Modelling of Ultrashort Electromagnetic Clusters Forming in Two-Stream Superheterodyne Free Electron Lasers

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Two-stream superheterodyne FELs are characterized by exceptionally high rates of the amplification of electromagnetic waves in the submillimeter-IR range. Such high rates of the amplification are achieved through the use of the additional amplification mechanism of SCW due to the two-stream instability [1]. There is a possibility of the generation of ultrashort intense clusters of an electromagnetic field on the basis of such multiharmonic TSFEL as a result of the superposition of many harmonics. Such ultrashort electromagnetic clusters, as well as ultrashort pulses can have wide practical application for a number of fundamental and applied researches in physics, chemistry, biology and medicine.

We focus on the study of the processes occurring in the multiharmonic TSFEL-klystron, which are intended to form ultrashort clusters of an electromagnetic field, and on clarification of conditions necessary for the creation of such clusters. In our study we carry out amplitude, phase and spectral analyses and find out the conditions necessary for short electromagnetic cluster formation in TSFEL. Plural three-wave parametric resonant interactions of wave harmonics are taken into account.

We have developed the cubic non-linear self-consistent theory of multiharmonic two-stream free electron lasers of a klystron type designed for forming of the powerful ultrashort electromagnetic clusters. We have studied the influence of the plural three-wave interactions of the growing SCW harmonics on the dynamics of main harmonic of TSFEL working in the mode of maximal powerful signal amplification. We have shown that accounting of such interactions can lead to the decrease of the saturation level of an electromagnetic signal eight times and more. We show that the forming of the clusters with duration ~ 40 fs is possible in the TSFEL with beam energy ~ 3.3 MeV. These devices can have wide practical applications as sources of powerful broadband electromagnetic signals.

1. V.V. Kulish, *Hierarchic Electrodynamics and Free Electron Lasers* (CRC Press: Taylor & Francis Group: 2011).