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GRAPHS OF SCATTERED PARTICLE ENERGIES VS SCATTERING ANGLES, AND
GRAPHS OF CENTER-OF-MASS SCATTERING ANGLES VS LABORATORY
SCATTERING ANGLES FOR NUCLEON-NUCLEON REACTIONS FROM
25 TO 3500 MeV AND FOR PION-NUCLEON REACTIONS
FROM 25 TO 2500 MeV

CESTI PRICES

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Abstract

Graphs are presented illustrating the laboratory energy of the scattered nucleon vs the laboratory energy of the incident nucleon where the scattering angle is a parameter for incident nucleon energies ranging from 25 to 3500 MeV. The same type of data is presented for pion-nucleon reactions with energies from 25 to 2500 MeV. Graphs of the scattering angle in the center-of-mass system vs the scattering angle in the laboratory system at various reaction energies for the same reactions and over the same energy ranges are presented. The data are applicable to the checking and the understanding of the results from an intermediate-energy intranuclear-cascade calculation.

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The need for the data in this report has occasionally risen while debugging an intermediate-energy intranuclear-cascade calculation, and while attempting to understand the energy and angular dependence of the results when comparisons with experiment are made. It was decided to calculate these quantities by computer in order to cover the energy and angular range of interest.

All of the energies and angles illustrated in Figs. 1 - 11 are laboratory system values.

Figures 1 - 3 illustrate the energy of the scattered nucleon vs incident nucleon energy in nucleon-nucleon scattering reactions ranging from 25 to 3500 MeV where the scattering angle is a parameter.

Figures 4 - 11 illustrate the energy of the scattered pion vs incident pion energy in pion-nucleon scattering reactions ranging from 25 to 2500 MeV using the scattering angle as a parameter.

Figures 12 - 22 are graphs of the center-of-mass scattering angle vs the laboratory scattering angle for nucleon-nucleon scattering reactions at various energies from 25 to 3500 MeV.

Figures 23 - 31 contain similar data, i.e., plots of the center-of-mass scattering angle vs laboratory scattering angle for pion-nucleon scattering reactions from 25 to 2500 MeV.

The expressions from which the data above were calculated are relativistic. It is assumed that the struck particle is at rest. The notation is defined as follows:

T_i = Kinetic energy (MeV) of the incident particle in the laboratory system

T_s = Kinetic energy (MeV) of the scattered particle in the laboratory system

v = Velocity of the center-of-mass system (in units of C)

p_s = The momentum (MeV/C) of the scattered particle, in the laboratory system

m_n = The nucleon rest mass in MeV

m_π = The pion rest mass in MeV

E = The total energy of the particle, $E = T + m$

θ = The scattering angle in the laboratory system

θ' = The scattering angle in the center-of-mass system.

The following expressions were derived using straightforward relativistic kinematics.

The energy of a nucleon, scattered at an angle θ , for a nucleon-nucleon scattering reaction of energy, T_i , is given by

$$T_s = \frac{T_i \cos^2 \theta}{1 + \frac{T_i \sin^2 \theta}{2m_n}} \quad (1)$$

The energy of a pion, scattered at an angle θ , for a pion-nucleon scattering reaction where the incident pion energy is T_i , is

$$T_s = \{ [-(E_i + m_n) (2E_i m_n + 2m_\pi^2) \pm \{ (E_i + m_n)^2 (2E_i m_n + 2m_\pi^2)^2 + [(E_i^2 - m_\pi^2) \cos^2 \theta - (E_i + m_n)^2] [(2E_i m_n + 2m_\pi^2)^2 + 4(E_i^2 - m_\pi^2) x m_\pi^2 \cos^2 \theta] \}^{1/2}] / 2[(E_i^2 - m_\pi^2) \cos^2 \theta - (E_i + m_n)^2] \} - m_\pi \quad (2)$$

where the minus sign in front of the square root is used for $\theta \leq 90^\circ$ and the plus sign is used for $\theta \geq 90^\circ$.

The scattering angle in the center-of-mass system, θ' , in terms of laboratory system quantities is

$$\theta' = \arctan \left[\frac{\sqrt{1-v^2} \sin\theta}{\cos\theta - \frac{vE}{p}} \right] \quad (3)$$

For nucleon-nucleon reactions

$$v = \frac{\sqrt{T_i^2 + 2T_i m_n}}{T_i + 2m_n}$$

$$E = T_s + m_n \quad \text{where } T_s \text{ is given by Eq. (1)}$$

$$p = \sqrt{T_s^2 + 2T_s m_n}$$

For pion-nucleon reactions

$$v = \frac{\sqrt{T_i^2 + 2T_i m_\pi}}{T_i + m_\pi + m_n}$$

$$E = T_s + m_\pi \quad \text{where } T_s \text{ is given by Eq. (2)}$$

$$p = \sqrt{T_s^2 + 2T_s m_\pi}$$

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ENERGY OF SCATTERED NUCLEON VS INCIDENT NUCLEON ENERGY AND LABORATORY SCATTERING ANGLE, Θ

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ENERGY OF SCATTERED NUCLEON VS INCIDENT NUCLEON ENERGY AND LABORATORY SCATTERING ANGLE, Θ

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ENERGY OF SCATTERED PION VS INCIDENT PION ENERGY AND LABORATORY SCATTERING ANGLE, Θ ORNL-DWG-67-8454

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ENERGY OF SCATTERED PION VS INCIDENT PION ENERGY AND LABORATORY SCATTERING ANGLE, Θ

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NUCLEON-NUCLEON SCATTERING AT 25. MEV LABORATORY ENERGY

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NUCLEON-NUCLEON SCATTERING AT 100. MEV LABORATORY ENERGY ORNL-DWG- 67-8463

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PION-NUCLEON SCATTERING AT 2500 MEV LABORATORY ENERGY

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