THEORY OF PARAMETRIC SUPERHETERODYNE FREE ELECTRON LASERS

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The nonlinear multi-harmonic theory of Two-stream Parametric Superheterodyne Free Electron Lasers (TPSFELs) is constructed [1]. The difference such systems from the "ordinary" Two-stream superheterodyne Free Electron Lasers (TSFELs) [2,3] consist in choice of the working physical mechanism. Here the effect three-wave parametric resonance for the electronic waves plays the same role that the effect of two-stream instability in the TSFELs. Thus, a superimposition of two different parametric amplification mechanisms (for three electron waves and for the system of two electromagnetic waves and one electron wave, respectively) forms a basis of the effect of superheterodyne amplification in the TPSFELs.

The following model is being analyzed. A two-stream relativistic electron beam (REB) consists of two one-stream partial REBs, which move with near velocities along one axis. The waves of electromagnetic signal, electromagnetic and electron-wave pumping move along the same axis. The parameters of the system are selected so that the fast space charge wave is stimulated in the system. This wave is in parametric resonance of an electromagnetic signal and electromagnetic pumping. Also parametric resonance of fast SCW with the wave of the electron-wave pumping is realized in the system, as a result idler SCW is generated. Thus in the investigated model we have simultaneously two pumping: electromagnetic and electronic – wave.

We consider that the region of interaction is limited in longitudinal direction, non-limited in transversal and is filled with an artificial magnet-dielectric [2]. The use of the artificial magnet-dielectric allows uniformly to describe both pumping – the Dopplertron and the H-ubitron within the framework of one model.

For the analysis are used method of an averaged quasi-hydrodynamic equation and the modernized method of slow changing amplitudes [3]. The system of the nonlinear shortened equation for amplitudes of electromagnetic waves is obtained.

The obtained equations have been analyzed in the quadratic approximation. As analysis shows that use of the system studied could be promising as a low noise narrow-band input amplifier of mm-IR range. Relevant project estimations for the optimum conditions of the system are found.

REFERENCES

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