PROPERTIES OF SYNCHROTRONIC AND CHERENKOV RADIATION IN BALLISTIC THEORY

(Abstracts of the report at the XVIII Scientific Conference on Radiophysics of the NNSU on May 13, 2014)

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Synchrotron and Cherenkov radiation is distinguished by a sharp directivity along the velocity V of the emitting particles. It was believed that this orientation is explained only by the special theory of relativity (SRT) and contradicts the ballistic theory of Ritz (BTR) [1]. But in fact, the properties of radiation following from the Ritz theory and the classical estimate of V correspond to experiments [2–4]. This also applies to measurements of the speed of synchrotron radiation in the experiment of E. Aleksandrov and at the SLAC facility, where the speed of radiation c' and electrons V was not measured directly [4, 5]. According to Ritz's theory, the speed of electrons V is added to the speed of light c relative to them, and the calculated speed $c' = c + V$ depends on the method of measuring V. In the classical estimation of V, the experimental results correspond to the Ritz theory [2–5].

The velocity V of particles is found by their momentum $p = m'V = eBR$, where R is the radius of the trajectory of a particle of mass m' and charge e in a magnetic field B. For ultrarelativistic particles, the momentum is $p \approx m\gamma c$, from which the γ-factor is found. In classical mechanics, m' is equal to the rest mass m and $V = \gamma c$ [4]. Adding V to the speed of light c concentrates radiation in a cone with the **V** axis and the angle of the generatrix $\theta = \arcsin(c/V) \sim 1/\gamma$ [2, 3].

The radiation pulse corresponds to the flight of the electron through the orbital segment $d \sim R\theta \sim R/\gamma$, from which the radiation enters the detector at a distance L [6]. From the beginning A of the segment d, the light will reach in time $t_A = (d + L)/(c + V)$, from the end B - in time $t_B = d/V + L/(c + V)$ after radiation into A. Pulse duration $\Delta T = t_B - t_A \approx d/c\gamma^2 \approx R/c\gamma^3$, in accordance with SRT [6], and their spectrum is formed by rotation frequency harmonics, up to $f \sim 1/\Delta T \sim \gamma^3 c/R$, which corresponds to experiment [6]. According to Ritz's theory, the spectrum also depends on the light path length L in the output channel, which is indirectly confirmed [2].

Similarly, in an undulator of length d, we find $\Delta T \approx d/c\gamma^2$, in agreement with experiment and SRT [6]. In an undulator with a magnet pitch b, the electron oscillation frequency is $f = V/b$, and the radiation frequency recorded by the Doppler effect is $f' = f(1 + V/c) \approx \gamma^2 c/b$ [3], in accordance with SRT [6]. That is, the relativistic and ballistic theories lead to close angular $\theta(\gamma)$, temporal $\Delta T(\gamma)$, and frequency $f'(\gamma)$ characteristics of synchrotron (undulator) radiation. A choice between theories can be made by direct measurements of the speed of particles from synchrotrons by the flyby method [4, 5]. Usually the relativistic velocity v is estimated from the SRT formulas connecting the momentum $p \approx m\gamma c$ and the particle velocity $v = c(1 - 1/\gamma^2)^{1/2}$. And the classical theory gives a superluminal value $V \approx \gamma c$, which does not contradict the principles of synchrotron operation [3, 4].

Another method of measuring V is based on the study of the Cherenkov radiation of particles: its properties also follow from Ritz's theory. Back in 1888, O. Heaviside predicted that a charge flying in a medium should emit. According to Ritz's theory, in a medium with a refractive index n, this radiation acquires only a fraction of the charge velocity V [5], so that the radiation velocity $c' = c/[n - V/(c + V)]$. If $V \geq c'$, then the wavefront envelope forms a cone of Cherenkov radiation, and within the framework of STR, radiation is generated at $v \geq c/n$. That is, the measurement of the particle speed at the threshold $v = c/n$ (SRT) and the threshold $V = c'$ (BTR) gives different values. However, the dependence of the threshold n on γ in SRT and BTR is similar. In threshold counters, the speed of ultrarelativistic particles is measured by the gas refractive index $n = 1 + \delta$ (where $\delta << 1$), at which radiation occurs. In SRT, $v = c/n \approx c(1 - \delta)$, whence the threshold value is $\delta = 1/2\gamma^2$. In ballistic theory, from the condition $V = c'$, the threshold $\delta = 1/\gamma^2$ coincides with the relativistic one up to a factor 1/2. This difference is caused by the inaccuracy of the c '(V) dependence at ultrarelativistic velocities ($\gamma >> 1$) and provides a simple test of the Ritz theory, where the measured value $\delta << 1$ corresponds to superluminal velocities $V \approx c\gamma \approx c/\delta^{1/2}$. That is, here, too, the main criterion for testing Ritz's theory is the direct measurement of V by the flight method [5].

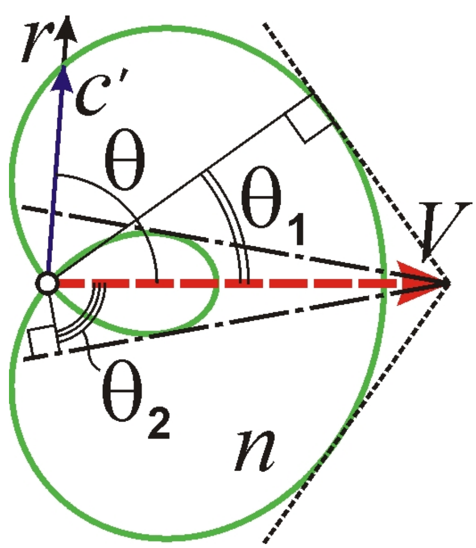

Fig.

The angle θ of the Cherenkov radiation in the Ritz theory is expressed ambiguously (see Fig.). If the velocity $c' = c/[n - V_r/(c + V_r)]$ in the direction θ is affected only by the radial component of the charge velocity $V_r = V\cos\theta$, then at $V \sim c$ the wave front takes the form $c'(\theta) = c/[n - (c/V\cos\theta + 1)^{-1}]$ other than a sphere. And at $V \geq c$ (in SRT it corresponds to $v \geq 0.71c$), the wavefront is self-intersecting, with a lobe-type singularity. Then, in addition to the normal cone of Cherenkov radiation (external envelope of the fronts, with angle θ_1 in the figure), a narrow cone is formed - the envelope of the petal (with angle θ_2). For n <1.5, this anomalous cone is formed at subthreshold values of γ. The radiation generation condition $V = c/[n - V/(c + V)]$ gives two solutions: $V_{1,2} = c(-1 \pm [1 + 4/(n - 1)]^{1/2})/2$, where V_1 corresponds to the generation threshold of normal Cherenkov radiation, and V_2 corresponds to subthreshold (anomalous) radiation, which exists in the range with $c \leq V \leq |V_2|$.

Subthreshold generation is confirmed by experiments [7]. If the cone of normal Cherenkov radiation narrowed with increasing n or V, then the anomalous one expanded, in accordance with Ritz's theory. In photographs [8], two rings were observed: one corresponded to the normal Cherenkov effect (θ1), and the second, anomalously wide ring, to radiation from particles with $v>c$ [8]. Within the framework of Ritz's theory, it is generated by the same particles: anomalous radiation and forms the 2nd ring (θ_2).

So, the properties of synchrotron, undulator and Cherenkov radiation do not contradict the Ritz theory, and its conclusions coincide with the STR. In some cases, the ballistic description is more accurate than the relativistic one and explains the anomalies of these emissions.

Sources:

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Installation date: 06/06/2014

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