Parton content of the real photon: astrophysical implications

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We have recently calculated the inclusive cross section of the reaction $\nu\gamma \rightarrow W^+X$ at the resonance region within the framework of the parton model [1]. We have considered a subprocess of annihilation of the neutrino with a positron coming from the photon into the W^+ boson.

The cross section of this subprocess near the resonance can be parameterized by the Breit–Wigner formula:

$$\hat{\sigma}(xs) = 24\pi \frac{\Gamma_i \Gamma}{(xs - m_W^2)^2 + m_W^2 \Gamma^2}, \quad (1)$$

where x is the fraction of the photon's momentum carried by the positron, s is the total center-of-mass energy squared of the $\nu\gamma$ reaction, m_W is the mass of the W^+ boson, Γ_i is the partial width of the initial channel (the partial width for the decay $W^+ \rightarrow \nu_e e^+$), and Γ is the total decay width of W^+ .

This cross section is two times greater than that given in [1]. This is because in (1) we have correctly treated the possible spin states of the initial particles.

In averaging the absolute square of the corresponding amplitude over the initial spin states, one has to pay attention to the fact that positrons may appear in two spin states, while the neutrino has only one state of negative helicity.

Thus, we write the corrected cross section of the reaction $\nu\gamma \rightarrow W^+X$:

$$\begin{aligned} \sigma(s) = & \frac{8}{3} \frac{\alpha \Gamma^2}{s^3} \left[2s + \frac{s^2 - 2m_W^2(s + \Gamma^2 - m_W^2)}{\Gamma m_W} \right. \\ & \times \left(\arctan \frac{s - m_W^2}{\Gamma m_W} + \arctan \frac{m_W}{\Gamma} \right) \\ & \left. + (s - 2m_W^2) \ln \frac{\Gamma^2 m_W^2 + m_W^4}{\Gamma^2 m_W^2 + (s - m_W^2)^2} \right] \ln \frac{s}{m_e^2}, \quad (2) \end{aligned}$$

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Fig. 1 Dependence of the cross section of the inclusive reaction $\nu_e \gamma \rightarrow W^+X$ on s in the resonance region (solid curve). The same, calculated for the closely related reaction $\nu_e \gamma \rightarrow W^+e^-$ [2], is shown by the dashed curve. The laboratory energy of the neutrino $E_\nu^{\text{lab}} \simeq s/4\varepsilon$ is calculated at $\varepsilon = 10^{-3}$ eV

where α is the fine-structure constant. One can obtain this result by multiplying equation (6) from [1] by a factor 2.

The dependence of this cross section on s is shown in Fig. 1 in comparison with calculations of the closely related process $\nu\gamma \rightarrow W^+e^-$ carried out in [2]. All the fixed parameters are the same as in [1].

One can see that in the considered range of variation of s the corrected cross section is about two times higher than the one from [2].

References

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