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INELASTIC SCATTERING OF 6.9 MeV PROTONS BY CHROMIUM ISOTOPES

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Angular distributions of inelastically scattered protons (initial energy 6.9 ± 0.05 MeV) due to excitation of the first levels of the $Cr^{50,52,54}$ isotopes are investigated. In the given case inelastic scattering mainly proceeds via the formation of compound nuclei, but the presence of a small deviation from symmetry with respect to 90° indicates that direct interaction is not negligible. The differences in the shapes of the angular distributions of the various isotopes may be interpreted on basis of the distorted wave theory.

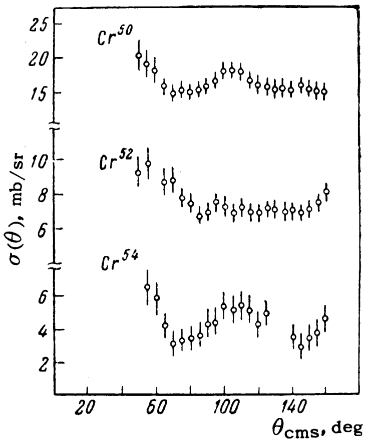
INELASTIC scattering of protons can be realized in two different ways. At energies approximately up to 10 MeV the dominating process is one with formation of a compound nucleus. At energies above 10 MeV inelastic scattering of protons occurs principally by direct interaction. It is impossible to demarcate sharply the spheres of influence of the two mechanisms, and in many cases, for nuclei of low and medium atomic weights, the direct processes can play a noticeable role even at relatively low energies.

The present investigation is devoted to a study of inelastic scattering of protons by chromium isotopes. Kikuchi et al have shown [1] that at 14.1 MeV direct interaction plays an important role in the inelastic scattering of protons by the Cr^{52}. On the other hand, at 7.02 MeV in an analogous case, the angular distribution of the protons turns out to be isotropic, pointing to the formation of a compound nucleus [2]. We note that in both cited investigations the chromium targets employed were of natural isotopic composition (83.76% Cr^{52}). Some deviations from isotropy were observed [3] in experiments with an enriched Cr^{52} target at a proton energy of 6.8 MeV.

In the present investigation the targets employed were thin free films of Cr^{50}, Cr^{52}, and Cr^{54} enriched to 87.7, 99.0, and 78.6%, respectively. The initial proton energy was 6.9 ± 0.05 MeV. The proton detector was a scintillation spectrometer, consisting of a thin CsI(Tl) crystal and an FÉU-15B photomultiplier. The energy spectrum was registered with an AINA-2 50-channel pulse-height analyzer. The absolute value of the differential cross section of inelastic scattering was determined under the assumption that pure Coulomb scattering takes place for elastic scattering in the angle region on the order of 20°. The target enrichment was sufficiently high and no corrections were introduced for contamination by other isotopes.

The results of the experiment are presented in the figure. The investigated groups of inelastically scattered protons can be separated in the energy spectrum down to angles on the order of 20°. However, the presence of strong elastic scattering and scattering by the slots produce a considerable background. On the other hand, subtraction of this background introduces a great uncertainty in the experimental results (we refer to experimental conditions with a scintillation spectrometer with a resolution of 4—5%). We therefore confined ourselves in our measurements to the region from 50 to 160° only.

The fact that the angular distributions of the inelastically scattered protons (groups connected with the excitation of the first excited states of Cr^{50}, Cr^{52}, and Cr^{54}) are practically symmetrical with respect to the 90° angle enables us to state that in this energy region the principal role in the inelastic scattering of the protons is played by the



Angular distributions of protons inelastically scattered by the chromium isotopes: Cr^{50} (Q = −0.787 MeV), Cr^{52} (Q = −1.450 MeV), Cr^{54} (Q = −0.835 MeV); E_{op} = 6.9 ± 0.05 MeV.

formation of the compound nucleus. The angular distribution for Cr^{52} agrees well with the data of [3]. Nevertheless, in all three angular distributions a small deviation is observed from symmetry about 90°.

This deviation is the consequence of the direct-interaction process, which makes some contribution to the inelastic scattering. To be sure, it is practically impossible to separate the results of the processes with formation of compound nucleus from the direct interaction; in our case it is merely obvious that the angular distributions cannot be reconciled with the results of the theory of direct interaction in the Born approximation, as has been done for 14.1 MeV [1]. The fact that in all three investigated cases the quantum characteristics of the excited levels are the same [4], and that there is nonetheless a noticeable difference among the distributions, can apparently be interpreted on the basis of the theory of direct interaction with account of the distorted waves [5]. Indeed, as shown by Val'ter et al [6], the angular distributions of protons elastically scattered by individual chromium isotopes at energies on the order of 7 MeV also differ noticeably from one another. To describe this result within the framework of the optical model it is necessary to modify the optical potential appreciably. If the potential of the optical model is different for the investigated isotopes, then we are justified in expecting also a different distortion of the waves during the scattering process, and consequently also a possible difference in the angular distributions.

The absolute value of the differential cross section decreases in the mean on going to the heavier chromium isotopes. This is understandable, if it is recognized that in this case there is no (p, n) reaction for Cr^{50}, since the threshold of this reaction lies above the energy of the incident protons. For the two heavier isotopes the (p, n) reaction competes with the inelastic-scattering process and the cross section of the last process decreases.

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