INVESTIGATION OF A POSSIBLE VIOLATION OF THE INDEPENDENCE OF THE DECAY OF A COMPOUND NUCLEUS OF THE SPIN OF THE INPUT CHANNEL

K.V. Karadzhev, V.I. Man'ko, A.N. Nersesyan, and F.E. Chukreev

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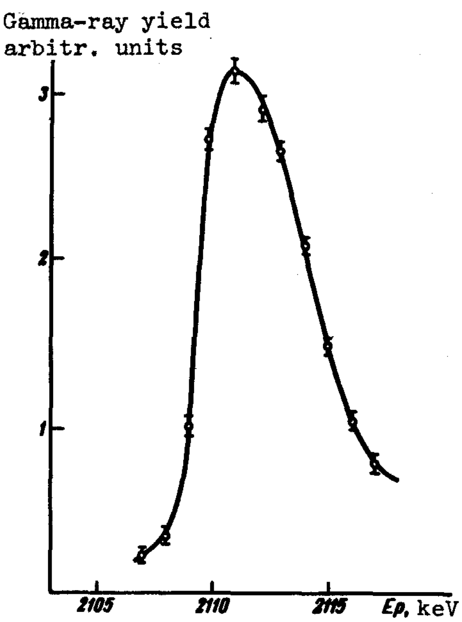
In verifying Bohr's hypothesis that the decay of a compound nucleus is independent of the method of its production, it is customary to compare the cross sections of the different reactions leading to the production of one and the same compound nucleus [1]. In [2] we proposed a different method, based on measurements of the angular distributions of the products of the nuclear reactions.

We have noted a strong disparity between the angular distributions of the α particles and γ rays from the reactions $P^{31}(p, \alpha)Si^{28}$ [3, 4] and $P^{31}(p, \gamma_0)S^{32}$ [5] (the transition to the ground level of the S^{32} nucleus), measured for the same resonance with spin and parity 1^- at a proton energy 2114 keV. Since the spin of the P^{31} target is $1/2^+$, it is obvious that in both aforementioned reactions there can be two input channels, with channel spins 0 and 1. The contributions of each of the two input channels to the cross section are characterized by a spin-mixing coefficient t, which shows what fraction of the reaction cross section goes through the input channel with spin s = 0. From measurements of the angular distribution of the α particles for the resonance with E = 2114 keV, carried out by us and independently by an American group [3, 4], it follows that t = 0.95 ± 0.01. (More details on the connection between the spin-mixing coefficient and the form of the angular distributions of the products of the reaction are given in our paper [2].) On the other hand, measurements of the angular distribution of the γ rays, performed by a Canadian group [5], yielded for the same resonance t = 0.72 ± 0.04, although these coefficients should be strictly identical if Bohr's hypothesis is valid.



Energy depencence of the cross section of the reaction $P^{31}(p,\gamma_0)S^{32}$ in the region of the 2114-keV resonance.

To explain the causes of these discrepancies, we have decided to repeat the measurements performed by the Canadian group. We obtained first the excitation function of the reaction $P^{31}(p, \gamma_0)S^{32}$ in the region of the resonance with E = 2114 keV, shown in the figure. The target was a thin layer of zinc phosphide P_3Zn_2, sputtered on a tantalum substrate. The γ rays were registered with a scintillation spectrometer with NaI(Tl) crystal having a height of 10 cm and a diameter of 9 cm, since the use of a semiconductor germanium detector is difficult in this case, in view of the small reaction cross section.

The latter circumstance, even when scintillation counters are used, makes it necessary to place the crystal as close as possible to the target, i.e., to work under conditions of poor geometry.

Since the spin and parity of the investigated resonance are known, we did not investigate the total angular distribution, but measured only the ratio of the yields of the γ rays at angles 90 and 0° to the beam of the incident protons. This ratio turned out to be N(90°)/N(0°) = 5.54 ± 0.5. Hence, introducing corrections for the geometry, we obtained a spin-mixing coefficient $t = 0.98^{+0.02}_{-0.10}$ It should be noted here that if the figure obtained by the Canadian group (t = 0.72) were correct, we should obtain N(90°)/N(0°) = 2.

Thus, it follows from our measurements that the coefficient of spin mixing turns out to be the same, within the limits of experimental error, for the reactions $P^{31}(p, \alpha)Si^{28}$, $P^{31}(p, p)P^{31}$, and $P^{31}(p, \gamma_0)S^{32}$.

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RECONSTRUCTION OF NN POTENTIALS FROM NUCLEAR DATA

A.I. Baz', A.M. Gorbatov, V.F. Demin, and I.G. Pasynkov

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We determined the parameters of the central NN potentials from the binding energies and the radii of nuclei that are more or less uniformly distributed over the entire periodic table: He^4, O^{16}, Ca^{40}, Zr^{92}, Yb^{176}, and Pu^{244}. The calculation was made in the fundamental approximation of the K-harmonics method [1] using the technique of [2]. The NN potentials in states with specified spin and isospin of the two nucleons S and T were chosen in the form of a superposition of two Gaussian potentials

$$V_{2S+1,2T+1}(r) = \sum_{i=1,2} V^{(i)}_{2S+1,2T+1} \exp\{-(r/r^{(i)}_{2S+1,2T+1})^2\}.$$

The potentials enter in the calculation of the nuclei in question in combinations of the type $V_{1,3} + V_{3,1}$ and $9V_{3,3} + V_{1,1}$. In this connection, we can put without loss of generality $V_{1,3} = V_{3,1}$ and $V_{3,3} = V_{1,1}$. The Coulomb interaction of the protons was taken into account exactly.

For the potentials $V_{3,1} = V_{1,3}$ we were able to find a "small island" of parameters near $V^{(1)}_{3,1} = -61.2$ MeV, $\tau^{(1)}_{3,1} = 2.05$ F and $V^{(2)}_{3,1} = 120$ MeV, $\tau^{(2)}_{3,1} = 0.95$ F.

All the succeeding investigations were carried out for such $V_{3,1} = V_{1,3}$.

The best results were obtained for $V^{(2)}_{3,3} = 0$, $V^{(1)}_{3,3} = 65$ MeV, $\tau^{(1)}_{3,3} = 1.5$ F and $V^{(2)}_{3,3} = 0$, $V^{(1)}_{3,3} = 12$ MeV, $\tau^{(1)}_{3,3} = 2.5$ F. These correspond to curves II and III of Fig. 1, respectively.

Curve I corresponds to the experimental data and curve V to the results for the Volkov potential [3], which lead to collapse starting already with Ca^{40}.

To investigate the problem of saturation of the nuclear forces, we investigated the dependence of the binding energy and the nuclear radii on $V_{3,3}$. The results are shown in Fig. 2. The points of curve I and the region to the left of it lead to collapse. The region between curves I and II is the region of transition from collapse to acceptable values of the radii and binding energies