Small-Angle Scattering of Fast Neutrons by Bi and Pb (*) (**).

L. DRIGO, C. MANDUCCI, G. MOSCHINI,
M. T. RUSSO-MANDUCHI, G. TORNIKLLI and G. ZANNONI

Istituto di Fisica dell'Università - Padova
Istituto Nazionale di Fisica Nucleare - Sezione di Padova

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Summary. — Differential cross-sections and polarizations of 2.45 MeV neutrons elastically scattered by Bi and Pb are measured for scattering angles of 2.1°, 3° and 5°. Energy separation is accomplished by conventional time-of-flight techniques. The results, when compared with the predictions of the electromagnetic interaction, indicate some deviation of σ(θ)P(θ) from the expected values, at least for the lowest angle. The observed cross-sections are systematically greater than those evaluated from the optical model, even if one takes into account the electromagnetic contribution.

1. Introduction.

The importance of the interaction of the magnetic moment of the neutron with the electric field of a target nucleus was first pointed out by SCHWINGER (1). The presence of this interaction introduces into the scattering amplitude a spin dependence even in those cases when the contribution from the specifically nuclear interaction is independent of the spin. In the approximations used by SCHWINGER, the differential neutron scattering cross-section σ(θ) and the

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corresponding polarization $P(\theta)$ at small-angle scattering are related by

$$\sigma(\theta)P(\theta) = k \text{Im} \ h_\gamma(\theta) \sigma/2\pi,$$

where $k$ is the wave number of the neutron, $\sigma$ the neutron total cross-section, and $h_\gamma(\theta)$ the electromagnetic contribution to the scattering amplitude, given by

$$h_\gamma(\theta) = -\frac{1}{2}(i\gamma) \cotg(\theta/2).$$

In this expression $\gamma$ is a constant depending on the neutron magnetic moment $\mu_n$ and the atomic number $Z$ of the target nucleus:

$$\gamma = |\mu_n| Z(\epsilon^2/m\epsilon^2).$$

More general calculations (2-3), allowing other interference terms to be taken into account, show that the magnitude of the product $\sigma(\theta)P(\theta)$ is not very sensitive to the parameters of the nuclear interaction, and that, with reasonable approximations (4), it can still be given by the Schwinger formula. This is found to be true at least for small values of the electric polarizability of the neutron (2). Consequently, the polarization could be computed by measuring the total cross-section, when the differential elastic cross-sections would be well known. Within the accuracy limits of the previous measurements (4), qualitative agreement seems to exist between predictions and experimental results. However, there is some evidence that the absolute magnitudes of the cross-section, as calculated in terms of an optical model plus electromagnetic interaction, and as measured, do not agree. Further experimental study may prove quite useful in resolving apparent ambiguities, and to a better understanding of the effects arising both from the extranuclear and specifically nuclear contributions.

2. - Experimental equipment.

In the present experiment, the differential cross-sections and the polarization of neutrons elastically scattered by Bi and Pb have been measured for scattering