ELASTIC SCATTERING OF 4.2-MeV PROTONS ON NICKEL ISOTOPES

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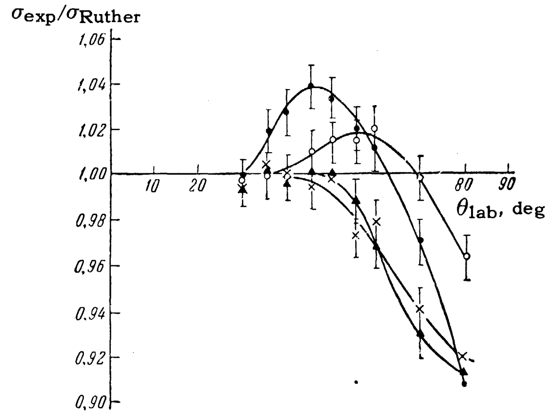
The angular distributions of 4.2-MeV protons elastically scattered on $Ni^{58,60,62,64}$ isotopes are obtained by a comparison method. The shapes of the curves for Ni^{58} and Ni^{60} (which have sharp maxima in the angular distributions) are found to differ from those for Ni^{62} and Ni^{64}. A possible explanation of this difference is discussed.

THE angular distributions of 4.2-MeV protons elastically scattered by $Ni^{58,60,62,64}$ nuclei have been experimentally measured in a range of angles between 30 and 80° in the laboratory system of coordinates. The method used in this work has been described by us previously.[1] The scattered protons were registered with a CsI(Tl) scintillation crystal and an FÉU-S photomultiplier. The electrical pulses of the photomultiplier were recorded with standard electronic equipment. The targets enriched to 95% were obtained by an electrolytic method and constituted self-supporting metallic foils about 1.0—1.5 micron thick. The energy resolution of the detector (~ 6%) readily permitted the segregation of inelastically scattered protons, since the energy of the first excited levels of all nickel isotopes exceeded 1.0 MeV. The angular resolution of the detector was ± 1.5%. The total error of our measurements was ± 1.0% and was chiefly determined by the geometry of the experiment. The geometrical error occurs as a result of the wandering of the intensity of the beam of accelerated particles over the target, which leads to a change in the scattering angle.

The experimental angular distribution curves are presented in the figure in the form of the ratio of the experimental cross section to the Rutherford cross section, $\sigma_{exp}/\sigma_{Ruther}$. The curves were obtained by a comparison method consisting of a comparison of the number of particles scattered at each angle by the investigated target with the number of particles scattered by a gold target for which at the given incident proton energies the angular distribution follows the Rutherford formula.[2] Notwithstanding the fact that the energy of the incident protons is considerably lower than the magnitude of the Coulomb barrier for nickel nuclei (B ~ 7 MeV), the angle dependence of the distribution of elastically scattered protons differs from the Rutherford angle dependence even at angles of 30—40°. We have noted previously[3] that in the



The angular distribution of the ratio of the experimentally measured cross section to the Rutherford cross section for nickel nuclei (E_p = 4.2 MeV): o – Ni^{58}, • – Ni^{60}, x – Ni^{62}, ▲ – Ni^{64}.

scattering of charged particles the competition between the Coulomb and nuclear interactions in a given energy range of the incident particles renders the differential elastic scattering cross section most sensitive to the structure of the peripheral part of the nucleus. In principle this allows us to obtain important information on the state of the surface of the investigated nuclei.

From the figure it can be seen that the character of the curves of the angular distribution of the elastically scattered protons for Ni^{58} and Ni^{50} differs considerably from the analogous curves for the Ni^{62} and Ni^{64} nuclei. It is known that a considerable difference exists between the angular distribution of protons elastically scattered by nuclei with even and odd atomic numbers,[4] a fact explained by the considerable smearing out of the nuclear surface by the odd nucleon.

In the present work we have investigated only nuclei with even atomic number A. However, in such nuclei the excess of paired nucleons outside the closed shell can also smear out the nuclear surface very strongly.[1,4,5] Consequently, it can be assumed that the surfaces of the Ni^{62} and Ni^{64} are smeared out more strongly compared with the surfaces of the Ni^{58} and Ni^{60} nuclei, and the differences in the behavior of the angular distributions of protons elastically scattered by these nuclei must be explained from this point of view. Inasmuch as the angular distributions of elastically scattered protons for Ni^{62} and Ni^{64} practically coincide, it can be assumed that the difference in the threshold of the (p, n) reaction which competes with the elastic scattering of protons does not manifest itself in this range of angles at the given incident-proton energy. If the contrary were true, the curve for Ni^{64} would have to be lower than that for Ni^{62}, since the thresholds of the (p, n) reaction for Ni^{62} and Ni^{64} are 4.80 and 2.45 MeV respectively. The maxima in the angular distribution for the Ni^{58} and Ni^{60} nuclei are, apparently, due to diffraction while for the Ni^{62} and Ni^{64} nuclei no noticeably expressed diffraction aspect has been noted. It is known, however, that a diffraction pattern is distinctly observed in nucleon scattering by nuclei with a sharp boundary and having dimensions commensurate with the wavelength of the incident nucleon (the diffraction condition $\lambda\!\!\!^{-} < R$). This confirms the above notion on the structure of the surfaces of nickel nuclei. In addition, it can be assumed that the Ni^{60} nucleus has a sharper boundary than the Ni^{58} nucleus, since the angular distribution of the elastically scattered protons for Ni^{60} has a sharper maximum. This is probably connected with the fact that Ni^{60}, unlike Ni^{58}, has a filled $2p_{3/2}$ neutron subshell (of the 32nd neutron).

We have measured the excitation function of elastic pp scattering for the $Ni^{58,60,62,64}$ nuclei at an angle of 120° in the energy range from 3.0—4.3 MeV. No noticeable resonances have been noted near the incident-proton energy of 4.2 MeV. It can therefore be assumed that the angular distributions of elastically scattered protons obtained in this experiment are not noticeably distorted by the effects of resonance scattering.

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