The theory of electro-magnetic radiation of electron transiting through the resonance-tunnel structure

M. Tkach, Ju. Seti, O. Voitsekhivska and R. Fartushynsky

Chernivtsi National University, Faculty of physics, 2 Kotsiubynsky Str., 58012 Chernivtsi, Ukraine, E–mail: ktf@chnu.edu.ua

The electro-magnetic radiation arises when the electrons are transiting through the resonance-tunnel nanostructure. This phenomenon is actively used for the creation quantum cascade lasers (QCL's) with unique physical characteristics. Besides, the radiation of QCL is in sub- millimeter range of wave lengths is actual for the applied utilization. The main problems are to produce a device working at the room temperature, has the minimal magnitude of the excited current and the maximal strength of electro-magnetic radiation in demanded range.

According to the practical urgency, it is necessary to develop the theory of electro-magnetic radiation arising when the electrons are transiting through the open nano-RTS with quasi-stationary states. The consequent theory correlating to the experimental data obtained for the QCL's, is still absent. The theoretical papers of this direction can be conditionally divided into two groups: in the first, it is used the Hamiltonian of the system, containing many fitting parameters, varying which one can obtain the correlation to the experiment; in the second, it is studied the model system within the approximation of effective masses and rectangular potentials for the electron in RTS. The disadvantage of the first approach is that the physical processes in RTS here are described unclearly. In the second one, the physical processes are clear but the rectangular potentials are changed into the delta-like ones, due to the mathematical obstacles, bringing to the rather rough evaluations which can not be compared to the experimental data. The consistent theory of electron-phonon interaction in RTS is absent at all.

In the paper it is established the theory of generalized conductivity in three-barrier nano-RTS. The system Hamiltonian contains the electron energy (with known effective masses and rectangular potentials) and the energy of electron interaction with electro-magnetic field. The spectral parameters (resonance energies and widths) of electron quasi-stationary states in RTS are calculated and analyzed. There are obtained the optimal sizes of RTS components, which can improve the physical characteristics of three-barrier lasers.