ELASTIC SCATTERING OF 1-GeV PROTONS BY ^{39}K and ^{40}Ca NUCLEI

G. D. Alkhazov, G. M. Amal'skii, S. L. Belostotskii, A. A. Vorob'ev, V. T. Grachev, O. A. Domchenkov, Yu. V. Dotsenko, V. E. Starodubskii, and M. A. Shuvaev
Leningrad Institute of Nuclear Physics, USSR Academy of Sciences
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We measured the differential cross section for elastic scattering of 1-Gev Protons by ^{39}K and ^{40}Ca nuclei in the angle interval θ_{cms} = 5 - 18 deg. An analysis within the framework of the Glauber theory with a single-particle nuclear density describes the experimental results adequately.

In earlier experiments [1 - 3] on the scattering of 1-GeV protons by ^{2}H, ^{4}He, ^{12}C, and ^{16}O nuclei, the results were on the whole adequately described by Glauber's theory [4, 5]. For a more detailed comparison of the theoretical predictions with experiment, it is of interest to increase the number of investigated nuclei, particularly heavier ones. For such nuclei, a description in which a single-particle nuclear density is used is more justified, since the correlation corrections decrease with increasing number of nucleons in the nucleus. This uncovers a possibility of investigating the neutron-density distribution density in nuclei, in addition to the charge density investigated in experiments on electron scattering by nuclei.

We have measured the differential cross sections for elastic scattering of 1-GeV protons by ^{39}K and ^{40}Ca nuclei in the scattering angle interval θ_{cms} = 5 - 14 deg and θ_{cms} = 5 - 18 deg, respectively. The measurements were performed with the synchrocyclotron of the Leningrad Institute of Nuclear Physics, using a magnetic spectrometer with a FWHM resolution 1.8 MeV. The experimental procedure is described in [6, 7]. We used targets weighing ∿ 80 mg (2×4×5 mm), made of chemically pure metals with natural isotropic content. The percentage content of the isotopes in the target is given in the table.

Isotope content in targets (%)

Target	Metallic potassium			Metallic calcium				
Isotope	^{39}K	^{40}K	^{41}K	^{40}Ca	^{42}Ca	^{43}Ca	^{44}Ca	^{48}Ca
Content %	93.08	0.01	6.91	96.97	0.64	0.15	2.06	0.18

The absolute normalization of the differential cross section for scattering by ^{40}Ca was performed at θ_{lab} = 18 deg by comparing the areas under the peaks of elastic scattering by ^{40}Ca and ^{1}H, in a manner similar to that used in [3]. The differential cross section for scattering by ^{39}K was normalized to the cross section for ^{40}Ca, likewise at θ_{lab} = 8 deg.

Figures 1 and 2 show the measured differential cross section and the theoretical curves calculated in the optical limit of Glauber's theory [8]. We used in the calculation the single-particle nucleon distribution density in the nucleus, assuming that the neutrons and protons have the same density distribution. The proton-nucleus elastic scattering cross section was taken from the form [4, 7]

$$F(q) = ik\int_0^\infty b\,db\,I_0(qb)\{1 - \exp[(-4\pi/ik)f(0)\int_0^\infty dz\,\rho(b,z)]\}. \quad (1)$$

Here $f(0) = (ik/4\pi)\sigma(1 - i\varepsilon)$ is the amplitude of the forward proton-nucleon elastic scattering, averaged over the p-p and p-n collisions (total cross section $\sigma = 4.4$ F^2, $\varepsilon = -0.33$), and $\rho(b, z)$ is the density distribution of the nuclear matter with allowance for the finite nucleon dimensions. In our case ρ coincides with the charge density measured in electron scattering. The function $\rho(r)$ was chosen in the form of a two- or three-parameter Fermi distribution:

$$\rho(r) = \rho_0[1 + \exp((r-R)/a)]^{-1}, \quad (2)$$

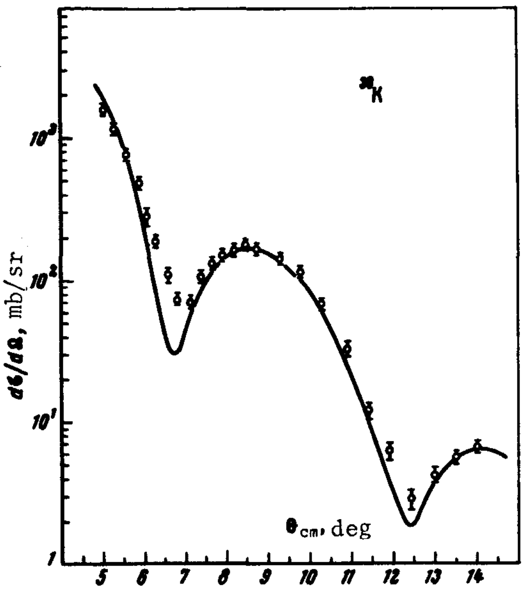

Fig. 1. Differential cross section for elastic scattering of 1-GeV protons by ^{39}K nuclei. The theoretical curve was calculated with a three-parameter Fermi distribution of the nuclear density: R = 3.741 F, a = 0.585 F, and w = -0.204.

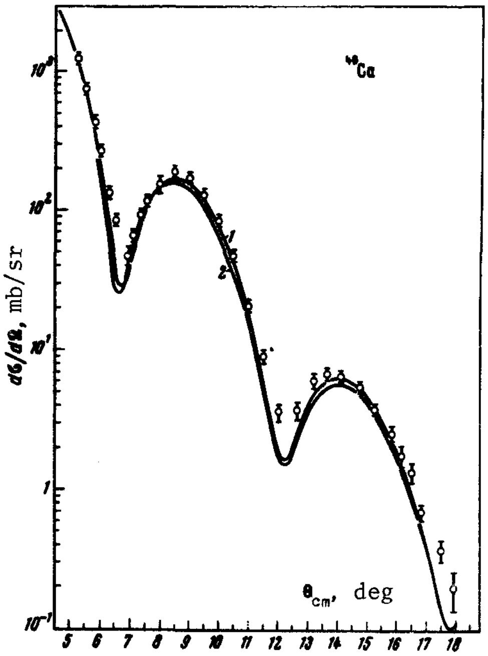

Fig. 2. Differential cross section for elastic scattering of 1-GeV protons by ^{40}Ca nuclei. Curve 1 corresponds to calculation with three-parameter Fermi distribution of the nuclear density: R = 3.725 F, a = 0.591 F, w = -0.169; curve 2 — calculation with two-parameter Fermi distribution: R = 3.6 F, a = 0.576 F.

$$\rho(r) = \rho_0[1 + w(r^2/R^2)][1 + \exp((r - R)/a)]^{-1}. \quad (3)$$

The parameters R, a, and w were taken from [9, 10], where they were determined from data on the scattering of high-energy electrons by ^{40}Ca and ^{39}K in the same momentum-transfer region as in our case. Since the parameters of the paired nucleon amplitude and charge density were taken from other experiments, the calculations involved no free parameters.

It is seen from Figs. 1 and 2 that on the whole there is good agreement between theory and experiment. In the case of ^{40}Ca, the curve corresponding to a density distribution in the form of the three-parameter relation (3) describes the data better than in the case of the usual Fermi distribution (2). The same relation (3) describes better the cross section for elastic electron scattering by ^{40}Ca. There is a discrepancy in the diffraction minima, but it can be decreased by taking into account the Coulomb interaction and the finite angular resolution of the spectrometer (± 0.2°). It can thus be concluded that Glauber's theory using only a single-particle nuclear density describes elastic scattering of protons by ^{40}Ca and ^{39}K sufficiently well. The assumption that the neutron and proton distributions are equal does not contradict the experimental data at the employed accuracy level.

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