Some Remarks on the Determination of Total Reaction Cross-Sections by means of the «Sum of Differences » Method (*)

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Summary. — The angular distributions of α-particles scattered from Cr, Fe, Zn and Ge at energy around 13 MeV have been measured in the angular range (20°–170°). Total reaction cross-sections are obtained from the optical-model analysis and compared successfully with the ones extracted by means of an extended «sum of differences» method. This new procedure allows us to minimize the method error and it is not affected by the experimental uncertainties due to the large Rutherford cross-section at forward angles.

1. – Introduction.

In the last years a model-independent method for the determination of the total reaction cross-section from charged-particle scattering has been proposed (1) and applied to α-particle scattering (2,3) and to heavy-ion reac-

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SOME REMARKS ON THE DETERMINATION ETC.

According to this "sum of differences" method (SOD), the total reaction cross-sections is evaluated by summing the differences between the Rutherford and the measured elastic-scattering differential cross-section. The sum starts from a suitable angle $\theta_0$ such that the elastic scattering is Rutherford for $\theta < \theta_0$ \footnote{R. H. Davis: in Nuclear Molecular Phenomena, edited by N. Cindro (Amsterdam, 1978).}. The choice of this angle is a very crucial point of the method, because it is very difficult to measure in the small-angle region the terms of the difference $\sigma_{\text{Roth}}(\theta) - \sigma_{\text{el}}(\theta)$, which becomes the difference of larger and larger numbers with decreasing angle \footnote{H. Oeschler, H. L. Harney, D. L. Hillis and K. S. Sim: Nucl. Phys. A, 325, 463 (1979).}. On the other hand, it is difficult to give a theoretical estimate of the method error which depends also on the choice of the angle $\theta_0$. In this paper, we suggest a different way to apply the SOD method in order to overcome the above-mentioned difficulties, at least for the cases in which the ratio $\sigma_{\text{el}}(\theta)/\sigma_{\text{Roth}}(\theta)$ shows a typical Fresnel pattern, as it may occur in $\alpha$-particle and heavy-ion scattering.

This procedure was checked for $\alpha$-particle-induced reactions on several nuclei in the mass region $50 < A < 75$ at energy around 13 MeV. The values of the total reaction cross-sections obtained in such a way will be compared with those deduced from optical-model calculations.

2. - Experimental arrangement and results.

The experiment was performed by using the Van de Graaff accelerator of the National Laboratory of Legnaro. The $\alpha$-particles, accelerated at energy around 13 MeV, were scattered by targets of natural Cr, Fe, Zn and Ge obtained by evaporation on thin carbon backings. Their thicknesses, measured by means of 2.0 MeV proton scattering, were $(32.5 \pm 0.5) \mu g/cm^2$ for Cr, $(19.0 \pm 0.4) \mu g/cm^2$ for Fe, $(163 \pm 2) \mu g/cm^2$ for Zn and $(75 \pm 1) \mu g/cm^2$ for Ge. The angle between the beam direction and the target plane was 45°. The total charge was measured by a current integrator within 1%. The scattered $\alpha$-particles were detected by seven solid-state detectors, in front of which circular tungsten collimators defined solid angles of $(0.130 \pm 0.002) \text{msr}$. During the measurements the target thickness was always monitored by a detector at 90° in the reaction plane. The pulses from the detectors were routed to a Correlatron 4096 channel analyser, by means of a Multiplexer made in the same Laboratory \footnote{F. Porto, S. Sambataro, K. Kusterer, K. P. Liu, G. Doukellis and H. L. Harney: to be published.}.

\footnote{M. Lombardi, C. Baicocchi, I. Carraro, P. Schiavon and G. Preti: Laboratory Report INFN-TC 78/5 of the Istituto Nazionale di Fisica Nucleare, Italia.}