IL NUOVO CIMENTO VOL. XLV B, N. 2 11 Ottobre 1966

Photoneutrons from ^{4}He (*).

F. FERRERO, C. MANFREDOTTI, L. PASQUALINI, G. PIRAGINO and P. G. RAMA
Istituto di Fisica dell'Università - Torino
Centro Studi Fisico-Biologici dell'Università - Torino
Istituto Nazionale di Fisica Nucleare - Sezione di Torino

(ricevuto il 7 Settembre 1966)

The total photoneutron emission from ^{4}He has been measured from the (γ, n) threshold (20.6 MeV) up to 80 MeV using an improved thermalized neutron detector (1) which, with a particular disposition of BF_3 counters, assures a neutron detection efficiency nearly constant for neutron energies up to 50 MeV. A two-meter long compressed ^{4}He (140 atm) target has been inserted in the central hole of the neutron detector. The use of such a long target implies several corrections to the yield points, namely: *a*) absorption of the γ-beam in the gas and in the back and front walls of the container; *b*) evaluation of the « effective length » of the target to account for the different efficiency of the detector for neutrons produced away from the centre of the counter; *c*) scattering of the beam and production of photoneutrons in the walls of the gas container. The last effect came out to be the most important one and the correction factor obtained by calculation has been checked measuring a « fictitious yield » with the container filled with H_2 at about the same pressure.

The yield curve, without any smoothing, has been analysed up to 35 MeV with the method proposed by COOK (2) and thereafter with the aid of the Leiss and Penfold tables (3). In Fig. 1 the cross-section and the corresponding integrated cross-section are plotted *vs.* the photon energies (4). From inspection of the figure one notes that some structures are present in the $(20 \div 30)$ MeV region. As a matter of fact the existence of a 1^- level, located at about 24 MeV, has been suggested by VLASOV and SAMOI-

---

(*) This work has been partially supported by the CNEN/EURATOM contract.

(1) S. COSTA and F. FERRERO: *Atti Accad. Sci. Torino*, vol. **99** (1964-65); G. PALMIERI and G. RICCO: *Nucl. Instr. and Meth.*, **33**, 120 (1965).

(2) B. C. COOK: *Nucl. Instr. and Meth.*, **24**, 256 (1963).

(3) J. E. LEISS and A. S. PENFOLD: *Phys. Rev.*, **114**, 1332 (1959).

(4) G. H. FERGUSON, J. HALPERN, R. NATHANS and P. F. YERGIN (*Phys. Rev.*, **95**, 776 (1954)) measured five values of the $\sigma(\gamma, n)$ in ^{4}He from threshold to 25.5 MeV with a thermalized neutron detector. Our corresponding cross-section values are in fairly good agreement with their results.

LOV ([5]) and many levels have been found by MILONE ([6]) in the ^{4}He (γ, p) reaction.

GORBUNOV and SPIRIDONOV ([7]), with a cloud chamber, measured the cross-section for all the photoreactions induced in ^{4}He from threshold to 170 MeV. In the case of the ^{4}He(γ, n)^{3}He reaction, however, they cannot measure the cross-section below 27 MeV being limited by the experimental bias. Since our detector measures all the photonuclear reactions in which one or more neutrons are emitted, we have compared our results with the corresponding ones obtained from the experiment performed by GORBUNOV and SPIRIDONOV ([7]). Our integrated cross-section (up to 80 MeV) is (40.5 ± 3) mb·MeV; this value is about 10% lower than the one deduced from ref. ([7]); as a consequence the absorption cross-section up to 170 MeV, as evaluated by GORBUNOV and SPIRIDONOV ([7]) ((95 ± 7) mb·MeV), reduces to ($89 \pm$ ± 6) mb·MeV. Being this value a little overstimated because in our experiment we count the (γ, 2n) reaction twice, it seems that the experimental absorption cross-section does not allow a clear distinction between a Rosenfeld, Inglis or Serber mixture for the nuclear forces ([8]). The r.m.s. radius, R_c, of the nuclear charge distribution ([9]) (corrected for the finite size of the proton charge

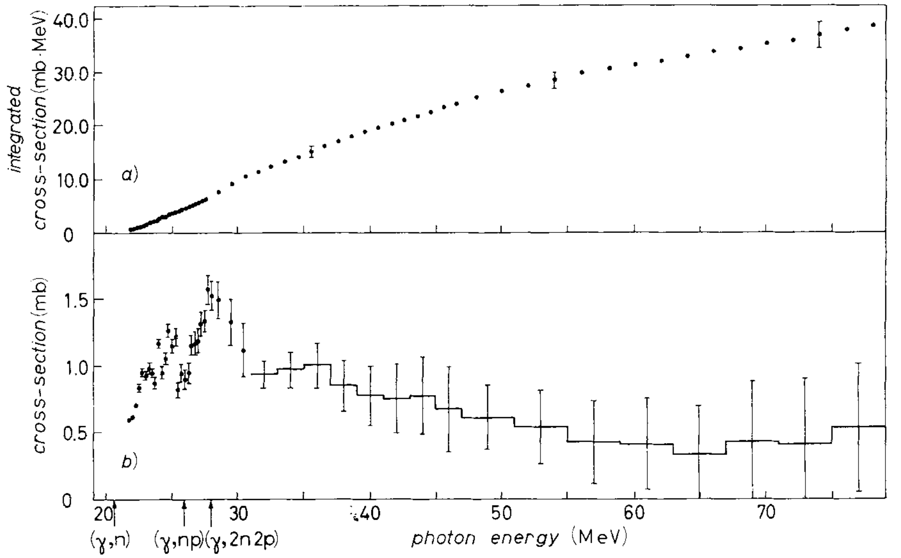

Fig. 1. – *a*) Integrated cross-section; *b*) cross-section for the ^{4}He(γ, Tn) reaction.

([5]) N. V. VLASOV and P. N. SAMOILOV: Report N 563 (1964), Institut of Atomic Energy I. V. Kurchatov. A detailed analysis of the possible levels in ^{4}He has been carried out by P. E. ARGAN, G. C. MANTOVANI, P. MARAZZINI, A. PIAZZOLI and D. SCANNICCHIO (*Suppl. Nuovo Cimento*, **3**, 245 (1965)).

([6]) C. MILONE: *Phys. Rev.*, **120**, 1302 (1960).

([7]) A. N. GORBUNOV and V. M. SPIRIDONOV: *Sov. Phys. JETP*: **6**, 16 (1958); *Žurn. Èksp. Teor. Fiz.*, **34**, 596, 600 (1958).

([8]) M. L. RUSTGI and S. N. MUKHERJEE *Phys. Rev.*, **129**, 717 (1962).

([9]) L. L. FOLDY: *Phys. Rev.*, **107**, 1303 (1957); MU. K. KHOKHLOV: *Sov. Phys. JETP*, **5**, 88 (1957).

distribution ([10])) deduced from the bremsstrahlung-weighted cross-section turns out to be (1.54 ± 0.06) fermi. This value is consistent with earlier experiments with electron scattering ([11]) but about 10% lower than the value obtained more recently ([12]).

Concluding, the value of the absorption cross-section at about 27 MeV obtained taking into account the contribution of the (γ, p) reaction ([7]) is (3.3 ± 0.4) mb: this value seems to indicate that a pure α-d cluster in ^{6}Li is somewhat improbable ([13]).

([10]) R. HOFSTADTER: *Ann. Rev. Nucl. Sci.*, **7**, 231 (1956).

([11]) R. W. MCALLISTER and R. HOFSTADTER: *Phys. Rev.*, **102**, 851 (1956).

([12]) R. F. FROSH, R. E. RAND, K. J. VAN OOSTRUM and M. R. YEARIAN: *Phys. Lett.*, **21**, 598 (1966).

([13]) S. COSTA, F. FERRERO, C. MANFREDOTTI, L. PASQUALINI and L. ROASIO: *Nuovo Cimento*, **42** B, 382 (1966).