Electric dipole and quadrupole cross sections for the reaction $^4He(\gamma,n)^3He$

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(Submitted September 14, 1976)
Pis'ma Zh. Eksp. Teor. Fiz. **24**, No. 8, 478–481 (20 October 1976)

The electric dipole and quadrupole cross sections are determined for the reaction $^4He(\gamma, n)^3He$ from the threshold to 150 MeV. The quadrupole cross sections of the reactions $^4He(\gamma, n)^3He$ and $^4He(\gamma, p)^3H$ agree within the limits of the experimental errors. A structure is observed in the dipole cross section.

PACS numbers: 25.10.+s

Using a diffusion-chamber installation[1] we obtained with good statistical accuracy and energy resolution new results on the investigation of the reaction $^4He(\gamma,n)^3He$. From 10 000 processed events we separated, for the first time, the electric dipole and quadrupole cross sections of this reaction in the energy interval up to the threshold of the meson production. The angular distribution was described in the analysis of the experimental results by the expression[2]

$$\frac{d\sigma}{d\Omega} = \frac{3}{8\pi}\sigma_d \sin^2\theta\left[1 + 2\sqrt{5\frac{\sigma_q}{\sigma_d}}\cos\eta\cos\theta + 5\frac{\sigma_q}{\sigma_d}\cos^2\theta\right],$$

where σ_d and σ_q are the electric dipole and quadrupole cross sections, respectively, and η is the difference between the phases of the dipole and quadrupole amplitudes.

Figures 1a, 1b, and 1c show plots of these cross sections against the photon energy. It is seen from Fig. 1b that the energy dependence of the dipole cross section reveals a structure. The positions of the individual peaks of the observed structure agree qualitatively with the level schemes of Meyerhof *et al.*[3] and of Gogsadze and Kapleishvili,[4] and with the singularities that ensue from an analysis of triangular diagrams by the Shapiro method[5] (see Fig. 2). Figure 1c shows plots of the quadrupole cross sections for the (γ,n) reaction and those obtained by us earlier[6] for the (γ,p) reaction. It is seen that within the limits of errors $\sigma_q(\gamma,n)$ agree well in magnitude and in shape with $\sigma_q(\gamma,p)$. This contradicts the estimate of the ratio of the quadrupole cross sections (γ,p) and (γ,n) reactions in the effective-charge theory (see, e.g., [7]), on the basis of which Leonardi and Lipparini[8] have derived quadrupole sum rules for ^4He. The result confirms qualitatively the conclusion deduced by Balashov[9] for heavier nuclei, namely that the induced effective charge of the neutron makes an appreciable contribution, and offers evidence favoring the assumption that the dominant contribution is made to the quadrupole cross

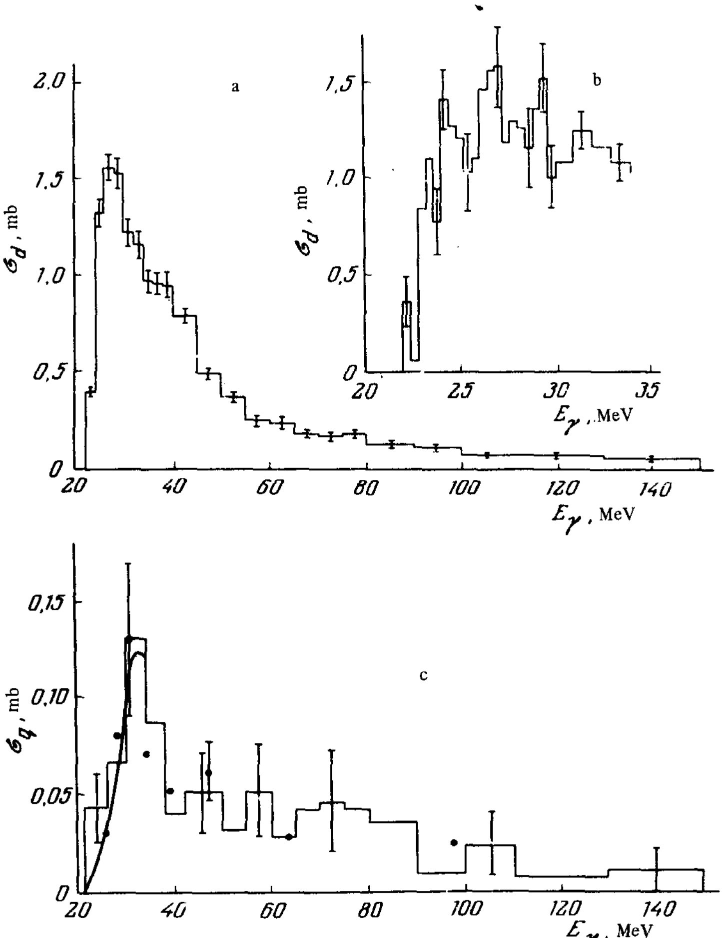

FIG. 1. a) Electric dipole cross section of the reaction $^4He(\gamma,n)^3He$, b) structure in the electric dipole cross sections, c) quadrupole electric cross section. Histogram—our data for the (γ,n) reaction, points—our data for the (γ,p) reaction,[6] curve—data of Meyerhof[10] for the (γ,p) reaction.

section for the photospallation of the nucleus ^4He by the isovector E2 transition. The appreciable contribution of the quadrupole absorption to the cross section of the reaction $^4He(\gamma,n)^3He$ indicates also that there were no grounds for neglecting the quantity $\sigma_q(\gamma,n)$ in [10].

An increase of the statistical accuracy of the experimental data for the electric dipole and quadrupole cross sections of the (γ,p) and (γ,n) reactions will make it possible in the future to estimate the contribution of the isospin components of the $E1$ and $E2$ amplitudes and to refine the characteristics of the resonant states of the ^4He nucleus.

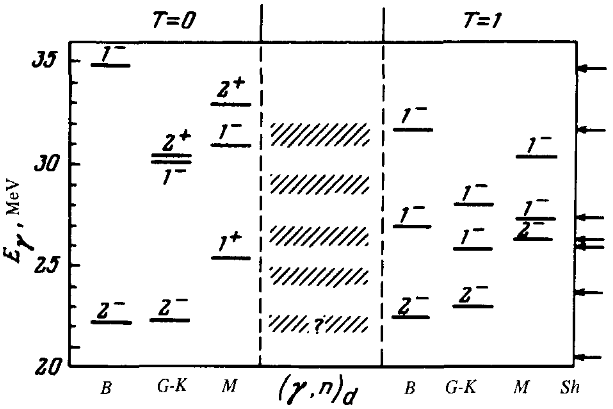

FIG. 2. Comparison of the level schemes of the ^{4}He nucleus with the structure in the dipole approximation: *B*—Barrett's level scheme,[11] *G-K*—level scheme of Gogsadze and Kopaleĭshvili,[4], *M*-level scheme of Meyerhof,[3] *Sh*-positions of the root and logarithmic singularities of Shapiro,[5], $(\gamma, n)_d$—positions of peaks in the dipole cross section of the reaction (γ, n).

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