the agenda sheet.

The largest value of t, (a_n) which might be found by the calculation is:

$$a_n\,(\max) = t_{max} = \frac{\alpha'_{max}}{\theta_1 \sqrt{B}} \qquad \text{where:}$$

$$\alpha'_{max} = \frac{1.2\,\lambda}{R} \qquad \text{and} \qquad R = 1.2\, M_2^{1/3}\,(10^{-13})$$

This is the value of t at which the Molière distribution is truncated.

The time of running may be estimated by the following rule:

2 seconds per Kilo-Particle-Kick if V = integer

4 seconds per Kilo-Particle-Kick if V ≠ integer

The MURA 2 Printer Board is required.

CURSES, PROGRAM 287 AGENDA

Address	Floating Point Data		
30		ID	Eight Figure Identification
32		N_p	Number of Particles per Run
33		L	Summation Limit #
34		ν	Betatron Tune
35		α_{SL}	Stability Angle = maximum angle of particle with equilibrium orbit
36		T	Kinetic Energy of Projectile } any units
37		E_1	Rest Energy of Projectile } but the same for
38		E_2	Rest Energy of Target Nucleus } all three
39		M_1	Mass Number of Projectile
40		M_2	Mass Number of Target
41		Z	Charge Number of Target *
42		x	Target Thickness in gm/cm^2
43		λ_c	Compton Radian Length of Projectile in cm. $
1	END		

2 BLANK CARDS

Sense Switch 2 UP ☐ DO NOT PLOT RESULTS

4 UP ☐ PRINT EVERY PRINT STEP

5 UP ☐ PRINT PARTICLE ESCAPES

6 UP ☐ PRINT MOLIÈRE DISTRIBUTION

NORMAL RUN, ALL DOWN

L Calculated by machine, unless specified.

* Z of Projectile always taken to be 1.

$ λ_c 2.10×10^{-14} for Proton, unless specified.