INFLUENCE OF THE STRUCTURE OF THREE-PARTICLE NUCLEI ON THE PHOTODISINTEGRATION CROSS SECTION

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Study of the photoeffect on $H^3$ and $He^3$ can yield new information on the structure of these nuclei. A prominent place among the latest experimental data on the photoeffect is occupied by the measurement [1,2] of the cross section of the reaction

$$\gamma + He^3 \rightarrow p + p + n \quad (Q = 7.72 \text{ MeV - reaction threshold}) \tag{1}$$

There is no acceptable theoretical description of the process (1) at present [2-5], since the expected cross section is more than triple the experimental values over a wide $\gamma$-quantum energy range.

We shall attempt to show the possible cause of the large disparity between theory and experiment. For this purpose we turn to the usual expression for the cross section of the disintegration of $He^3$ by a $\gamma$ quantum of energy $E_\gamma$:

$$d\sigma = \frac{16}{9}\frac{e^2}{\hbar c}\pi^2 E_\gamma \left|\int \exp(-i\vec{K}\cdot\vec{\rho})\psi_k(r)\rho_z\psi_i(\vec{\rho}, \vec{r})d^3\rho d^3r\right|^2 \frac{d^3K\, d^3k}{(2\pi)^6 d(E_\gamma - Q)}. \tag{2}$$

If we turn attention to the region of integration with respect to the variables $\vec{\rho} = \vec{r}_3 - (\vec{r}_1 + \vec{r}_2)/2$ and $\vec{r} = \vec{r}_1 - \vec{r}_2$ ($\vec{r}_1$, $\vec{r}_2$, and $\vec{r}_3$ are the radius vectors of the protons and neutrons), then we can note that the presence of the factor $\rho$ in the dipole operator $\rho_z$ and of the P wave from the expansion of the exponential $\exp(-i\vec{K}\cdot\vec{\rho})$ describing the motion of a neutron with momentum $\vec{K}$ relative to the proton center of mass guarantees integration over a region corresponding to a large distance between the neutron and the protons. The direct overlap of the S-state of the protons $\psi_k(r)$ (k is the momentum of relative motion of two protons) with the corresponding remainder in the wave function $\psi_i(\vec{\rho}, \vec{r})$ of $He^3$ strengthens this circumstance. It can therefore be assumed that the radial functions of $H^3$ and $He^3$ used in [2-5] did not have the correct structure for large $|\vec{\rho}|$.

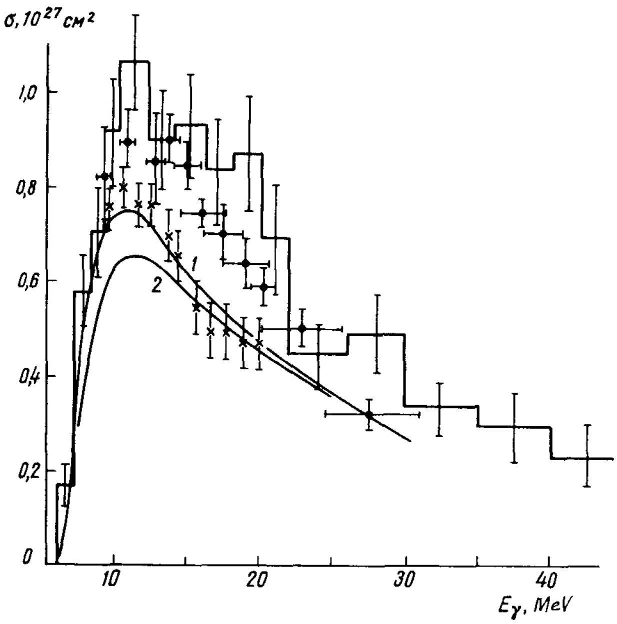
Special attention is paid in [7,8] to the asymptotic structure of the wave functions of $H^3$ and $He^3$ with respect to the variable $\vec{\rho}$, a structure of interest to us and of very great importance for integrals such as in (2). The authors of [7,8] propose that when one nucleon moves far from the other two, the function $\psi_i(\vec{\rho}, \vec{r})$ should have in the asymptotic region the form of the product of a Hankel function $h_0^{(1)}(i\alpha\rho)$ (which approaches $e^{-\alpha\rho}/\rho$ as $\rho \rightarrow \infty$) by some "quasideuteron" function of the remaining particle pair, and the parameter $\alpha$ is determined by the binding energy of the removed nucleon in the nucleus. In this paper we obtain the cross sections for the photodisintegration of the nuclei $H^3$ and $He^3$ via channel (1) and via the channel $H^3(He^3)(\gamma, d)n(p)$ (with a Hulthen deuteron function), under the assumption that the ground state of the nucleus is described by the function of Dalitz and Thacker [8]:

$$\psi_i(\vec{\rho}, \vec{r}) \sim F(\alpha_u, r_{13})F(\alpha_u, r_{23})F(\alpha_e, r_{12}),$$

$$F(\alpha, r) = \{[\exp(-\alpha(r - d)) - \exp(-\gamma(r - d)) + Z[\exp(-\gamma(r - d)) - \exp(-\beta(r - d))]\}r^{-\frac{1}{2}}, \quad (3)$$

$$r_{13} = |r_1 - r_3|, \quad r_{23} = |r_2 - r_3|, \quad r_{12} = |r_1 - r_2|,$$

with $\gamma = 1.0\ F^{-1}$, $\beta = 5.5\ F^{-1}$, $d = 0.5$ F, $z = 1.375$, $\alpha_u = 0.249\ F^{-1}$, and $\alpha_e = 0.172\ F^{-1}$ for $He^3$, and $\alpha_u = 0.26\ F^{-1}$ and $\alpha_e = 0.188\ F^{-1}$ for $H^3$. The rms radii of the proton distribution in $H^3$ and $He^3$ are 1.47 and 1.66 F. In addition to approximation (3), we used several traditional assumptions: (i) dipole $\gamma$ quanta are absorbed; (ii) the singlet interaction of identical nucleons in channel (1), which forms the principal maximum of the energy spectrum [2-5] and increases by several times the cross section compared with calculations without this interaction, is chosen in the form of a well of depth $V_0 = 16.8$ MeV and width $a_0 = 2.37$ F [2]; (iii) we neglect the interaction between the neutron (proton) and the protons (neutrons) in the three-particle channel $He^3(\gamma, n)2p(H^3(\gamma, p)2n)$, and also the necleon-deuteron interaction in the reactions $He^3(\gamma, p)d$ and $H^3(\gamma, n)d$; (iv) no account is taken of Coulomb effects.



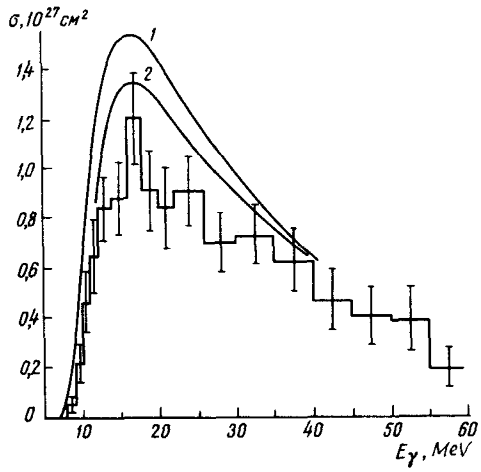




Fig. 2. 1-- $\gamma + He^3 \rightarrow p + p + n$; 2-- $\gamma + H^3 \rightarrow n + n + p$.

Fig. 1. 1-- $\gamma + He^3 \rightarrow p + d$; 2-- $\gamma + H^3 \rightarrow n + d$.

As seen from Figs. 1 and 2, the function (3), unlike the functions of Delves [3], Gunn and Irving [4], and Gauss [2,4,5], fits the experimental data with accuracy not worse than 20 - 30%. It can be assumed that allowance for the Coulomb distortions of the wave functions in N-d scattering will lead to even better results.

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## SCATTERING OF COLD NEUTRONS IN IRRADIATED KBr and NaCl CRYSTALS

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There is unquestioned interest in the investigation of the scattering of neutrons in irradiated alkali-halide single crystals. To this end, we irradiated KBr and NaCl single crystals with gamma rays. The gamma source was the In-Ga radiation loop built into the reactor of the Georgian Academy Physics Institute. The dose intensity was $0.8 \times 10^6$ r/hr [1].

Before irradiation, the crystal was cooled in a cryostat and placed in the path of a neutron beam monochromatized by a multiple-slit mechanical monochromator. The resolution was 25% in terms of the wavelength, which ranged from 1 to 12 Å. The initial beam divergence was 5', and the divergence of the beam scattered by the sample was 50'. The maximum background with the shutter open and the monochromator rotor standing still was 0.08 neut/cm$^2$. Under no conditions can rotation of the monochromator increase this background, which is three orders of magnitude lower than the intensity of 1-Å neutrons passing through the crystal, and one order lower for 12-Å neutrons (Fig. 1).

From the point of view of the procedure for measuring neutron transparency, we consider the sample thicknesses chosen (6.3 mm for KBr and 2.2 mm for NaCl) to be optimal, since they afforded a transmission 0.6 - 0.9 in the indicated wavelength interval.

To suppress the inelastic scattering of neutrons by thermal lattice vibrations, the experiment was carried out at liquid-air temperature.

The intensity of the neutron beam passing through the irradiated crystal was compared with the intensity through the same crystal prior to irradiation. The variation shown for KBr is shown in Fig. 2. The ordinates represent the quantity $(I_0 - I)/I_0$ (per cent), where $I_0$ and I are the intensities of the neutrons passing through the KBr crystal before and after irradiation, respectively. We see from this figure that a neutron scattering maximum is observed at wavelengths 5 and 8 Å. With increasing irradiation time, the height of the maxima increases in proportion to the irradiation time. A similar curve was obtained also for 20 hours' irradiation, but the measurement error was quite large and did not permit an unambigu-