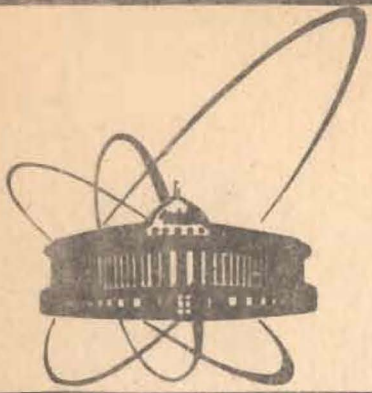

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ENERGY DEPENDENCE OF THE TOTAL CROSS SECTION FOR NEGATON-POSITON PAIR CREATION BY GAMMA QUANTA IN LIQUID XENON, MEASURED IN BUBBLE CHAMBERS

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The total cross sections for the negaton-positon pair production process initiated by gamma quanta with energies from about 15 MeV up to about 2500 MeV in liquid xenon have been measured using 26 litre xenon bubble chamber of the Joint Institute for Nuclear Research at Dubna and the 180 litre xenon bubble chamber of the Institute of Theoretical and Experimental Physics in Moscow. "Total" means here that the cross sections for pair creation on atomic electrons are included too.

The gamma qianta were from decays of the neutral pions generated in collisions of charged pions with xenon nuclei at energies 2.34 and 3.5 GeV.

The energies of the gamma quanta were determined from the total-track-lengths of electrons in the gamma-quanta-initiated electron-photon showers [1-3].

1. METHOD

In the xenon bubble chambers: the smaller of the dimensions (13.5x x6.8x4) t_0^3 and the larger (25x10x10) t_0^3, where $t_0 = 4.1$ cm is the radiation length in liquid xenon, gamma quanta with energies over about 10 MeV are recorded with the efficiency near to 95 , when appeared in the center of a chamber. PiO mesons, produced intensively in hadron-xenon nucleus collisions, are the source of the gamma quanta. These quanta create the negaton-positon pairs in the coulomb fields of atomic nuclei and electrons, and — this way — initiate the electron-photon showers in liquid xenon; the showers are visible well in the chambers. The energies of the recorded gamma can be determined with the mean accuracy of about $(10 \div 15)\%$, and their conversion lengths λ can be measured with the accuracy of about 1 mm; the potential length L for a quantum in the chambers is measurable quantity as well, with the accuracy of about 1 mm too [4,5].

The mean value of the conversion length $<\lambda>$ for n gamma quanta at a given small energy interval and with the conversion lengths λ_i, and the potential lengths in chambers L_i of an i-th gamma quantum from this energy interval are related as [6,7]:

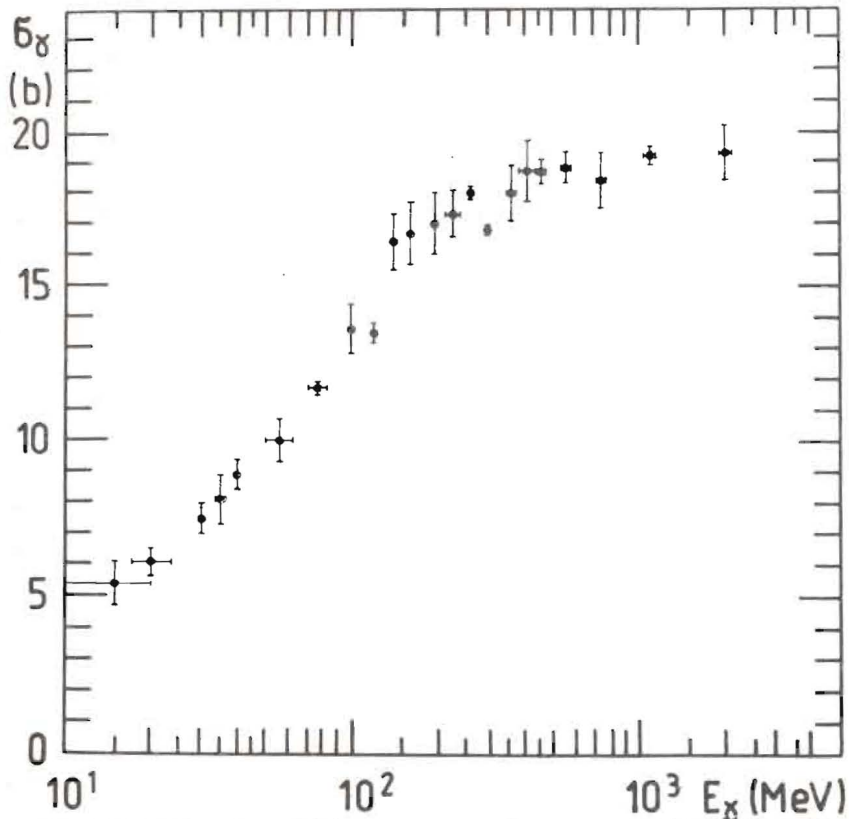
$$<\lambda> = \frac{1}{n} \sum_{i}^{n} [\lambda_i + L_i / (\exp \frac{L_i}{<\lambda>} - 1)] . \qquad (1)$$

The cross section $\sigma_\gamma(E_\gamma)$ at an energy E_γ of the gamma quantum for the negaton-positon pair creation is:

$$\sigma_\gamma(E_\gamma) = \frac{1}{\langle \lambda(E_\gamma) \rangle} \cdot \frac{A}{N\rho} = \langle \mu(E_\gamma) \rangle \cdot \frac{A}{N\rho}, \qquad (2)$$

where A is the mass number — for xenon nucleus it is A = 131, N is the Avogadro number, ρ = 2.2 g/cm^3 is the density for liquid xenon.

For the cross section determination, the gamma-quanta-initiated showers registered on the chamber photographs were collected in the scanning, and groupped into small intervals at a given energy $E_\gamma \pm \Delta E_\gamma$, where ΔE_γ is about 10% of the E_γ value. All registered gammas ascribed to pion-nucleus collisions singled out in the scanning were measured and analysed without any selection.



Energy dependence of the total cross section for negaton-positon pair creation by gamma quanta in liquid xenon; σ_γ, the cross section in barns; E_γ, the energy of the gamma quanta in MeV.

More details on the method of the cross section determination can be found in our former works on this subject [4,5].

2. EXPERIMENTAL DATA

About 21000 gamma-quanta-initiated showers were found in scanning of over 300000 chamber photographs — in three series of measurements. Experimental data presented in the figure include the new results of measurements and the results published in our previous works [4,5].

3. DATA ANALYSIS

The energy dependence of the cross section $\sigma(E_\gamma)$ obtained in this work does not differ from the corresponding dependence obtained on our previous work [4,5]. The comparison of it to the corresponding dependence calculated [8] shows that experimental values of the cross sections are systematically shifted up — the shift is about 8% at energies $E_\gamma \gtrsim 100$ MeV, and it seems to appear due to the Born's approximation used [4,5].

The measured cross sections are both for the pair creation in the field of atomic nuclei and in the field of atomic electrons. The rough estimation of the ratio between the first and the second part of it gives in average the value 0.03. In the estimation, known formulas [9] were used.

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