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COMPARISON OF THE RIGID PROJECTILE APPROXIMATION WITH EXACT CALCULATIONS FOR α-α SCATTERING

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We compare the results for the distribution of the number of wounded nucleons obtained in the rigid projectile approximation with the results of exact calculations for α-α interactions at CERN ISR energies.

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The cross section for inelastic nondiffractive collision of two α-α particles colliding at impact parameter b is:

$$\sigma(b) = \int \prod_{i=1}^{4} ds_i^2 \prod_{j=1}^{4} d\vec{\tilde{s}}_j^2 D_A(\vec{s}_1 \dots \vec{s}_4) D_B(\vec{\tilde{s}}_1 \dots \vec{\tilde{s}}_4) \sigma(\vec{b}, \vec{s}_1 \dots \vec{s}_4, \vec{\tilde{s}}_1 \dots \vec{\tilde{s}}_4), \tag{1}$$

where

$$\sigma(\vec{b}, \vec{s}_1 \dots \vec{s}_4, \vec{\tilde{s}}_1 \dots \vec{\tilde{s}}_4) = 1 - \prod_{i=1}^{4} \prod_{j=1}^{4} (1-\sigma_{ij}) \tag{2}$$

and $\sigma_{ij} = \sigma(\vec{b} - \vec{s}_i + \vec{\tilde{s}}_j)$ is the probability of nucleon-nucleon inelastic collision at impact parameter $\vec{b} - \vec{s}_i + \vec{\tilde{s}}_j$. The nuclear density of α particle can be described by the formula:

$$D(\vec{s}_1 \dots \vec{s}_4) = \frac{1}{(\pi R^2)^3} \exp\left(-\frac{\vec{s}_1^2 + \vec{s}_2^2 + \vec{s}_3^2 + \vec{s}_4^2}{R^2}\right) \delta^{(2)}\left(\frac{\vec{s}_1 + \vec{s}_2 + \vec{s}_3 + \vec{s}_4}{4}\right) \tag{3}$$

and the nucleon-nucleon interaction probability can be approximated by a Gaussian form:

$$\sigma(b) = \frac{\sigma_{pp}}{\pi a^2} \exp\left(\frac{-b^2}{a^2}\right), \tag{4}$$

where σ_{pp} is the total nucleon-nucleon nondiffractive cross-section.

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We can expand Eq. (1) in a series the terms of which can be interpreted as probabilities of different types of collisions [1] and on this basis we can calculate probability distribution $P(n)$ of number of wounded nucleons n in one particle. Results are plotted in Fig. 1.

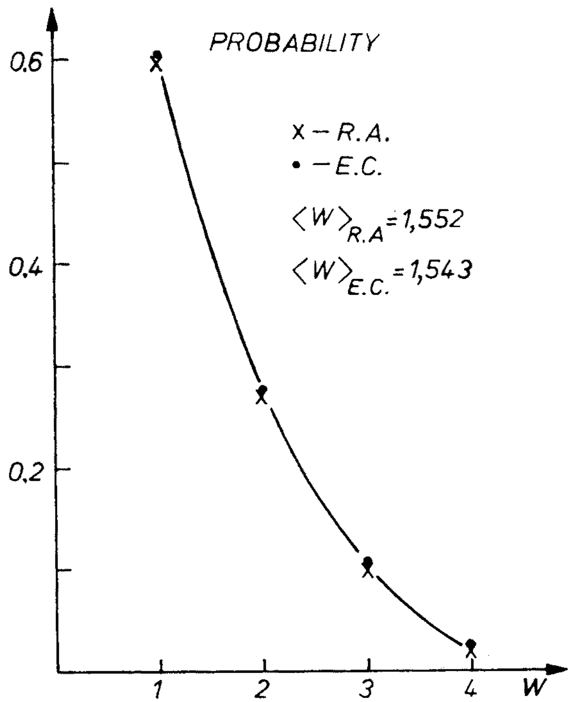

Fig. 1. Probability distribution of number of wounded nucleons in α-α interactions. Crosses — rigid projectile approximation, dots — exact calculations

$P(n)$ can also be obtained by use of rigid projectile approximation. In this approximation the total nondiffractive cross-section is given by a formula [2–4]:

$$\sigma = \int d^2b[1-(1-\gamma(b))^4], \tag{5}$$

where

$$\gamma(b) = 1- \int d^2sD(s-b)\,[1-\sigma(s)]^4 \tag{6}$$

and

$$\sigma(s) = \int dxD(x)\tilde{\sigma}(s-x),$$

$$\tilde{\sigma}(s-x) = \frac{\sigma_{pp}}{\pi a^2}\exp\left(-\frac{(s-x)^2}{a^2}\right),$$

$$D(x) = \frac{4}{3\pi R^2}\exp\left(-\tfrac{4}{3}\,\frac{x^2}{R^2}\right). \tag{7}$$

Eq. (5) gives the following distribution $P(n)$:

$$P(n) = \frac{1}{\sigma}\int d^2b \binom{4}{n} (\gamma(b))^n (1-\gamma(b))^{4-n}.$$

The total α-α nondiffractive cross-section obtained from Eq. (5) (using the same value of parameters a, R, σ_{pp} as in Ref. [1]) is 210 mb. This differs from the result of the exact calculation 220.8 mb by about 5% only. Figure 1 presents a comparison of $P(n)$ obtained from exact calculations and rigid projectile approximation. We see that these results are in good agreement. Also the average numbers of wounded nucleons agree very well with each other.

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