ON THE NATURE OF THE 3.79 MeV *EXCITATION ENERGY LEVEL IN THE* Si^{30} *NUCLEUS*

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A multi-angle magnetic analyzer is employed to study the energy spectra and angular distributions of protons from the $Si^{29}(d, p)Si^{30}$ reaction in the ground state and also at levels with excitation energies of 3.79 and 8.09 to 8.149 MeV. The spins, parities, and relative reduced widths of these states are determined.

THE present work is devoted to a study of the energy spectra and angular distributions of protons from the stripping reaction $Si^{29}(d, p)Si^{30}$.

Isotopic Si^{29} targets on were prepared a silver backing in the electromagnetic separator of the Atomic Energy Institute of the USSR Academy of Sciences by depositing the isotope on the non-irradiated liner of the isotope receiver. The beam of silicon ions with energy 30 keV was collected on a bulky silver "knife" of the receiver. The incoming ions penetrated into the surface layer of the "knife" and this layer was sputtered by the bombarding ions. The sputtered silver and silicon atoms (in a ratio ~ 7:1) settled on a silver foil (0.5 μ), which was fastened on the unexposed shadow side of the receiving container. The concentration of the silicon in the film produced on the foil, and consisting of a mixture of silver and silicon atoms, was 200 $\mu g/cm^2$ with a content of ~ 70 per cent of Si^{29}.

The energy spectra of the protons in the energy interval from 5 to 15 MeV and their angular distributions in the interval from 10 to 90° were obtained simultaneously with the aid of a multi-angle magnetic multispectrograph analyzer [1,2] The energy of the bombarding deuterons was 6.59 MeV, which is much higher than the Coulomb barrier of the silicon nucleus, and it is sufficient to compare the results of the experiments with simple stripping theory [3]. Figure 1 shows a typical energy spectrum of the protons, obtained in the first channel of the multispectrograph.

In addition to the already known [4,5] values of the angular momentum of the "sticking" neutron l_n for the ground state of the Si^{30} nucleus, and also levels with excitation energies 2.24 MeV and (8.09—8.149) MeV, we obtained for the first time an angular distribution of a proton group, corresponding to the Si^{30} level with excitation energy 3.79 MeV (see Fig. 2). From a comparison with simple stripping theory [3] we determined the value of l_n for this level. In addition, we determined the relative reduced widths $C^2\theta^2[J]$ of the Si^{30} levels observed in our experiments (C^2 is the coefficient of addition of isotopic spins, introduced in [12] (formula II.29) and [J] is the statistical factor in the same formula). The tables prepared by Lubitz [6] were used in the numerical calculations. The results are listed in the table.

Of particular interest is the numerical value of the reduced width of the 3.79-MeV level, for which $\gamma\gamma$-correlation experiments [7] yield spin and parity $J^\pi = 0^+$. Our own data confirm this value of the spin and parity, and also indicate unambigu-

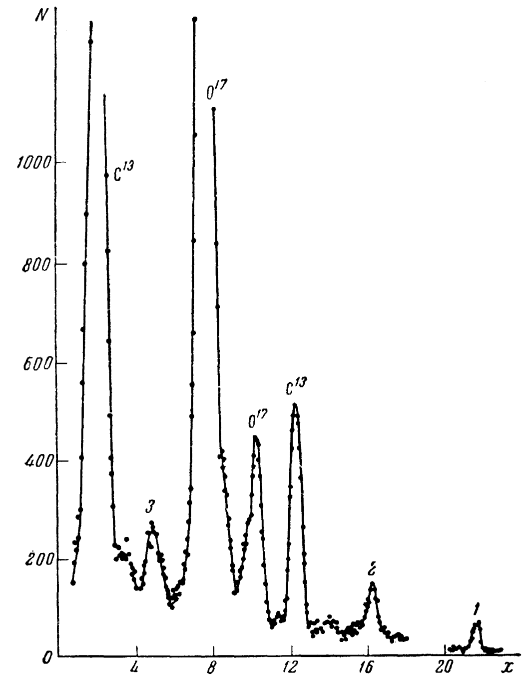

FIG. 1. Energy spectrum of protons emitted at an angle $\theta = 10°$ (N – number of proton tracks in the field of view of the microscope, x – coordinate along the photographic film in millimeters). Proton groups 1, 2, and 3 correspond to states of Si^{30} with excitation energies $E_1 = 0$, $E_2 = 3.79$ MeV, and $E_3 = (9.09\text{-}8.149)$ MeV.

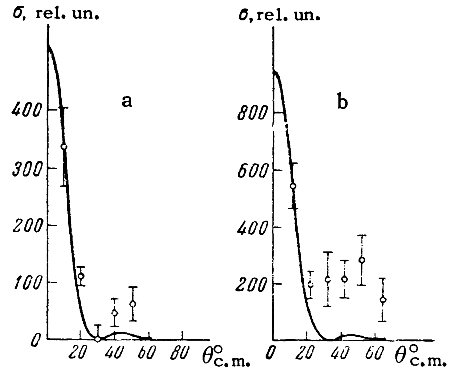

FIG. 2. Angular distributions of proton groups in relative units: a – for the ground state of Si^{30}; b – for states with excitation energy 3.79 MeV. The solid curves have been calculated by Butler's formula[3] with $l = 0$ and $r_0 = 6.44 \times 10^{-13}$ cm.

Level energy, MeV	l_n	J	$C^2\theta^2$ [J], Rel. un.
0	0	0^+	1
3.79	0	0^+	1.7±0.6
8.09+8.149	1	$0^-, 1^-, 2^-$	5.0±1.5

ously that the neutron is captured in the s-state. One of the possible interpretations of the nature of this level is the break in the correlation of the $(2s_{1/2})^2$ neutron pair of the ground state of the Si^{30}. In this case the 3.79 MeV level can be called a two-quasiparticle level.

In a recent paper by Cohen and Price[9], devoted to a study of the stripping reaction in the region where the $3s_{1/2}$ subshell is filled (tin isotopes), an attempt was made to find such a two-quasiparticle level with $J^{\pi} = 0^+$ for several nuclei. However, for such relatively heavy nuclei as the tin isotopes, the system of excitation levels turn out to be too complicated, containing several 0^+ levels each, so that the authors of [9] had to confine themselves only to an estimate of the excitation energy of such a level. When comparing this estimate with double the value of the pairing energy[10] for the corresponding nuclei ($2E_n \approx 2.2$ MeV), a considerable discrepancy, on the order of 30 per cent, is observed, one of the reasons of which is the ambiguity in the identification of the two-quasiparticle level 0^+ as carried out in [9].

An analogous comparison of double the pairing energy of the $2s_{1/2}$ neutrons in Si^{30}, which is in accordance with [10] is equal to 3.70 MeV, with the excitation energy of the 0^+ level in Si^{30} (3.79 MeV), shows an almost complete agreement between these quantities, and can be regarded as an argument in favor of the aforementioned interpretation of the 3.79-MeV level.

The foregoing arguments are crude approximations, particularly since no account is taken of collective effects, as is the case with the paper by Birbrair[11]. A detailed theoretical calculation of the reduced widths of both the 3.79-MeV level as well as others, with account of collection motions and pair correlations, and a comparison of such calculations with experiment, is of undoubted interest.

In conclusion, the authors consider it their pleasant duty to thank V. G. Solov'ev for a discussion of the results.

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