Polarization in elastic scattering of 1-GeV protons by the nuclei ^{40}Ca and ^{208}Pb and the parameters of the spin-orbit amplitude

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The polarization was measured in elastic scattering of 1-GeV protons by the nuclei ^{40}Ca and ^{208}Pb in the angle range $\theta_{cms} = 1.8$–13 deg. The spin-orbit amplitude parameters averaged over the protons and neutrons are obtained with the aid of Glauber's theory.

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Despite the large number of experimental studies devoted to nucleon-nucleon (NN) scattering, at energies around 1 GeV there are still no data on the spin-dependent parts of the NN-interaction amplitude. This is caused by the difficulties in the organization of the so called "complete experiment" on the scattering of free neutrons. At the same time, one can attempt to obtain information on the spin-orbit proton-neutron interaction from an analysis of the polarization in the elastic scattering of protons by nuclei. In fact, in the case of elastic scattering of protons

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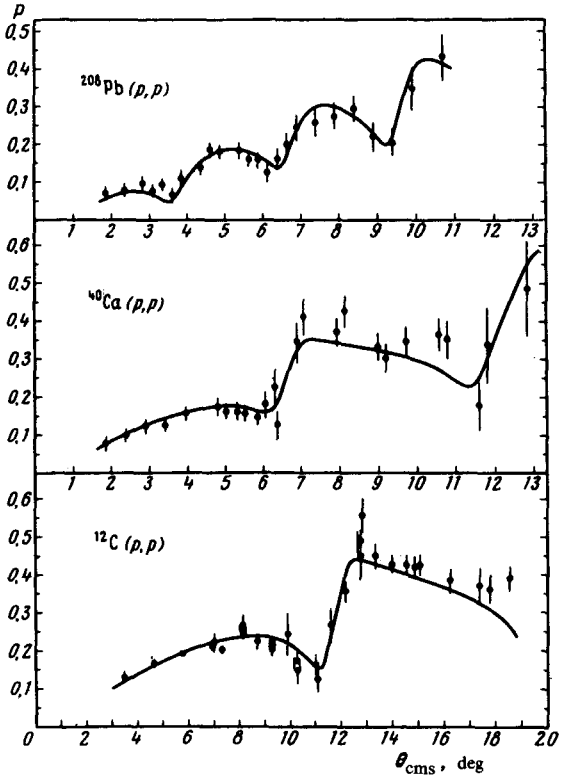

FIG. 1. Angular dependence of the polarization in elastic scattering of 1-GeV protons by the nucle ^{12}C,[2] ^{40}Ca, and ^{208}Pb.

by nuclei with zero spin the contribution made to the cross section by other spin-dependen amplitudes (in an approximation where the nucleon correlations are small) is strongly suppresse so that the corresponding polarization is determined by the spin-orbit part of the NN interactio Data on the spin-orbit part of the NN interaction would permit a more detailed analysis of th differential cross sections for elastic scattering of protons by nuclei for the purpose of the investig tion of the neutron distribution.[1]

We present here the results of measurements of the polarization in elastic scattering of proto of energy 1 GeV by the Nuclei ^{40}Ca and ^{208}Pb. These data, together with those obtained by u earlier[2] on the polarization in scattering by ^{12}C, analyzed with an aim at finding the parameters c the spin-orbit nucleon-nucleon amplitude.

The polarization was measured by a double-scattering scheme with the aid of a magneti spectrometer with FWHM resolution 2 MeV. The experimental procedure was described essentia ly in[1]. Since the angular dependence of the first scattering was much stronger than in the case c ^{12}C, the horizontal angle spread of the spectrometer was decreased to ± 0.1 deg. The results of th measurements are shown in Fig. 1. It is seen that in all cases the polarization has a characteristi diffraction structure. Figure 1 shows also curves obtained by least-square reduction of the exper mental data. The reduction was carried out using Glauber's theory in the approximation in whic the nucleon-nucleon correlation are small, which makes it possible in the case of nuclei with zer

ABLE I. Parameters used in the calculations for the distribution of the density of the nuclear ıatter and of the central amplitude[1,3,4]. The spin-orbit amplitude parameters γ, ϵ_s, and β_s were ɔtained in the course of the reduction of the experimental data.

Nucleus	Nuclear-density distribution parameters			Central-amplitude parameters			Spin-orbit amplitude parameters		
	R, F	a, F	W	σ, F^2	ϵ_c	β_c, F^2	γ, F	ϵ_s	β_s, F^2
^{208}Pb	6.578	0.576	−0.061	4.32	−0.327	0.239	0.14 ±0.01	−0.4 ±0.2	0.9 ±0.2
^{40}Ca	3.7	0.627	−0.169	4.4	−0.26	0.239	0.14 ±0.01	−0.7 ±0.2	0.70 ±0.09
^{12}C	2.172	0.547	−0.111	4.4	−0.26	0.239	0.156 ±0.006	−0.01±0.1	0.56 ± 0.03

ɔin to retain in the nucleon-nucleon scattering matrix only the central amplitude $f_c(q)$ and the ɔin-orbit amplitude $f_s(q)$. The amplitudes $f_c(q)$ and $f_s(q)$ averaged over the neutrons and the rotons were parametrized in the form

$$f_c(q) = (k\sigma/4\pi)(\epsilon_c + i)\exp(-\beta_c q^2/2), \tag{1}$$

$$f_s(q) = \gamma q (k\sigma/4\pi)(\epsilon_s + i)\exp(-\beta_s q^2/2). \tag{2}$$

'he parameters of the central amplitude were fixed, while the parameters of the spin-orbit mplitude were obtained in the course of the reduction of the experimental data (see Table I). We sed in the calculations a three-parameter distribution of the density of the nuclear matter

$$\rho(r) = \rho_0 \left(1 + W\frac{r^2}{R^2}\right)\left[1 + \exp\left(\frac{r-R}{a}\right)\right]^{-1} \tag{3}$$

/ith the parameters taken from[1,3,4] (see Table I).

The obtained values of γ and β_s turned out to be close in value for all three nuclei. On the ther hand, ϵ_s changes noticably on going from ^{12}C to ^{40}Ca and ^{208}Pb. To determine more accurately he parameters of the spin-orbit interaction it is apparently advisable to expand the group of ıvestigated nuclei, and also to carry out a joint theoretical analysis of the polarization and ifferential-cross-section data, including the corrections to Glauber's theory and allowance for the ucleon correlations.

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