PAIR PRODUCTION IN THE FIELD OF AN ELECTRON

By **P. Nemirovsky**

Lebedev Physical Institute, Academy of Sciences of the USSR

(Received August 1, 1946)

The passage of hard electromagnetic radiation through matter along with the production of pairs in the field of the nucleus gives rise to a similar process in the field of the electrons. The possibility of such a process was first pointed out by Perrin (1), who, however, made no estimation of the effective cross section of the process.

In contradistinction to the pair production in the nuclear field such a process leads to the transfer of finite energy to the recoil particle (electron). Experimentally, one must observe three particles originating from a single point. Ogle and Kruger (2) have really observed such triplets.

In the present note the cross section of this process is calculated. The calculation is carried out by the usual method of Dirac's perturbation theory. The phenomenon dealt with is a third-order process in which three particles take part. In such a process the momentum and energy of the particles (in the system of the inertia centre) satisfy the following conservation laws:

$$p_0 + p_+ + p_- = 0, \tag{1}$$

$$E_0 + E_+ + E_- = E_k + k_0, \tag{2}$$

where k_0 is the energy of the incident quantum and $E_k = \sqrt{k_0^2 + m^2c^4}$ — the energy of the electron in the initial state, m—the electron mass; p_0, p_+, p_-, E_0, E_+, E_- are the energy and momentum of each particle in the final state.

The differential cross section of such a process is then defined as [*cf.* Heitler (3)]

$$d\sigma = \frac{2\pi}{h(c+v)} \mid H_{if} \mid^2 \rho_E \, d\Omega_0 \, d\Omega_+ \, dp_+, \tag{3}$$

wehre H_{if} is the matrix element of the transition, v — the velocity of the inertia centre and ρ_E the density of states. In our case

$$\rho_E = \frac{1}{(2\pi)^6} \frac{1}{hc} p_+^2 p_0^2 \frac{1}{\dfrac{\partial E}{\partial p_0} + \dfrac{\partial E}{\partial p_-}\dfrac{\partial p_-}{\partial p_0}}. \tag{4}$$

The matrix element H_{if} takes into account, besides the Coulomb transfer of momentum, also the exchange of transverse photons between the pair constituents and the recoil electron. Likewise account is taken of the antisymmetry of the wave function in the coordinates of both electrons taking part in the process.

To obtain the total cross section the differential cross section (3) has to be integrated over 5 variables. For energies close to the threshold (4—6 mc^2) the integral can be evaluated accurately, yielding for the effective cross section the formula

$$\sigma = 0.087\, \alpha r_0^2 \frac{(k_0 + \sqrt{k_0^2 + m^2c^4} - 3mc^2)^2}{(mc^2)^2} \times \frac{\sqrt{k_0^2 + m^2c^4}}{k_0 + \sqrt{k_0^2 + m^2c^4}}, \tag{5}$$

where α is Sommerfeld's constant, r_0 — the classical electron radius and k_0—the photon energy in the system of the inertia centre. With an energy of $3mc^2$ in this system which corresponds to a photon energy $4mc^2$ in the observer system, the cross section is seen to become zero.

With an energy of the incident photon equal to 5.3 mc^2 in the observers system (this corresponds to experimental data), the cross section $\sigma = 0.4 \cdot 10^{-29}$ cm^2, which is somewhat less than the value derived by Ogle and Kruger. One cannot draw definite conclusions, however, from the two cases observed by these authors. For large photon energies the calculations show that the dependence of the cross section on the photon energy is the same as for the production of pairs in the field of the nucleus. It should be noted that when the energies are large the most probable are the processes with small recoil. Owing to the smallness of the energy of the third particle, the processs will be observed as a usual pair production.

1 F. Perrin, C. R., 197, 1100 (1934).
2 W. Ogle a. P. Kruger, Phys. Rev., 67, 282 (1945).
3 Heitler, The Quantum Theory of Radiation, Oxford, 1936.

CONCERNING THE PROBLEM OF IONOSPHERE INVESTIGATIONS DURING THE SOLAR ECLIPSE IN BRAZIL ON MAY 20, 1947

By **J. Alpert** and **A. Ainberg**

Lebedev Physical Institute, Academy of Sciences of the USSR

(Received October 12, 1946)

Ionosphere investigations during solar eclipses are repeatedly mentioned in the literature (1,2) as being of great importance to the solution of such problems as the influence of the solar corpuscular radiation on the ionization of the upper layers of the atmosphere and to the estimation with greater precision of the physical constants characterizing the total balance of ionization in various layers.

Up to the present no definite data concerning the problem of a corpuscular eclipse are available; as concerns the ultra-violet eclipse, the numerous observations have shown that the variation in the ionization of the E layer almost fully follows the course of the solar eclipse, thereby making it possible to determine, from experimental data, the value of the recombination coefficient of this layer. Sufficiently reliable data regarding the extent to which the ionization of the F_1 layer depends on the ultra-violet radiation of the sun are still lacking.

As to the F_2 layer, its degree of ionization as a function of various factors varies in a complicated manner, and particularly during the solar eclipse. Therefore, observations conducted during solar eclipses are of great importance to the elucidation of the nature of the yet unknown processes taking place in the F_2 layer.

As we have learned from Prof. A. A. Michailov, on May 20, 1947, a total solar eclipse (with a duration of the totality over 4 min.) will take place and will be favourable to both astrophysical and radio