lifetime is consistent only with the identification of the 42-kev transition as $E3$ or $M3$ since Weisskopf's formulas appear to be valid within a factor of 10^4. It is not possible to choose between $E3$ and $M3$ on the basis of the lifetime measured here.

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Multiple Photon Production in Electron-Positron Annihilation

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DUE to the small value of the fine structure constant, multiple processes in quantum electrodynamics have not received much attention. In fact, it is usually believed[1,2] that the cross section for a process involving multiple production of photons is always much smaller than the cross section for a similar process involving the production of a lesser number of photons.

In order to see whether the above belief is justified even at very high energies, we have investigated the multiple production of photons due to the annihilation of an electron-positron pair. It is found that in the extreme relativistic case the cross section for the production of three photons in the electron-positron annihilation is

$$\sigma_3=\alpha^3\frac{c^2\hbar^2}{\mu E}\left(\log\frac{2E}{\mu}\right)^3, \tag{1}$$

where α is the fine structure constant, μ is the rest energy of the electron or the positron, E is the energy of the incident positron, and we have assumed that the electron is at rest. Further, an estimate of the cross section for the production of n photons in the electron-positron annihilation shows that

$$\sigma_n\approx\pi^{3-n}\alpha^n\frac{c^2\hbar^2}{\mu E}\left(\log\frac{2E}{\mu}\right)^{2n-3}. \tag{2}$$

We can now compare the cross sections (1) and (2) with the cross section for the production of two photons in the electron-positron annihilation, which in the extreme relativistic case is given by[1]

$$\sigma_2=\pi\alpha^2\frac{c^2\hbar^2}{\mu E}\log\frac{2E}{\mu}. \tag{3}$$

It is then evident that σ_n is of the same order as σ_2 when

$$\frac{\alpha}{\pi}\left(\log\frac{2E}{\mu}\right)^2\approx 1. \tag{4}$$

Thus, in spite of the smallness of the fine structure constant, the role of multiple processes in quantum electrodynamics is not negligible at very high energies.

Recently Schein and co-workers[3] have observed a very unusual shower of about 20 photons, which are unaccompanied by charged particles and are contained in a very narrow cone. Due to the absence of charged particles in the photon shower, it seems that these photons were produced by the annihilation of a charged particle and its antiparticle. Moreover, in order to account for the narrow width of the photon shower, Schein[4] has estimated that the energy of the incident particle is about 10^8 times its rest energy. Now, when $E\approx 10^8\mu$, we find that $(\alpha/\pi)[\log(2E/\mu)]^2\approx 1$, and therefore in such a case multiple production of photons can easily take place. This shows that Schein's photon shower could have been produced by the annihilation of an electron-positron pair, the energy of the incident positron being about $10^8\mu$ or about 0.5×10^{14} ev.

It should be noted that it would be rather difficult to provide any other explanation for the event observed by Schein. For instance, in the annihilation of a proton-antiproton pair the probability for the production of π mesons far exceeds the probability for the production of photons,[5] and therefore the proton-antiproton annihilation can hardly give rise to a pure photon shower.

The present investigation also serves to show that more attention should be paid to the study of multiple photon production in various elementary processes in quantum electrodynamics. Multiple processes may provide us with a test of the validity of the present quantum electrodynamics at exceedingly high energies.

A detailed account of this work will be published shortly.

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