Features of the relativistic motion of a single electron entering a waveguide [[1]](#footnote-1)\*)

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Studies [1,2] considered the relativistic motion of electrons in the field of a rectangular cross section waveguide detailing the features of averaged forces acting on electrons. A similar work was made in [3] implementing the Bogolyubov averaging method [4] using $g=e\left|E\right|/ωMc$ as the expansion parameter. Here $\left|E\right|$ is the amplitude of the electric field of the waveguide, $ω$ is the frequency, $e$ is the charge, $M$ is the mass of the particle and $c$ is the speed of light in vacuum. One of the advantages of the Bogolyubov averaging method is that it allows to find the equations of motion averaged over fast oscillations (drift equations) and to calculate periodic additions to the smoothed dynamical variables explicitly and up to any order of approximation over $g$ in principle. In the given report we implement the Bogolyubov technique in order to analyze the averaged motion of a relativistic electron in the field of an arbitrary *Нmn* mode wave, produced in a rectangular waveguide. The periodic additions to the smoothed variables are derived up to the second order of approximation over the small parameter $g$. The expressions for the averaged (ponderomotive) force acting on a single relativistic electron are obtained. Numerical integration of the exact and averaged equations of motion is performed at different initial conditions of injection and for various wave modes in the waveguide. It is shown that the matching accuracy of the results significantly depends on the right settings of the initial conditions of the averaged dynamical variables, which in turn are defined by their respective periodic additions. The existence of critical injection momentum of the particle below which the electron cannot penetrate the waveguide is demonstrated. Similar effect of diffraction and refraction of the particle in electromagnetic fields was discussed in [5]. Features of the relativistic particle’s motion along the propagating axis are also studied. It is shown that the second order periodic additions to the longitudinal momentum contain more complicated oscillations than analogical additions to the transverse components of the momentum vector. It leads to decreased precision measurements of the averaged longitudinal momentum.

References

1. Serov A.V. JETP, 2001. V. 119(1), P. 27-34.
2. Serov A.V. Quantum electronics. 1998. V. 25, №3, P. 197-200.
3. Castillo R.A.H., Milantiev V.P. Prikladnaya Physica. 2011. №6, P. 68-73.
4. Bogolyubov N. N., Mitropol'skii Y. A. Asymptotic methods in nonlinear oscillation theory // Izd. Nauka, Moscow. – 1974.
5. Kibble T.W.B. Phys. Rev. 1966. V. 150, №4. P. 1060-1069.
1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/XLVII/Lt/ru/FI-Milant%27ev.docx) [↑](#footnote-ref-1)