THE RADIATION EMISSION BY A HIGH ENERGY ELECTRON-POSITRON PAIR AND ULTRARELATIVISTIC HYDROGEN-LIKE ATOM MOVING THROUGH THICH TARGET.

A.V.Koshelkin

Theoretical Physics Department, Moscow Engineering Physics Institute
Kashirskoye sh., 31, Moscow 115409, Russia.

1.INTRODUCTION.

We consider the radiation emission by a set of ultrarelativistic charged particles which undergo multiple elastic collisions with atoms of a amorphous scattering medium. The radiation emission by a high energy electron-positron pair and an ultrarelativistic hydrogen-like atom in the medium is investigated theoretically in detail.

2.STATEMENT OF THE PROBLEM.

We consider the system of charged ultrarelativistic ($E_\mu \gg m_\mu$) clasically fast ($E_\mu \gg \omega$ is a radiation frequency) particles which do not interact with each other (E_μ , m_μ , and e_μ are the energy, the mass and the charge of the particle, $\hbar=c=1$). These particles enter a homogeneous, semi-infinite, amorphous scattering medium. In the initial period, t=0, particles are located in the points $\vec{r}_{01}$, $\vec{r}_{02}$, ... , $\vec{r}_{0N}$, and are the velocity $\vec{v}_{01}$, $\vec{v}_{02}$,..., $\vec{v}_{0N}$, equal to $v_0=[1-(m_\mu/E_\mu)^2]^{1/2}$ They are directed under the $|\vec{\Delta}_\mu| \ll 1$ ($\mu=1,...,N$ - is the number of the particles) angle to the $\vec{e}_z$ vector (vector of the inward normal to the boundary of the medium) at t=0 . Let the characteristic longitudinal size of the beam L_b be such that $L_b v_0^{-1} \ll T$ (the time when the particles move in the medium.

3.SOLUTION OF THE PROBLEM.

The specrtal-angular distribution of the energy emitted by these particles is

$$\frac{d\varepsilon_\omega}{d\omega d\Omega_{\vec{n}}} = \frac{\omega^2}{2\pi^2} \mathrm{Re} \sum_{\mu,\nu=1}^{N} e_\mu e_\nu \cdot \int_0^T dt \int_0^\infty d\tau \cdot \tag{1}$$

$$[\vec{n}\times\vec{v}_\mu]\cdot[\vec{n}\times\vec{v}_\nu]\cdot\exp\{-i\omega\tau + i\vec{k}\cdot(\vec{r}_\mu-\vec{r}_\nu + \vec{r}_{0\mu}-\vec{r}_{0\nu})\},$$

$\vec{k}$ is the wave vector of the radiation field, $d\Omega_{\vec{n}}$ is an element of solid angle in the direction $\vec{n}=\vec{k}/k=\vec{k}/\omega$, $\vec{r}_\mu=\vec{r}_\mu(t+\tau)$, $\vec{v}_\mu=\vec{v}_\mu(t+\tau)$, $\vec{r}_\nu=\vec{r}_\nu(t)$, $\vec{v}_\nu=\vec{v}_\nu(t)$ are coordinates and velocities of the particles at the time $t+\tau$ and t respectively,

τ is the time scale of the radiation formation (the coherence time), and the t is the time at which the radiation is emitted.

To calculate the observed spectral distribution of the emission energy of the particles in the medium, $dE_\omega/d\omega$, we must average expression (1) over all possible trajectories of the scattering particles in the scattering matter [1]. To solve this problem it is necessary to find [2] two-time distribution function of the particles in a scattering medium. In the case of ultrarelativistic classically fast particles the solution of the problem is determined by the Fourier component of this function

$F_k(\vec{v}_\mu, \vec{v}_\nu, t, \tau)$:

$$\frac{dE_\omega}{d\omega} = \frac{\omega^2}{2\pi^2} \mathrm{Re} \sum_{\mu,\nu=1}^{N} e_\mu e_\nu \int d\Omega_{\vec{n}}\, d\vec{v}_\mu\, d\vec{v}_\nu \int_0^T dt \int_0^\infty d\tau$$

$$[\vec{n}\times\vec{v}_\mu]\cdot[\vec{n}\times\vec{v}_\nu]\cdot \exp\{-i\omega\tau + i\vec{k}\cdot(\vec{r}_\mu - \vec{r}_\nu +$$

$$+ \vec{r}_{o\mu} - \vec{r}_{o\nu})\}\cdot F_k(\vec{v}_\mu, \vec{v}_\nu, t, \tau)$$

The function $F_k(\vec{v}_\mu, \vec{v}_\nu\ t, \tau)$ satisfies to the following equations and the initial conditions [2]:

$$\frac{\partial F_k(t,\tau)}{\partial \tau} - i\vec{k}\cdot\vec{v}_\mu(\vec{\eta})\cdot F_k(t,\tau) =$$

$$= \varkappa_\mu^2 \frac{q}{4} \cdot \frac{\partial^2 F_k(t,\tau)}{\partial \vec{\eta}}$$

$$\frac{\partial F_k(t,0)}{\partial t} - i\vec{k}(\vec{v}_\mu(\vec{\eta}) - \vec{v}_\nu(\vec{\phi}))F_k(t,0) =$$

$$= \frac{q}{4} \cdot \left[\frac{\varkappa_\mu \partial}{\partial\vec{\eta}} + \frac{\varkappa_\nu \partial}{\partial\vec{\phi}}\right]^2 F_k(t,0)$$

$$F_k(0,0) = \delta(\vec{\eta} - \vec{\Delta}_\mu)\cdot\delta(\vec{\phi} - \vec{\Delta}_\nu)\cdot$$

$$\cdot \exp[i\vec{k}\cdot(\vec{r}_{o\mu} - \vec{r}_{o\nu})],$$

$$\varkappa_\mu = U_\mu(\vec{g})\cdot E\cdot E_\mu^{-1}\cdot U(\vec{g}),$$

where q is the average square of of multiple scattering angle for a positron per unit of path [3], $U_\mu(g)$; E_μ; $U(g)$; E correspond to the Forier component of the potential of interaction with the atom of a medium and the energy for the particles which number is μ and for the positron respectively; $\vec{\eta}$ and $\vec{\phi}$ the angle vectors which are connected with $\vec{v}_\mu(\vec{\eta})$ and $\vec{v}_\nu(\vec{\phi})$ by the ordinary formulae of the theory of multiple scattering in a amorphous medium [3].

4. RESULTS.

The theory of radiation emission by the set of nonidentical particles which are scattered multiple elastic in a amorphous medium is developed. The spectral-angular distribution of the emission energy by these particles is obtained.

The emission by an ultrarelativistic electron-positron pair ($-\varkappa_{positron} = \varkappa_{electron} = -1$) in a scattering medium is researched in detail. We have shown that the interference of waves emitted by the electron and by the positron leads to the suppresion of the intensity of the emission energy at long wave frequency range while at shortwave frequency region the interference effects is negligible an the value of the emission energy is proportional to the number of the irradiating particles. We show that under the certain conditions the emission spectrum of the electron-positron pair has overbending point which is situated on the frequencies in order of qE^2m^{-2}. It is shown that the angular distribution of the emission energy of the electron-positron pair has a maximum which is on the emisson angles $\theta_k \cong (q\,T)^{1/2}$.

We consider the radiation emission by a hydrogen-like atom in a "strong" scattering medium. We show that under the certain conditions ($q_n \leq q$; $Z_n^2 \ll (q/q_n)^{1/2}$, where q_n and Z_n are the average square of multiple scattering angle per unit path and the charge of the core for hydrogen-like atom) the spectral distribution of the emission energy by this atom has step-like view. The width and the height of the "step" depend sufficiently on the charge and on the mass of the core of the emitting hydrogen-like atom.

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