MICROSCOPIC ANALYSIS OF 1.37 GeV α-^{12}C ELASTIC SCATTERING IN TERMS OF A MODIFIED GLAUBER MODEL

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The elastic differential cross section of 1.37 GeV α-particles scattered by ^{12}C nuclei have been recently measured and analyzed[1] in terms of an improved first order approximation to the multiple scattering theory. We report here an analysis carried out in the framework of the Glauber multiple scattering model, which leads to a better agreement with the experimental data.

In the Glauber approximation[2] the elastic scattering amplitudes for collisions between nuclei with mass numbers A and B in the impact parameter representation assumes the form[3,4]

$$(1)\quad F_{AB}(\Delta)=Q(\Delta)\,\frac{ip}{2\pi}\int d^2b\,\exp(i\bar{\Delta}\cdot\bar{b})\Gamma_{AB}(b)$$

where p,Δ are the incident c.m. momentum and momentum transfer respectively, and $Q(\Delta)$ is a center-of-mass correlation factor. The nucleus-nucleus profile function $\Gamma_{AB}(b)$ is expressed in the form

$$(2)\quad \Gamma_{AB}(b)=\langle\Psi_A^0\Psi_B^0|1-\prod_{i=1}^{A}\prod_{j=1}^{B}\left(1-\gamma_{ij}(\bar{b}-\bar{s}_i^A+\bar{s}_j^B)\right)|\Psi_A^0\Psi_B^0\rangle$$

in terms of the elementary N-N profile functions γ_{ij}, which are defined as the Fourier transforms of the amplitudes. Ψ_A^0 and Ψ_B^0 are the ground state wave functions of the nuclei, expressed in intrinsic coordinates; $\bar{s}_i^A$ and $\bar{s}_j^B$ are the projections of nucleon intrinsic coordinates on the impact parameter plane. In the standard assumption of independent particles the elastic nucleus-nucleus scattering amplitude is expressed therefore in terms of the nuclear densities and the elementary amplitude only.

The above information implies very cumbersome calculations, related both to the classification of the different multiple scattering processes and to the actual evaluation of the multidimensional integrals. It was shown by Czyż and Maximon[3] that in the so-called optical limit the profile is well approximated by

$$\Gamma_{AB}=1-\left(1-C(b)\right)^{AB} \qquad (3)$$

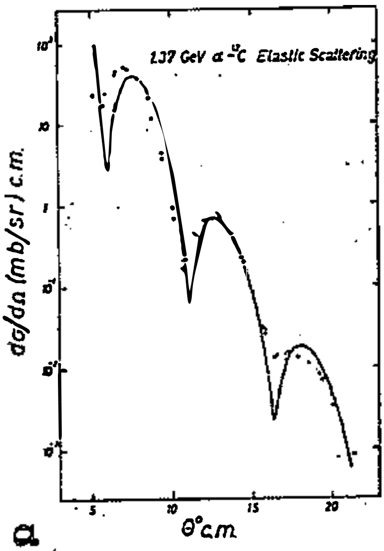
where

$$C(b)=\langle\Psi_A^0\Psi_B^0|\gamma(\bar{b}-\bar{s}^A+\bar{s}^B)|\Psi_A^0\Psi_B^0\rangle. \qquad (4)$$

In an alternative derivation[5] formula (3) can be obtained from the Goldberger-Watson multiple scattering theory in the hypothesis that the virtual excitations of the colliding nuclei give negligible contributions to the elastic cross-section[6]. It is this derivation that justifies the use of formula (3) in the case being analyzed.

The single particle nuclear densities have been assumed of the gaussian type for the α-particle and of the modified gaussian type $[\rho_c(r)\propto(1+\beta r^2)\exp(-r^2/R_c^2)]$ for the ^{12}C nucleus with the parameters taken from ref.[7]. We have used two different elementary profiles γ_{np} and $\gamma_{pp}=\gamma_{nn}$, both of the gaussian form $[\gamma(b)=\sigma(1-i\alpha)\exp(-b^2/2a)/4\pi a]$ with parameters corresponding to the Igo[8] N-N scattering amplitude parametrization. We warn that the use of different profiles leads to a slight modification of formula (3). The numerical results are displayed in fig. 1a. The good agreement with the experimental data obtained by this "no free parameter" fit strongly supports the validity of the above model.

In order to improve our achievements we have also carried out a best fit. Since at present the density distributions are more reliable that the N-N amplitudes, a single profile was used and the parameter variation was limited to the profile. The best fit results are illustrated in fig. 1b and, as one can see, the improvement is noticeable.



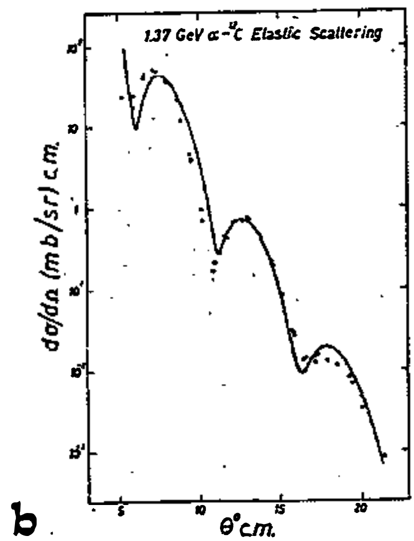


Fig. 1: a) "No free parameter" fit to the 1.37 GeV α-^{12}C elastic scattering, obtained by formula (3). The experimental points are taken from ref[1]. The density and profile parameters are R_α=1.31 fm, $R_{^{12}C}$=1.64 fm, β=0.49 fm^{-2} and σ_{pp}=11.62 mb, σ_{np}=16.51 mb, α_{pp}=0.71, α_{pn}=0. , a_{pp}=0.005 fm^2, a_{pn}=0.026 fm^2.

b) Best fit with a single profile and fixed densities as given in a). The best fit parameters are σ=14.99 mb, α=0.27, a=0.038 fm^2.

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