ON THE POSSIBILITY OF AVERAGING THE RELATIVISTIC EQUATIONS for ELECTRON MOTION IN THE FIELD OF INTENSE LASER RADIATION

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The character of motion of an electron in the field of the electromagnetic wave essentially depends on its intensity which is defined by the parameter $g=eE/ωm\_{e}c$*.* For the laser radiation this parameter is written in the form:

 $g= 0.85∙10^{-9}λ\sqrt{I}$, (1)

where $I=(cE^{2}/8π)[W/cm^{2}]-$ is intensity of the laser pulse, $λ\left(μm\right)$ is the wavelength. Derivating expression for the averaged (ponderomotive) force of the intense laser radiation
$(g\geq 1)$, one usually supposes that the amplitude of the wave varies slowly than its phase (e.g. [1]). At the same time specific conditions for the change of these parameters are not considered. However, at the relativistic motion the frequency, which “sees” the particle, decreases due to the Doppler-effect: $ω^{'}=ω(1-v\_{z}/c).$ Here $v\_{z}$ is the component of the particle velocity in the direction of propagating of the laser pulse. The Doppler frequency shift leads to the slowing down of the velocity of the changing of the phase of the wave, acting on the particle. So, changing the phase may be related to the changing of the amplitude. In that case averaging of the equations is impossible.

The given report has the aim to obtain the necessary conditions for averaging of the relativistic equations of motion of electron in the field of intense laser pulse. Laser radiation is considered in the paraxial (quasi-optical) approximation [2]. There is small parameter

 $μ=a/z\_{R}≡2/ka\ll 1.$ (2)

Here *а* is the dimension of the laser beam at the focal plane, $z\_{R}=ka^{2}/2$ is the Rayleigh length, $k=2π/λ=ω/c$ is the wave number. In the case of tightly focused laser radiation with the intensity $I\geq 10^{22}$ $W/cm^{2}$ the dimension of the focal spot may be of the order of the wavelength. In such case paraxial approximation is not valid [3].

For averaging over the phase of the wave it is necessary to phase to be “fast” [4]. Analysis shows that averaging is possible (the phase remains “fast” during motion) under the condition

 $ g^{2}\ll πa/λ$. (3)

One can see, that the averaging of the equations of motion is possible only in the case of moderate intensity of the relativistically strong laser radiation $(g≈1-3)$ and rather wide laser beam ($a/λ\gg 1). $

References

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