MULTIPLE SCATTERING OF 75—200 keV PROTONS IN SOLID SUBSTANCES

A. A. BEDNYAKOV, V. N. DVORETSKIĬ, I. A. SAVENKO, and A. F. TULINOV

Institute of Nuclear Physics, Moscow State University

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THE study of the multiple scattering of low-energy heavy charged particles which we began with carbon[1] was continued with substances of higher Z. Using nuclear-track plates mounted perpendicular to the beam axis, we measured the angular distributions of protons scattered by thin foils of aluminum and copper. The method of measurement was somewhat better than that used previously: an electrostatic analyzer, mounted behind the scattering chamber, made it possible to measure directly the proton energy before and after penetration of the target. These measurement data were used both in the theoretical analysis of the results and as a means of checking the target thickness.

The angular distributions of the multiply scattered protons were obtained for a set of copper foils from 190 to 530 $\mu g/cm^2$ thick in the initial energy range E_0 = 193—93 keV and for aluminum foils 52, 82 and 183 $\mu g/cm^2$ thick in the range E_0 = 184—75 keV. Additional measurements were also carried out with polystyrene targets (46 and 82 $\mu g/cm^2$), and these provided refined data for carbon at energies < 100 keV.

The analysis of the results for copper and aluminum was based on the Molière-Bethe theory [2], and the modification suggested in [1] was used for polystyrene. Figure 1 shows some of the angular distributions obtained for copper, and Fig. 2 gives the results of a comparison of the experimental and theoretical angular distribution half-widths, $(\theta_{1/2})_E$ and $(\theta_{1/2})_T$, for all the cases examined (E_k = proton energy after penetration of the target).

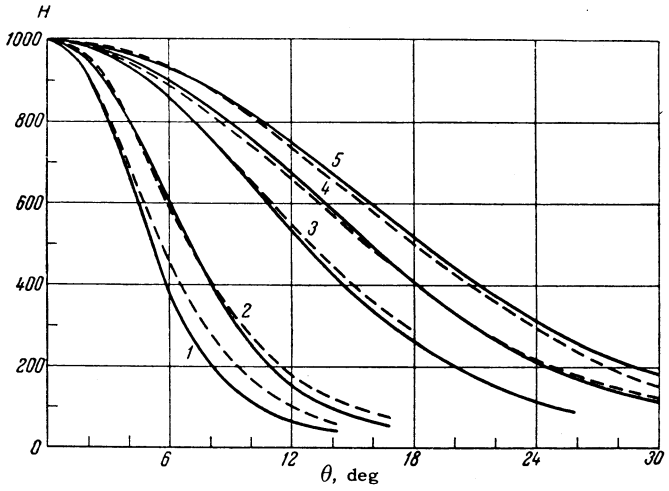

FIG. 1. Angular distributions for copper: dashed curves = experimental, continuous-line curves = theoretical. Curves 1: l = 190 $\mu g/cm^2$, E_0 = 163 keV; 2: l = 248 $\mu g/cm^2$, E = 162 keV; 3: l = 420 $\mu g/cm^2$, E_0 = 162 keV; 4: l = 450 $\mu g/cm^2$, E_0 = 150.5 keV; 5: l = 530 $\mu g/cm^2$, E_0 = 158.5 keV.

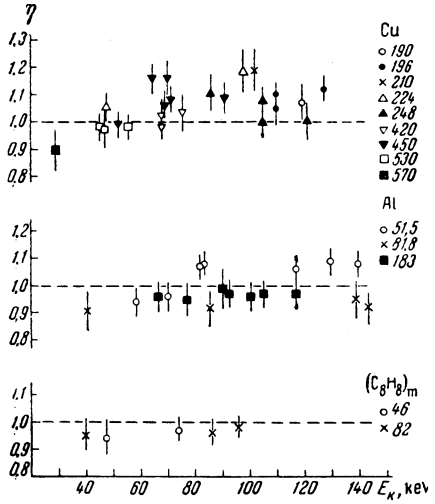

FIG. 2. Ratio $\eta = (\theta_{1/2})_E/(\theta_{1/2})_T$ in copper, aluminum and polystyrene for foils of various thicknesses (in $\mu g/cm^2$).

It can be seen that the theoretical calculations are in fairly good agreement with the experimental data for practically all values of the proton energy and target thickness as far as the region of multiple scattering, where the effective number of collisions is ≤ 15. This agreement is somewhat surprising, in that the theoretical calculations made no allowance for the effect of the charge-exchange process, although at energies as low as this it is very considerable and affects, in particular, the magnitude and nature of the specific energy losses.

[1] Bednyakov, Boyarkina, Savenko, and Tulinov, JETP **42**, 740 (1962), Soviet Phys. JETP **15**, 515 (1962).

[2] H. A. Bethe, Phys. Rev. **89**, 1256 (1953).

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