The quantity $N_{\sigma_0 \tau_0}$ was calculated for the ground state of He^4 with a two-body potential which has oscillator character at short distances and equals zero at distances larger than 1.7 $\times 10^{-12}$ cm. Taking as a first approximation only the lowest states in the sum (1), we find that $N_{\sigma_0 \tau_0}$ equals 0.015 for the collective, 0.014 for the single-particle, and 0.011 for the two-particle coordinates respectively. Thus we find that for the α particle either of these mechanisms can be applied with sufficient accuracy.

However, one can expect that for heavier nuclei the collective model will yield rather larger values for $N_{\sigma_0 \tau_0}$ than the other models. Because of the short range of the nuclear forces, collective oscillations of many nucleons will be more difficult to establish than oscillations of individual nucleons. Even a rough estimate of the magnitude of $N_{\sigma_0 \tau_0}$ as a function of the atomic number would be of interest.

The influence of the Pauli principle reduces to the circumstance that, for example in the excitation of the collective oscillation, the more tightly bound nucleons cannot be excited since those states are already occupied by other nucleons. This will also result in excitation of other degrees of freedom simultaneously with the excitation of the collective coordinate. One can take for a measure of the forbiddenness of collective transitions the quantity $Q = 1 - w_1/w_2$ where w_1 and w_2 are the probabilities of the collective dipole transition calculated with and without the Pauli principle respectively. In the oscillator model we have $Q = 9/25$ for O^{16} and $Q = 5/9$ for Ca^{40}.

As can be seen the Pauli principle will also lead to quenching of the collective degrees of freedom.

Thus the collective model of the electric dipole excitation can be applied only for the lightest nuclei. For heavier nuclei the single and the two-particle mechanisms will play the more important role.

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MEASUREMENT OF THE DEGREE OF LONGITUDINAL POLARIZATION OF BETA PARTICLES

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MEASUREMENTS of the degree of longitudinal polarization of β electrons have been made by many authors (cf. for example the survey of Smorodinskiĭ[1]).

In the present work the longitudinal polarization was converted to transverse by passing the electrons through crossed magnetic and electric fields. After emerging from the field region, the electrons passed through a system of diaphragms and impinged on a thin gold scatterer. Electrons scattered through an angle of 120° were recorded by Geiger counters. In the experiment we measured the magnitude of the left-right scattering asymmetry, which is a measure of the polarization of the electrons.

The length of the field region, l, was 300 mm, and the gap between the plates to which the high voltage was applied was 14 mm. The size of the magnetic field H and electric field E needed to rotate the spin of electrons with momentum p through angle φ was found from the relation

$$\varphi = eHl\sqrt{1-\beta^2}/pc; \quad E = \beta H.$$

The absolute values of the applied fields were found to an accuracy of about 1% from conversion lines of known energy. The measurements were carried out for an electron energy of 340 kev and an angle φ equal to 90°.

The end points of the spectra of the isotopes studied differed very much, which could result in

Nucleus	P^{32}	Sm^{153}	Lu^{177}	Ho^{166}	In^{114}
Relative value of the polarization	1.047±0.012	1.00	0.945±0.012	0.930±0.012	0.965±0.030
Absolute value (error = ±4%)	0.94	0.90	0.85	0.84	0.86

errors which are very difficult to evaluate. In order to have the same conditions of measurement for all substances, we made a preliminary energy separation of the electrons. The spectrum of the electrons entering the region of action of the crossed fields extended from ~ 250 to 450 kev.

The work can be divided into two parts. The first consisted in a comparison of the polarization of electrons from P^{32}, In^{114}, Lu^{177}, Sm^{153}, and Ho^{166}. After making the relative measurements, the absolute value of the polarization of the Sm^{153} β particles was measured.

The relative measurements were made by measuring, under identical conditions, the left-right asymmetry in the scattering of β particles of the isotopes enumerated above by gold of thickness 0.55 mg/cm^2.

In making relative measurements of polarization, it is not necessary to know the apparatus asymmetry. All that is necessary is that the apparatus asymmetry be small and remain constant. For this reason, the apparatus asymmetry was not determined in these measurements. Instead, we repeatedly measured the asymmetry in scattering of β particles from Sm^{153} by gold. This source had sufficient intensity so that we could get a statistical accuracy better than one percent in a relatively short time. Numerous measurements of the asymmetry for Sm^{153} showed that the spread in values of the apparatus asymmetry did not exceed 0.5%. As an additional check, we made some special experiments in which the source was moved in various directions from its working position, and also in which the applied fields were changed by an amount 2 or 3 times as great as the error in their setting when making the relative measurements. In these control experiments, to an accuracy of one percent, we noted no dependence of the results on these factors.

We used sources with a mean thickness of 0.6 to 0.9 mg/cm^2. To determine the depolarization in the source, we did an experiment in which we compared the asymmetry for a Sm source of thickness 0.8 mg/cm^2 with the asymmetry when the same source was covered by a layer of inactive Sm of the same thickness deposited on an aluminum foil of thickness 0.8 mg/cm^2, so that the average path of electrons in the source material was increased by a factor of three. From this experiment we found that the depolarization in the source of thickness 0.8 mg/cm^2 for an electron energy of 340 kev is (0.6 ± 1.2)%. Considering that the upper limit for this effect does not exceed 1.8%, we find that the spread in values for the depolarization correction for different sources does not exceed 0.6%.

The results of the relative measurements of polarization of β particles are given in the top line of the table. The polarization of the Sm^{153} betas is arbitrarily set equal to unity. From the results given, it is clear that the degree of longitudinal polarization is different for different isotopes. It is interesting to note that the polarizations in the case of P^{32} and In^{114}, both of which are allowed Gamow-Teller transitions, differ by (8 ± 4)%.

Absolute measurements of the degree of polarization of the electrons were made for the most intense β emitter, Sm^{153}.

The apparatus asymmetry was measured by using thin aluminum scatterers (thicknesses 4 and 8 μ). The scattering asymmetry was measured using gold scatterers with thicknesses 0.55, 0.36, and 0.18 mg/cm^2. The thicknesses of the gold scatterers were determined by weighing to relatively low accuracy. However, for a correct extrapolation to zero thickness with good accuracy, it is necessary to know only the relative values of the weights. These relative values were found from the counting rates for scattered electrons.

As already stated, in our experiments the spin was rotated through 90°. Under these conditions, even a relatively large error in determining the angle of rotation (for example 10%) cannot lead to any significant error in the measurements. Special experiments, in which the electron spins were turned through 75, 90, and 115°, confirmed this to a high degree of accuracy.

From the measurement and extrapolation to zero thickness, we obtained a value of the asymmetry corresponding to a degree of longitudinal polarization of 0.85 ± 3% (in units of v/c). Corrections were made to this value to take account of the following effects: 1) depolarization in the source $(0.6 \pm 1.2\%)$; 2) scattering of electrons from the diaphragms, 0.5%; 3) scattering of electrons from the backing on which the gold was deposited, 0.6%; 4) arrival at the counters of electrons multiply scattered in the chamber in which the gold scatterers were placed, $(3 \pm 1.5\%)$; 5) the finite range of angles and energies of the electrons which were recorded, 0.3%; 6) a coefficient for the apparatus asymmetry, 1.00 ± 0.02.

The total of all these corrections to the experimental value of the polarization does not exceed 5%. Introducing these corrections gives a value of the polarization for Sm^{153} equal to $0.90 \pm 4\%$.

The absolute values for the degree of polarization of the other nuclei which were investigated were found from the relative measurements, and are shown in the lower line of the table.

From the table we see that we succeeded in making the relative measurements to sufficiently high accuracy. It should be noted that the accuracy achieved by us in the absolute measurements is clearly insufficient. It is probable that we can improve it significantly in the near future. We also propose to make an absolute calibration of the apparatus using a beam of accelerated electrons, polarized by single scattering on gold.

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POSSIBILITY OF INVESTIGATING THE LEVELS OF THE COMPOUND NUCLEUS PRODUCED BY INTERACTION BETWEEN SLOW NEUTRONS AND ISOMERS

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An investigation of the interaction between slow neutrons with energy $E < 1$ kev and unexcited heavy nuclei disclosed the resonant structure of the cross section and yielded the parameters of the levels of the compound nucleus. There are no similar data in the 10 or 100 kev range, since the experimentally-measured cross sections are averaged over many resonances, owing to the insufficient resolving power of the apparatus as well as to the Doppler broadening.

To obtain information on the levels of the compound nucleus at high excitation energies, use can be made of the interaction between neutrons and isomers. If a nucleus in an excited isomer state is bombarded with slow neutrons, a group of levels will be excited tens or hundreds of kev above the levels of the compound nucleus that results when the unexcited target nucleus is bombarded with slow neutrons. Such an experiment would help explain how the widths and densities of levels change in a nucleus of given Z and A when the excitation energy is shifted by several tens or hundreds of kev. The spins of the two level groups should be different, since the spins of the isomer and ground states differ by several units.

It is easy to estimate very roughly the number of isomer nuclei, necessary for such an experiment, in the following manner. Let a beam of monoenergetic neutrons pass through a target of area $S \sim 1\ cm^2$. Then the necessary number of isomer nuclei is $N \sim S/\sigma$, where σ is the cross section in the neighborhoods of resonance. Assume $\sigma \sim 10^3$ barns. Then the necessary number of nuclei amounts to 10^{21} or several tenths of a gram. The isomers can be accumulated by activation in a nuclear reactor, separated from fission fragments, or produced in accelerators. In a modern reactor with a neutron flux $\Phi \sim 10^{14}$ at an activation cross section $\sigma_a \sim 1$ barn, it is possible to accumulate within several months $\sigma_a \Phi t$ long-lived isomer nuclei, or 10^{-3} times the number of the nuclei in the original isotope. The fractions of several isomers in fission fragments are of the same order. Thus, an accumulation of enough isomer nuclei for the experiment is quite feasible.

The spin of the compound nucleus can be determined for many isomer nuclei.

In interactions between slow neutrons and isomers it is possible to have, along with elastic scattering (n, n) and radiation capture (n, γ), also inelastic scattering with emission of a fast neutron (n, n'), when the emitted neutron carries away the excitation energy of the isomer. When the isomer is bombarded by thermal or epithermal neutrons, the resultant fast neutrons should be highly monoenergetic. For isomers with excitation energy on the order of 100 kev, owing to the small density of the initial states and the high density of the final states, the cross section for such