ELASTIC SCATTERING OF 10–15 Mev ALPHA PARTICLES BY GOLD AND ALUMINUM

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The angular distribution of 10 — 15 Mev α particles elastically scattered by gold and aluminum has been studied. The differential cross-sections for scattering of α particles by gold obey the Rutherford formula for angles between 10 and 140°. The angular distribution of α particles elastically scattered by aluminum is characterized by the presence of maxima and minima.

A study of the departures of the experimental cross sections for elastic scattering of α particles from the cross sections calculated by the Rutherford formula, makes it possible to obtain information on the radius and potential of the nuclear interaction of α particles. For this purpose the angular distributions of α particles with energies 20 — 43 Mev, scattered elastically by light and heavy nuclei, have been studied in detail.[1-6] The angular distribution of α particles with energies 8 — 20 Mev, elastically scattered by nuclei, has been insufficiently studied. In the present work measurements have been carried out on the angular distribution of 10 — 15 Mev α particles scattered by gold and aluminum nuclei.

The experiments were made with the cyclotron of the Physico-Technical Institute of the Academy of Sciences. The target — a thin gold or aluminum foil — was placed in the center of the 500 mm diameter brass chamber. Ya-2 photographic plates, with emulsion 100 μ thick, were placed around the target at equal distances and at equal angles of inclination to the axis of the collimated beams of scattered α particles. The windows of the casettes containing the plates were covered with 3.9 μ thick aluminum foil. Irradiation of the plates was carried out in several doses, and the ranges of angles 10 — 30, 30 — 50, 50 — 90 and 90 — 140° were covered consecutively. The overlap of angles in the ranges chosen made it possible to have "coupling plates," which provided a check on the readings of the monitor (Faraday cup with integrating circuit). The α-particle tracks with fixed (corresponding to calculation) values of range were counted with an MBI-2 microscope.

The energy of the primary α particle beam was determined from the range-energy curves in aluminum and in the photographic emulsion, for α particles scattered by gold, and for the protons from the reaction $Al^{27}(\alpha, p)Si^{30}$. In the latter case the Q values were used, determined by the magnetic analysis method[7] for transitions to the ground state and to the first, second and third excited states of Si^{30}.

The experimental scattering cross section in the center-of-mass system (for an angle $\Theta_{c.m.}$) was determined by using the formula

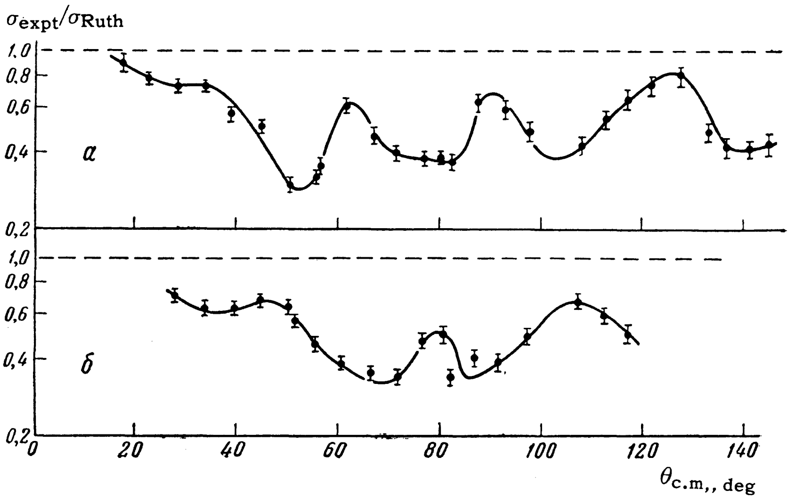
$$\sigma_{expt} = \frac{N_T(\theta_{lab})}{n_\alpha n_n G} \sin\theta_{lab} \frac{\sin^2\theta_{lab}}{\sin^2\theta_{c.m.}} \cos(\theta_{lab} - \theta_{c.m.}),$$

where $N_T(\Theta_{lab})$ is the number of α-particle tracks traversing a fixed area of plate examined at a given angle Θ_{lab} (laboratory system), n_α is the number of α particles falling on the target, determined from the charge in the Faraday cup, n_N is the number of nuclei referred to 1 cm^2 of target, and G is a coefficient determined by the geometrical conditions of the experiment.

The angular distribution of 10.4, 13.6, and 14.7 Mev α particles, elastically scattered by a 0.25 mg/cm^2 thick gold foil was studied by the method described. It was established that the differential cross section for scattering of α particles by gold satisfies the Rutherford formula in the range of angles 10 — 140°. The result holds generally for all α-particle energies studied here. The absolute values of the cross sections were determined with an error not exceeding 15%.

The elastic scattering of α particles by aluminum was studied for energies of 10.4 and 13.6 Mev in the primary beam (corresponding to α-particle energies in the c.m. system of 9.05 and 11.9 Mev). The target was 0.13 mg/cm^2 thick aluminum foil.

The points in the figure represent the ratio of the experimental cross sections for elastic scattering to the cross sections calculated by the



Angular distribution of α particles, elastically scattered by aluminum: a – for $E_{\alpha c.m.} = 11.9$ Mev, b – for $E_{\alpha c.m.} = 9.05$ Mev.

Rutherford formula. Apart from the statistical and geometrical errors of the experiment, errors related to incomplete separation of the groups of elastically and inelastically scattered α particles are also taken into account. For scattering at small angles the geometrical errors are dominant. while for scattering at large angles ($\Theta_{c.m.} > 90°$) the errors connected with separation of the inelastically scattered α particles are dominant.

It follows from the figure that the ratio $\sigma_{expt}/\sigma_{Ruth}$ is less than unity, and for $\Theta_{c.m.} > 30°$ a non-monotonic variation of angular distribution of the α particles is observed. Since the investigation was carried out with an angular interval of 5°, some details of the distribution could have passed unnoticed.

The results obtained are in qualitative agreement with the data on the distribution of elastically scattered α particles of energy 20 — 43 Mev [4–6] by aluminum. The difference consists in the maxima of this distribution being less pronounced for energies 10 — 14 Mev. If we proceed from the analogy between elastic scattering and the diffraction of light, [4] then we should expect the relative position of the maxima in the distribution of elastically scattered α particles to obey the relation

$$kR\Delta\left(\sin\frac{\theta}{2}\right)=\frac{\pi}{2},$$

where k is the α-particle wave-vector, R the interaction radius and Θ the scattering angle (c.m. system). For $E_{\alpha c.m.} = 11.9$ Mev the mean distance between the maxima is 0.19 (on a $\sin \Theta/2$ scale). This corresponds to an interaction radius $R = 5.9 \times 10^{-13}$ cm.

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11