ON THE TRANSITION RADIATION BY RELATIVISTIC ELECTRON WITH EQUILIBRIUM AND NONEQUILIBRIUM COULOMB FIELD ON THIN METALLIC PLATE

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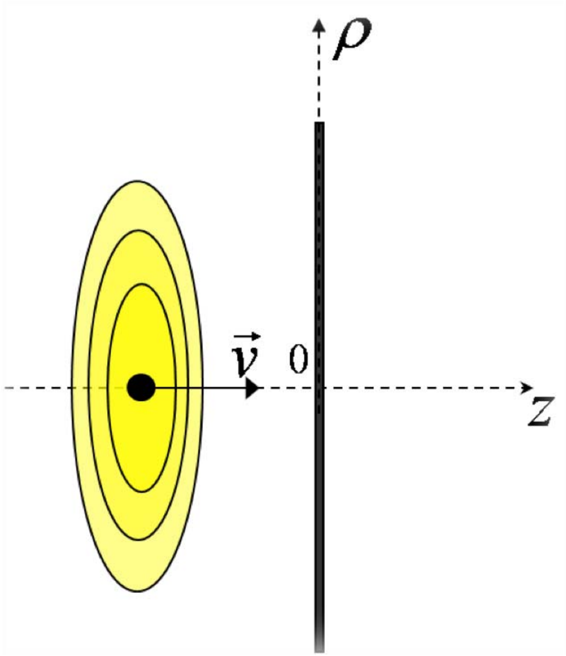
- Transition radiation electromagnetic field structure
- The problem of radiation measurement
- Analogy in Bremsstrahlung
- Transition radiation by "half-bare" electron

N. Shul'ga, S. Trofymenko, V. Syshchenko // J. Kharkiv National University, 2010

TRANSITION RADIATION BY ELECTRON WITH EQUILIBRIUM FIELD



Total field:

$$\varphi = \varphi^C + \varphi^f$$

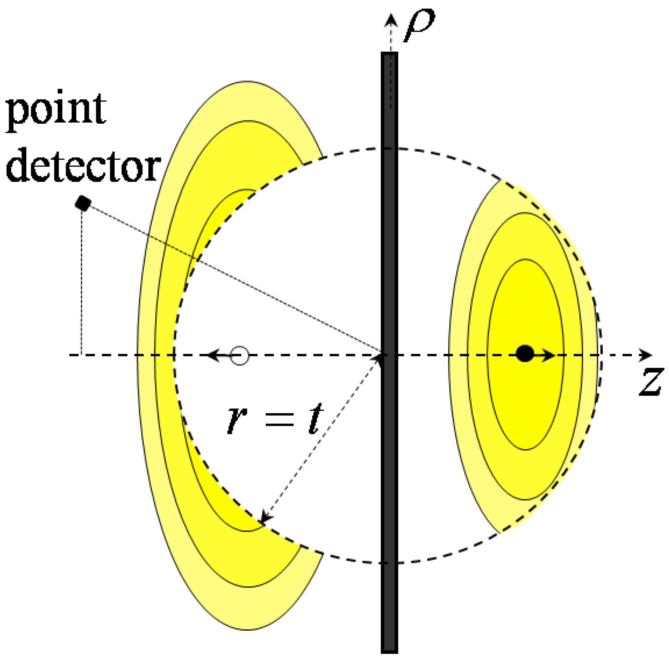
Boundary condition:

$$\vec{E}_\perp^C(\vec{\rho}, z=0, t) + \vec{E}_\perp^f(\vec{\rho}, z=0, t) = 0$$

Fourier integral for radiation field:

$$\varphi^f(\vec{r}, t) = -\frac{e}{2\pi^2 v}\int d^2k_\perp \int_{-\infty}^{\infty} d\omega \frac{1}{k_\perp^2 + \omega^2/p^2} e^{i\left(z\omega\sqrt{1-k_\perp^2/\omega^2} - \omega\ t + \vec{k}_\perp\vec{\rho}\right)}$$

STRUCTURE OF TR ELECTROMAGNETIC FIELD



$$E = 50\,Mev \qquad \lambda \approx 0.1cm$$

$$l_C \approx 2\gamma^2\lambda \approx 20m \qquad l_T \approx \gamma\lambda \approx 10cm$$

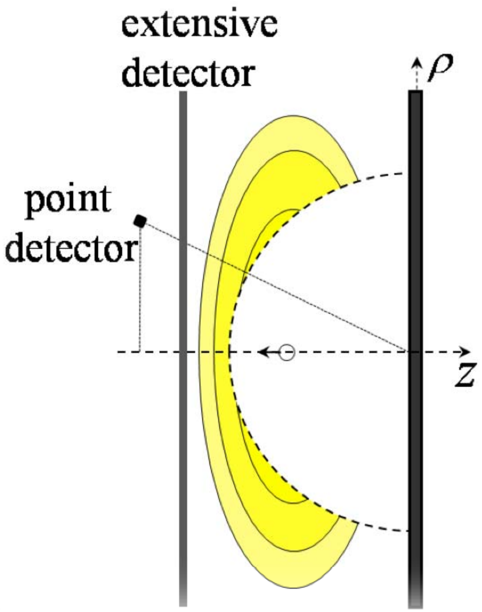
For $t > 0$ **:**

$$z > 0: \quad \varphi(\vec{r},t) = \left[\frac{e}{\sqrt{\rho^2\gamma^{-2} + (z - vt)^2}} - \frac{e}{\sqrt{\rho^2\gamma^{-2} + (z + vt)^2}}\right]\theta(t - r)$$

$$z < 0: \quad \varphi(\vec{r},t) = \left[-\frac{e}{\sqrt{\rho^2\gamma^{-2} + (|z| - vt)^2}} + \frac{e}{\sqrt{\rho^2\gamma^{-2} + (z - vt)^2}}\right]\theta(r - t)$$

It is not the same as in *B. Bolotovsky, A. Serov // Phys. Usp., 2009*

THE PROBLEM OF TRANSITION RADIATION MEASUREMENT



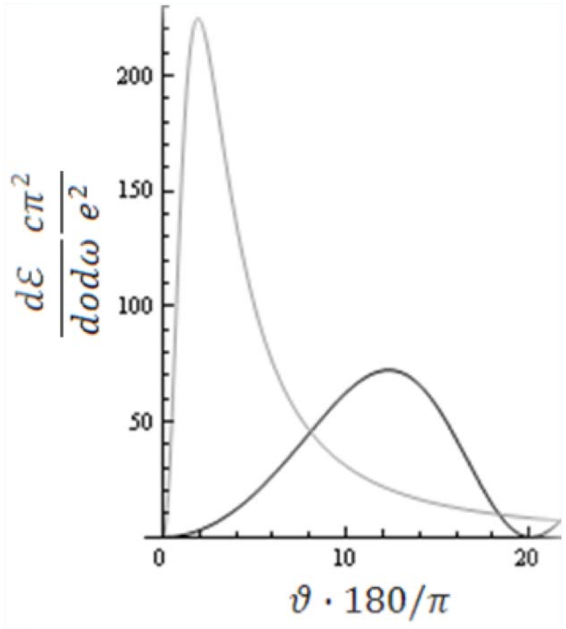
Point detector $\Delta\rho << \gamma / \omega$:

$|z| >> l_c$:

$$\frac{d\varepsilon}{d\omega do} = \frac{e^2}{\pi^2}\frac{\vartheta^2}{\left(\gamma^{-2}+\vartheta^2\right)^2}$$

$|z| << l_c$:

$$\frac{d\varepsilon}{d\omega do} = \frac{4e^2}{\pi^2}\frac{1}{\vartheta^2}\sin^2\left(\frac{\omega\,|z|\vartheta^2}{4}\right)$$



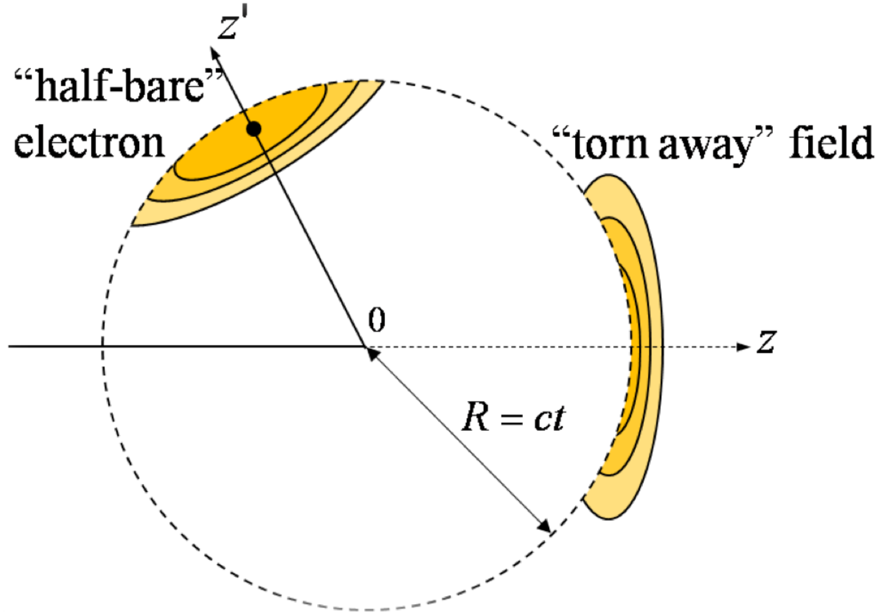
- Verzilov V. // Phys. Lett. A. , 2000
- Dobrovolsky S., Shul'ga N. // NIM B, 2003

Extensive detector (infinite plate) $\Delta\rho >> \gamma / \omega$:

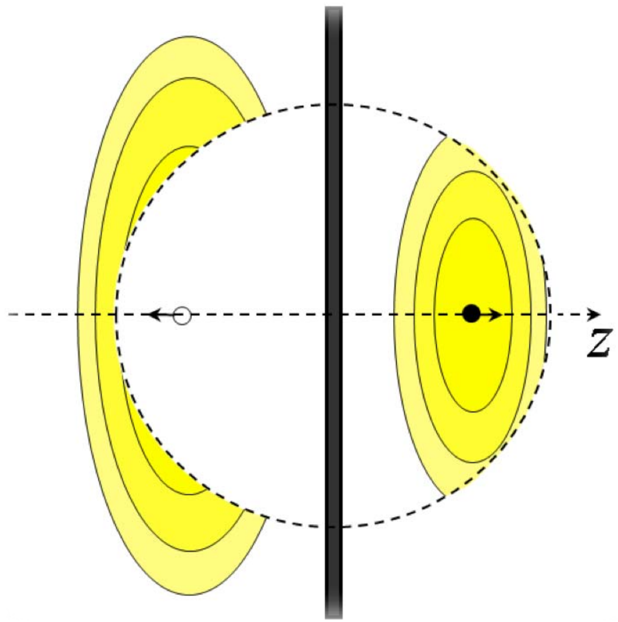
arbitrary z :

$$\frac{d\varepsilon}{d\omega do} = \frac{e^2}{\pi^2}\frac{\vartheta^2}{\left(\gamma^{-2}+\vartheta^2\right)^2}$$

THE ANALOGY IN BREMSSTRAHLUNG



Bremsstrahlung



Transition radiation

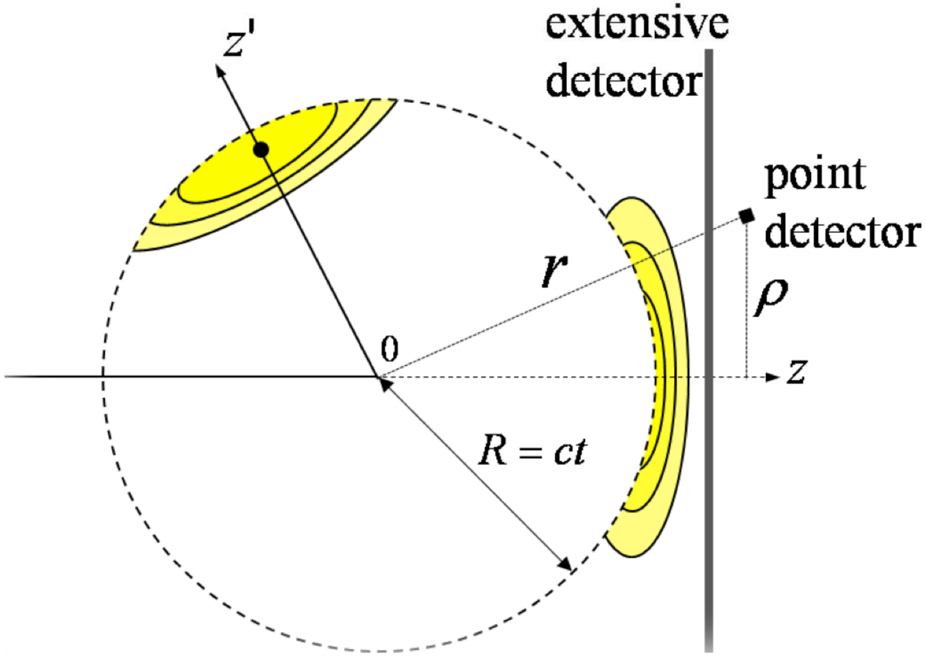
The total field for $t > 0$:

$$\varphi(\vec{r},t) = \theta(r-t)\varphi_{\vec{v}}(\vec{r},t) + \theta(t-r)\varphi_{\vec{v}'}(\vec{r},t)$$

A. Akhiezer, N. Shul’ga *High Energy Electrodynamics in Matter*, 1996

N. Shul’ga, V. Syshchenko, S. Shul’ga // Phys. Lett. A, 2009

THE ANALOGY IN BREMSSTRAHLUNG



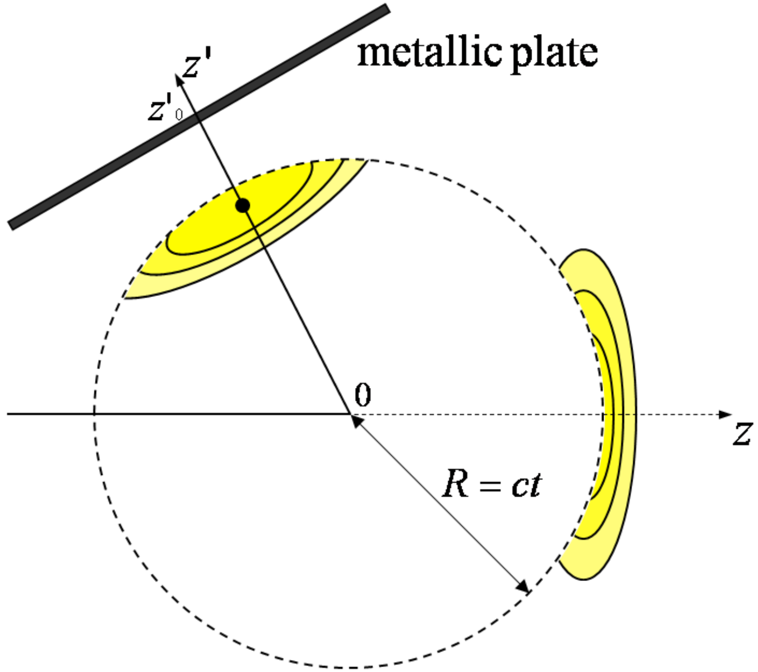
$$|z| >> l_c :$$

$$\frac{d\mathcal{E}}{d\omega do} = \frac{e^2}{\pi^2}\frac{\vartheta^2}{\left(\gamma^{-2}+\vartheta^2\right)^2}$$

for both point and extensive detectors

$$|z| << l_c : \begin{cases} \dfrac{d\mathcal{E}}{d\omega do} = \dfrac{4e^2}{\pi^2}\dfrac{1}{\vartheta^2}\sin^2\left(\dfrac{\omega\ |z|\vartheta^2}{4}\right) & \text{– for point detector} \\[2ex] \dfrac{d\mathcal{E}}{d\omega do} = \dfrac{e^2}{\pi^2}\dfrac{\vartheta^2}{\left(\gamma^{-2}+\vartheta^2\right)^2} & \text{– for extensive detector} \end{cases}$$

TRANSITION RADIATION BY ELECTRON WITH NONEQUILIBRIUM FIELD



Transition radiation by "torn away" field :

$$\frac{d\mathcal{E}}{d\omega do} = \frac{e^2}{\pi^2}\frac{\vartheta^2}{\left(\gamma^{-2}+\vartheta^2\right)^2}$$

does not depend on z_0

Transition radiation in wave zone by electron with nonequilibrium field :

$$\frac{d\mathcal{E}}{d\omega\, do} = \frac{e^2}{\pi^2}\frac{\vartheta^2}{\left(\vartheta^2+\gamma^{-2}\right)^2}\, 2\left\{1-\cos\left[\frac{\omega\, z'_0}{2}\left(\gamma^{-2}+\vartheta^2\right)\right]\right\}$$

TRANSITION RADIATION BY ELECTRON WITH NONEQUILIBRIUM FIELD

Transition radiation in wave zone by electron with nonequilibrium field :

$$\frac{d\mathcal{E}}{d\omega\ do} = \frac{e^2}{\pi^2}\frac{\vartheta^2}{\left(\vartheta^2+\gamma^{-2}\right)^2}2\left\{1-\cos\left[\frac{\omega\ z'_0}{2}\left(\gamma^{-2}+\vartheta^2\right)\right]\right\}$$

- suppression of radiation for $z'_0 << l_C$

- period of oscillations $\Lambda = \dfrac{4\pi}{\omega(\vartheta^2+\gamma^{-2})}$

- the oscillations can be observed for $z'_0 < \dfrac{2\pi}{\Delta\omega\ (\vartheta^2+\gamma^{-2})}$

$\Delta\omega$ – detector's resolution for frequency ω

COCNCLUSIONS

- Analogous electromagnetic field structure for TR and Bremsstrahlung
- Similar effects in TR and Bremsstrahlung
- Possibility of measurements in pre-wave zone
- Same results for point and extensive detectors in wave zone
- Substantial dependence of results on the detector's size in pre-wave zone
- Manifestation of electron's state with nonequilibrium field by it's transition radiation