

To determine x_2 , we note that $x_1 + x_2 = -2p_+^{(4)}k^{(4)} = 2(\varepsilon_+ E - p_+ k \cos \theta) = E^2 - k^2$. Then, using Eqs. (16) and (17), we find

$$x_2 = \frac{E^2 - k^2}{2k^2} [t(-x) - u \cos \varphi]. \quad (18)$$

Substituting the expressions (16) and (18) in the cross section (10), integrating the expression (12) over $d\Omega_+ d\Omega_- = 2\pi d \cos \theta d \cos \psi d\varphi$, and going over to the variable k in accordance with (14b), we obtain the spectrum of the electrons and positrons:

$$I(\varepsilon, \omega_1, \omega_2) \equiv \frac{dN}{d\varepsilon} = \frac{r_0^2 d\Omega_+}{16\omega_1^2 \omega_2} \int_a^b \frac{k^2 + E\Delta}{k^3} [\Phi(k, x) + \Phi(k, -x)] dk, \quad (19)$$

where

$$\Phi(k, x) = \left[1 + \frac{4}{E^2 - k^2} - \frac{8}{(E^2 - k^2)^2} \right] \frac{2k}{R(k, x)} - \frac{16k(k^2 + 2x\Delta)}{(E^2 - k^2)^2 R^3(k, x)} - 1, \quad (20a)$$

$$R(k, x) = \sqrt{4 \frac{k^2 - \Delta^2}{E^2 - k^2} + (2x + \Delta)^2}; \quad \varepsilon = \varepsilon_{\pm}. \quad (20b)$$

The upper and lower limits of integration over k for given ε are determined from the condition $\sqrt{k^2 + \varepsilon^2 - 2kp} \leq E - \varepsilon \leq \sqrt{k^2 + \varepsilon^2 + 2kp}$, which follows from integration of the δ function,

$$\int \dots \delta(E - \varepsilon - \sqrt{k^2 + \varepsilon^2 - 2kp \cos \theta}) d \cos \theta, \quad (p = p_{\pm}).$$

Solving the inequality, we obtain

$$|x| \leq \frac{k}{2} \sqrt{1 - \frac{4}{E^2 - k^2}}; \quad k^2 \leq b^2 = \frac{1}{2} \left[\frac{E^2}{4} - 1 + x^2 + \sqrt{\left(\frac{E^2}{4} - 1 + x^2 \right)^2 - E^2 x^2} \right], \quad (21a)$$

$$k^2 \geq a^2 = \max \left\{ \Delta^2; \frac{1}{2} \left[\frac{E^2}{4} - 1 + x^2 - \sqrt{\left(\frac{E^2}{4} - 1 + x^2 \right)^2 - E^2 x^2} \right] \right\}. \quad (21b)$$

From analysis of the expressions (21) there follows directly the interval of variation of $x = \varepsilon - E/2$. For $1/\omega_1 + 1/\omega_2 \leq 2$, we find that $1 \leq \varepsilon \leq E - 1$. For $1/\omega_1 + 1/\omega_2 > 2$ electrons (and positrons) at rest cannot be produced. Indeed, in this case it follows from the condition $a^2 (= \Delta^2) \leq b^2$ that

$$|x| \leq \frac{\Delta}{2} \sqrt{1 - \frac{4}{E^2 - \Delta^2}}.$$

Substituting here the values $\Delta \equiv \omega_2 - \omega_1$ ($\omega_2 \geq \omega_1$) and $E \equiv \omega_1 + \omega_2$, we obtain

$$1 < \frac{\omega_1 + \omega_2}{2} - \frac{\omega_2 - \omega_1}{2} \sqrt{1 - \frac{1}{\omega_1 \omega_2}} \leq \varepsilon \leq \frac{\omega_1 + \omega_2}{2} + \frac{\omega_2 - \omega_1}{2} \sqrt{1 - \frac{1}{\omega_1 \omega_2}}. \quad (22)$$

Note that from (22) we obtain directly the previously obtained condition $\omega_1 \omega_2 \geq 1$ for the threshold of the photoproduction reaction in an isotropic cloud.

Integration of (19) and (20) leads in the general case to cumbersome expressions. However, in the most important case when the γ rays of high energies ω_2 produce a pair in a cloud of soft photons ($\omega_1 \ll 1$) it is possible to obtain a fairly simple analytic expression for the spectrum of the produced particles. Indeed, it follows from the condition $\omega_1 \ll 1$ that $1/\omega_1 + 2/\omega_2 > 2$, and then the lower limit of integration in (10) for all admissible values of x is $\Delta = \omega_2 - \omega_1$, and the values of the momentum vary in the narrow interval $\omega_2 - \omega_1 \leq k < \omega_2 + \pi_1$. Replacing k in front of the root in (21a) by $\omega_2 \approx E$ and solving the resulting inequality k^2 , we find the upper limit for the given ε :