PAIR PRODUCTION IN THE FIELD OF AN ELECTRON

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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)]

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

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

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

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, Fhys. 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

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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 observations in Brazil *. In this connection computations have been made of the expected variation of ionization of the E layer during this eclipse, which, when compared with the results of observations, will allow the recombination coefficient to be determined with greater precision.

As is known computations in this case are reduced to the graphical integration of the equation

$$\frac{dN}{dt} = J_0 f(t) \cos \chi(t) - \alpha N^2$$

which describes well the course of ionization of the E layer.

In the equation N is the degree of ionization of the layer, J_0 — the number of newly formed electrons per 1 cm³ of the layer at midday at the equator, $f(t)$ — the ratio of the area of the uncovered part of the sun's disc to its total area, $\chi(t)$ — the zenith distance of the sun, and α—the effective coefficient of recombination.

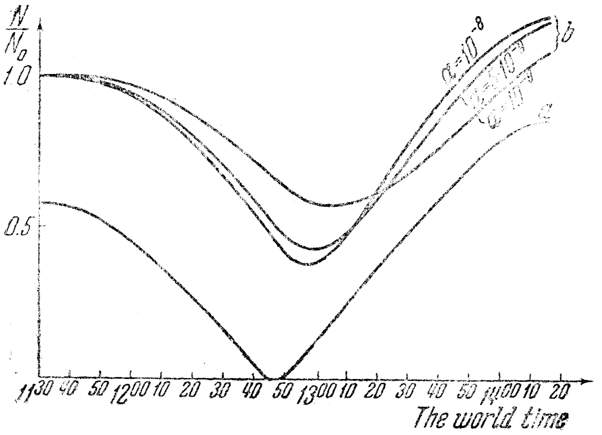

Fig. 1. $J_0 = 150$—250

We have carried out a graphical integration of the equation for different values of α and J_0. The computed results are presented in Fig. 1. The curves a in the figure show the course of variation of $f(t) \cos \chi(t)$ for the latitude $\varphi = -12°57'9$ S and longitude $\lambda = 38°41'$ W in the region of S. Salvador (Bahia) in Brazil at the altitude $h = 110$ km. The curves b characterize the relative variation N/N_0 of the ionization during the solar eclipse for different values of α and J_0 (N_0 is the degree of ionization of the layer at the moment of the beginning of the eclipse).

From the curves it is seen that owing to the considerable duration of the totality of the eclipse, which at the above indicated place lasts for 260 sec., an essential variation of ionization of the E layer should be observed, permitting a more precise measurement of the coefficient α than during previous eclipses.

It should be noted that observations during the forthcoming eclipse will evidently be very favourable for the explanation of the problem of the ionization processes in the F_1 and F_2 layers, as well as of the corpuscular radiation of the sun for various velocities of particles.

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* We take the opportunity of expressing our sincere gratitude to Prof. Michailov for admitting to us the results of astronomical calculations of this eclipse.

[1] A. Higgs, Monthly Not. Roy. Astr. Soc., **102**, 24 (1942).
[2] Я. Альперт и Б. Горожанкин, Изв. АН СССР, сер. физ. (J. Alpert, a. B. Gorozhankin, Bull. Acad. Sci. URSS, série phys.), **8**, 85 (1944).

INVESTIGATION OF METALS AT TEMPERATURES BELOW 1°K

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Only a few metals where investigated at temperatures below 1°K. It is, therefore, of great interest to perform similar investigations with other metals.

The temperatures were obtained by means of the method of adiabatic demagnetization. The corresponding apparatus was of a simplified construction, it did not possess any vacuum jacket and its main part consisted of a thin-walled glass ampulla within which a globule pressed of the investigated metal together with the iron-ammonium alum was placed. The globule had a diameter which was less by 1—2 mm, than the inner diameter of the ampulla and thus could be placed within it without touching the walls. The upper and the lower ends of the ampulla were freely filled with powdered salt, which during the demagnetization "evaquated" the space between the ampulla walls and the globule, located in the middle part of the ampulla. The ampulla was filled with helium at a low pressure and was sealed off.

The time of heating from 0.06 up to 1.2°K could be varied as desired and usually was equal to 70—80 min. The measurements were performed by means of ballistic method. In this case the appearance of superconductivity was characterized by a change of the sign of the deflection on the heating curve.

Control experiments carried out with cadmium showed the values of T_c, H_c and dH_c/dT, which were in a good agreement with the data otbained by Kürti and Simon (¹).

By means of such an apparatus six metals were investigated: Si (0.073°K), Cr (0.082 °K), Sb (0.152°K), W(0.070 °K), Be (0.064 °K), Rh (0.086°K). In brackets is shown the lowest temperature at which the metal was investigated. All these metals did not become superconducting (²).

Also uranium was investigated and found to be superconducting below 1.3°K. The negative results of Shoenberg are to be ascribed to the insufficient purity of his specimen. Our experiments with insufficiently pure uranium also failed to detect superconductivity, whereas with pure metal superconductivity was found for three different specimens.

All the metals used were of a higher purity than the usual chempure metals.

[1] Kürti a. Simon. Proc. Roy. Soc, (A), **151**, 610 (1935)
[2] D. Shoenberg, Proc. Cambr. Phys. Soc., **36**, 84 (1940).