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ELECTRIC FIELD OF A NEUTRAL CURRENT-CARRYING RING
(On the Edwards et al. Experiments)

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The essense of the discussed effect is the appearance of the electric field round an electrically neutral conductor after current excitation in it (without external admission of electrons). First, the communications on a possible observation of this effect were published in the seventies [1—3]; recently, a new experiment [4] has been performed by the same authors.

It is usually considered that the cause of arising the electric field is the appearance of the conductor electric charge. Since the number of electrons does not change when the current is excited and, as before, it is equal to the number of ions, the total electric charge is invariable, too. Therefore according to the generally accepted opinion, the electric field, one would think, should not arise and after putting conduction electrons into motion.

Earlier when clearing up the field nature of a pair of electrical charges of different signs, one of which is moving [5], we have however answered a similar question affirmatively. The appearance of the electirc field in this case was conditioned by different behaviours of the field of resting and moving charges. The appearance of new articles devoted to this problem [6—9] induced us to develop the corresponding calculation.

Let us consider a ring conductor with steady conduction currents. For simplicity we limit the calculation of field on the z-axis of the ring.

For the electric potential created by resting positive charges (ions) of the length element $\Delta s = r\Delta\varphi$ we have

$$\Delta\Phi^{+} = \rho^{*}\Delta\, s/R. \tag{1}$$

Here r is the ring radius; φ, the azimuthal angle (in the ring plane); ρ^{*}, the linear density of ions*; R is expressed through the distance from the ring center to the point of potential measuring P by the formula $R = (z^2 + r^2))^{1/2}$. Under condition the number of electrons does not change after putting them into motion and so equality

$$\rho L = -\rho^{*} L \tag{2}$$

has to take place, where L is the conductor length. Whence with evidence it follows that $\rho = -\rho^{*}$.

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*Before current excitation its value is equal exactly to the corresponding conduction electron density (with an opposite sign).

Based on Lienard — Wiechert's potential for the electric field created by moving conduction electrons with velocity, we have

$$\Delta\Phi^{-}_{LW} = \rho\Delta s(R_r - \boldsymbol{\beta}\,\mathbf{R}_r)^{-1} = \rho\Delta s[R(1-\beta\cos\vartheta_\rho)]^{-1}. \qquad (3)$$

Here the index «r» stresses that the distance figuring in (3) is the «retarded one», i.e. it connects the «retarded» (true) position of a charge (at a preceding instant of time) with the observation point (*P*). In the case of a moving charge it differs from the actual distance (*R*) between *P* and the charge position at the same moment of time. This difference for the resting charge dissapears therefore the index loses the sence, and it can be thrown off. In the considered case point *P* is on the axis of the ring ($\vartheta = \pi/2$), and so the second term in the right side of eq.(3) goes to zero. As a result, for the summary electric potential created by a conductor element Δs, we obtain [10]*

$$\Delta\Phi = \Delta\Phi^{+} + \Delta\Phi^{-}_{LW} = 0. \qquad (4)$$

However, one should pay attention to the following. According to the contemporary presentation, the electric field of a moving charge squeezes. In so doing, the behaviour of the potential is described by the formula

$$DELAT\Phi = \frac{\rho\Delta s}{R(1-\beta^2\sin^2\vartheta)^{1/2}}, \qquad (5)$$

where ϑ is the angle between the movement direction of the charge and the radius-vector **R**. Just from eq.(5) follows that the equipotential surfaces of a moving charge have indeed the form of an oblate ellipsoid (spheroid). Eq.(5) follows from eq.(3) on the basis of the known transition formula (see, e.g., [12a])

$$\mathbf{R} = \mathbf{R}_r - \boldsymbol{\beta} R_r. \qquad (6)$$

As in the considered case $\sin\vartheta \cong 1$, then

$$\Delta\Phi^{-} \cong \rho\,\frac{\Delta s}{R}\left(1 - \frac{1}{2}\beta^2\right) \qquad (5')$$

and so already $\Delta\Phi \neq 0$. After simple integration over φ for the total electric potential, we get

$$\Phi \cong \frac{\beta^2 Q_e}{2R} = \frac{\pi I^2 r}{\rho R c^2}, \qquad (7)$$

*In this connectin see, e.g., [11] as well.

where Q_e is the total electric charge of conduction electrons. Instead of (5) the expression for electric field vector

$$\mathbf{E}^{-} = \frac{e\mathbf{R}}{R^3}\,\frac{1-\beta^2}{(1-\beta^2\sin^2\vartheta)^{3/2}} \qquad (8)$$

is usually given in the text-books (see, e.g., [12b]). The sum of (8) and Coulomb's analog for ion are also different from zero what is more, the electric field is not equal to zero also outside the ring axis.

Thus, as it follows from eqs.(7) and (8), the EKL-effect must take place.

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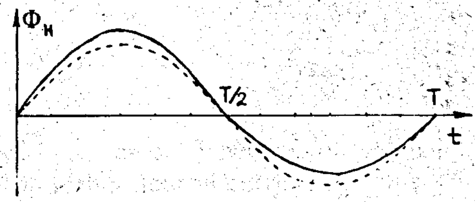
ADDITION
(Electric field of a Bohr atom)

The considered problem has an interesting application at an atomic level. According to eq.(1), the atom electric field created by electron rotation is not equal to the nucleus electric field. The sum of Lienard — Wiechert's potential for electron and Coulomb's potential of nucleus (proton) is

$$\Phi_H = \frac{e[R(1+\beta\sin\varphi) - R_e]}{R(R_e - \beta R\sin\varphi)} \cong \frac{e}{R}\beta\sin\varphi\,(1+\beta\sin\varphi). \qquad (A.1)$$

This dependence is presented in the Figure. Although for Bohr atom $\beta \approx 10^{-2}$, we give $\beta = 0.3$ in order to stress a contribution of the second term. According to (A.1), the mean quantity (over a period *T*) is



$$\Phi_H \cong \frac{e\beta^2}{2R}. \qquad (A.2)$$

As $T \approx 10^{-16}$ c, just eq.(A.2) defines the atom electric field potential.

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