Notizen

The ^{9}Be Photoneutron Cross Section from 17—25 MeV

U. Kneißl, G. Kuhl, K. H. Leister and A. Weller *

Institut für Kernphysik, Strahlenzentrum der Justus Liebig-Universität Giessen, D-6300 Giessen (BRD)

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We measured the ^{9}Be photoneutron production cross section $\sigma(\gamma, \mathrm{T}, \mathrm{n}) = \sigma(\gamma, \mathrm{n}) + 2\,\sigma(\gamma, 2\,\mathrm{n}) + \sigma(\gamma, \mathrm{p\,n})$ in the energy range from 17—25 MeV with quasimonoenergetic photons from positron annihilation in flight. In contrast to experiments of Thomas, Crawford and Thies (1972) and Hughes (1973), performed with bremsstrahlung photon sources we found no pronounced structure in this energy range.

The nucleus ^{9}Be is known to have a very low photoneutron threshold of 1.667 MeV. In the single particle shell model description the groundstate of ^{9}Be consists of an unpaired $P_{3/2}$ neutron outside a core of four $S_{1/2}$ and four $P_{3/2}$ nucleons. The resonances observed in photoneutron cross section measurements [1-4] at energies smaller than about 17 MeV correspond to dipole excitations to states in ^{9}Be caused by transitions of the unpaired or weakly coupled neutron [5].

The giant dipole resonance due to the excitation of the core should appear in the energy region of about 17 — 30 MeV. Above 16.88 MeV the (γ, p) channel is open and at energies between 17 and 25 MeV the $(\gamma, \mathrm{n})\ ^8\mathrm{Be}^* \rightarrow 2\,\alpha$ process via the 16.91 MeV state in ^{8}Be mainly contributes to the photoneutron cross section [6].

A many particle shell model calculation of Majling et al. [7] shows that much dipole strength is concentrated in two bumps around 21 and 25 MeV. This is also in agreement with an older measurement of the total photoneutron cross section of Costa et al. [8]. Recent experiments of Thomas, Crawford and Thies [1] as well as of Hughes [2] performed with bremsstrahlung show a pronounced structure in the (γ, Tn) cross section between 17 and 25 MeV. Especially in the measurement of Thomas et al. seven resolved resonances appear in this energy interval. As these results are obtained by an unfolding procedure which is necessary in bremsstrahlung experiments it is desirable to confirm this structure by a measurement with monoenergetic photons in order to make a more reliable comparison of the observed resonances with Majling's calculations. We therefore measured the photoneutron cross section with our quasimonoenergetic photon beam from positron annihilation in flight.

The experiment was performed at the Giessen 65 MeV electron linear accelerator. The monochromatic photon facility consists of an electron-positron converter between the two sections of the machine, an energy analyzing deviation system, the annihilation target (0.75 mm Be) and a cleaning magnet, which deflects the positron beam into a sensitive Faraday cup [9].

The photon energy is determined by the positron energy which is given by the magnetic field of the deviation system. An additional absolute calibration of the photon energy was done with a large volume Ge(Li)-detector [10]. The energy resolution in our experiment was about 300 keV ($\Delta E^+/E^+ = 0.75\%$). The photon flux was monitored by the positron current measured by the Faraday cup and an integrator system. The absolute calibration of the photon flux was performed with a $6'' \times 8''$ NaJ(Tl)-γ-spectrometer [11]. The results are in agreement with the calculated photon yield [11]. As a $4\,\pi$-neutron detector we used a Gd-loaded liquid scintillator tank ($\varnothing$ 1 m). The absolute efficiency of the arrangement was determined by a ^{252}Cf-source of known neutron multiplicity $\bar{\nu}$ [12]. In addition we tested our absolute cross section scale once more by measuring the $^{12}\mathrm{C}(\gamma, \mathrm{n})$-cross section.

The ^{9}Be sample consisted of a cylinder of pure Be (11 cm $\varnothing$) with a density of 9,43 g/cm^2. In order to check the energy resolution we measured the $^{16}\mathrm{O}(\gamma, \mathrm{n})$ cross section with its well known structure under the same conditions and beam adjustments. Our ^{16}O-results are in excellent agreement with earlier measurements with monochromatic photons of the Livermore [13, 14] and Saclay groups [15]. Figure 1 shows our Be-results together with those of Hughes [2], Thomas, Crawford, and Thies [1] and the calculated dipole strengths of Majling, Kukulin, and Smirnov [7]. Though our energy resolution was sufficient as checked on ^{16}O we did not observe such a detailed structure in the Be-cross section as in the bremsstrahlung experiments. This is also in agreement with recent total absorption data of the Mainz group [16]. At energies of 21.4 and 23.8 MeV where strong peaks were seen in the curve of Hughes,

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Reprint requests to Prof. Dr. U. Kneißl, Institut für Kernphysik, Strahlenzentrum, Justus Liebig-Universität, *D-6300 Giessen.*

bumps in our cross section curve are evident. The smaller peaks at 17.4, 20.1 MeV may also be indicated in our results, whilst there is no correspondence to the resonance obtained by Thomas et al. We therefore believe that the pronounced structure observed by Thomas et al. and also the deep valleys at 22.5 and 24.8 MeV seen by Hughes may be generated by the bremsstrahlung-yield to cross section transformation, which is especially difficult in the ^{9}Be case due to the low threshold of 1.667 MeV. The qualitative agreement of our results with the many particle shell model calculation of Majling et al. shows that the shell model describes the general feature of the dipole absorption in ^{9}Be and the neutron decay mode.

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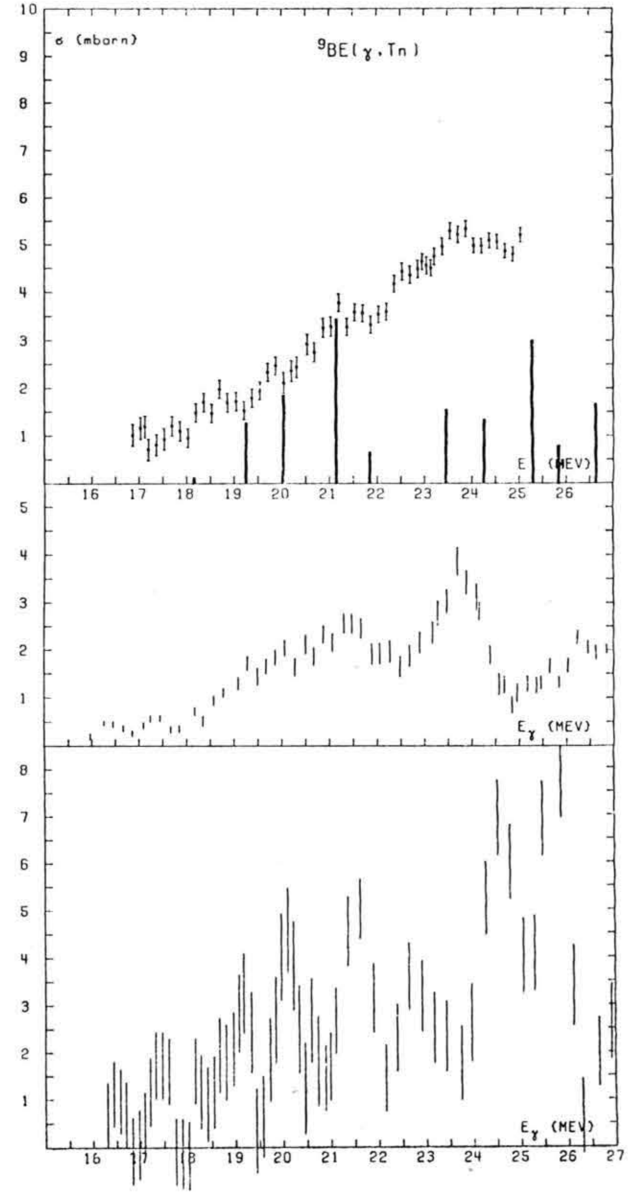

Fig. 1. Upper part: Present experiment with dipole strengths according to Majling [7]. Second curve: Results of the bremsstrahlung experiment of Hughes [2]. Below: Data given by Thomas et al. [1].