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ELASTIC SCATTERING OF Li⁶ IONS ON MEDIUM AND HEAVY NUCLEI

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Abstract. — The elastic scattering of Li⁶ ions on Si28, Ca40, Ni58, Sn120, Au197, Pb208 was studied within the angle range from 10° to 170° at Eₐ = 30 MeV. The results of the optical-model analysis are presented.

The elastic scattering of Li⁶ ions is of considerable interest from two points of view. First, Li⁶ ions occupy an intermediate position between light particles (from proton to alpha-particle) and heavy ions (usually from boron). The scattering of these two groups of bombarding species is rather different. In particular, the optical-model analysis gives quite different depths of real part of potential for light and heavy particles: for light particles V ~ 50 N (N is the number of nucleons in the incident nucleus) and for heavy ions the potentials are quite shallow. Thus the study of Li⁶ scattering can fill the gap between light and heavy ions data and possibly provide some understanding of the difference mentioned.

Secondly, the knowledge of the optical-model parameters for Li⁶ is necessary for the progress of lithium-induced reaction theory.

The elastic scattering of Li⁶ ions was studied previously on a limited number of light mass target nuclei [1]. Besides, the measurements were done only up to relatively small angles. Meanwhile it is very important to investigate the elastic scattering up to the largest possible angles since the cross sections in this region are very sensitive to various modes of optical-model calculations and exhibition of non-potential scattering processes.

In this report the data concerning the elastic scattering of Li⁶ ions on Si28, Ca40, Ni58, Sn120, Au197, Pb208 target nuclei are presented. The results obtained on lighter target nuclei are described in the following reports [2], [3]. The cross sections were measured in the range of angles between 10° and 170° at the incident energy of Li⁶ ions of 30 MeV. The lithium ions were accelerated at the variable-energy cyclotron of the I. V. Kurchatov Atomic Energy Institute.

The differential cross sections for Si28, Ca40, and Ni58 target nuclei are shown in figure 1. The diffraction structure is observed, being quite pronounced on Si28 and Ca40. The main peculiarity of the angular distributions for this group of nuclei is a strong decrease of the cross sections with the angle (by 3 to 4 orders of magnitude compared to the Rutherford cross section).

For the nuclei with Z = 50-82 the Coulomb parameter is sufficiently large (η = 17.3 for Pb208) and the diffraction structure is not seen (Fig. 2). However, even for Pb208 the cross section at the large angles differs from the Rutherford one. It is interesting to note that the angles at which this difference arises correspond to the maxima of the cross sections of Li⁶-dissociation process [4].

The optical-model analysis of the angular distributions measured was performed. The calculations were done with the same and different geometries of the real and imaginary parts of potentials (four- and six-parameter calculations).

In 4-parameter calculations the starting values of the real potential V₀ were taken in the range 10-20 MeV (« shallow » potential) and 250-280 MeV (« deep » potential). For Si28 and Ca40 the best agreement in the forward hemisphere is reached with the shallow potential, but no values of V₀, W₀ and diffuseness parameter « a » can describe the variations of the cross section in the backward hemisphere.

The optical-model analysis of Sn120, Au197 and Pb208 showed that calculated angular distributions are only sensitive to « a » and depend very weakly on V₀ and W₀. The six-parameter calculations (see [2]) give the best fits for « deep » potentials (Table 1). Using different form-factors for real and imaginary parts it is possible to reproduce the general behaviour of the cross sections at large angles for Si28 and Ca40 but the details of the experimental curves cannot be explained. The disagreement in position of some maxima and minima takes place even at the relatively small angles. This means that the application of the
Fig. 1. — Differential cross sections of elastic scattering of Li$^6$ ions on Si$^{28}$, Ca$^{40}$, Ni$^{58}$ at the incident energy of 30 MeV. Solid curves are the optical-model fits.

Table I

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<tr>
<th></th>
<th>Si$^{28}$</th>
<th>Ca$^{40}$</th>
<th>Ni$^{58}$</th>
<th>Sn$^{120}$</th>
<th>Au$^{197}$</th>
<th>Pb$^{208}$</th>
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<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
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<tr>
<td>$r_w$</td>
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<td>1.63</td>
<td>1.60</td>
<td>1.70</td>
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<td>1.70</td>
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<tr>
<td>$a_V$</td>
<td>0.71</td>
<td>0.76</td>
<td>0.82</td>
<td>0.80</td>
<td>0.84</td>
<td>0.50</td>
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<td>0.80</td>
<td>0.70</td>
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<td>240</td>
<td>250</td>
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<tr>
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<td>12</td>
<td>18</td>
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<td>18</td>
<td>13.5</td>
</tr>
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</table>

The general trend of decreasing of the cross sections with the angle is quite natural because the Li$^6$ nucleus is weakly bound one and cannot survive a large change of a linear momentum. In the scattering on the heavy target nuclei this manifests itself in the mentioned above correlation between the rise of the dissociation cross section and the deviation of the elastic scattering cross section from the Rutherford one.

optical model to the analysis of Li$^6$ scattering should be considered as rather questionable.
References


[2] CHUEV (V. I.), DAVIDOV (V. V.), NOVATSKII (B. G.), OGOBLIN (A. A.), SAKUTA (S. B.), STEPANOV (D. N.), this Conference.

[3] CHUEV (V. I.), DAVIDOV (V. V.), NOVATSKII (B. G.), OGOBLIN (A. A.), SAKUTA (S. B.), STEPANOV (D. N.), this Conference.