Observation of Sideband Instability in the Novosibirsk Terahertz Free Electron Laser

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***Abstract*- Sideband instability was observed very clearly in the long-pulse regime of the Novosibirsk terahertz free electron laser (FEL) by a Bruker vacuum Fourier spectrometer IFS-66v. For positive frequency detuning, simultaneous generation of six sideband modes was observed. Mode competition and mode switching have been registered. Negative frequency detuning decreased the number of sideband modes and an single-mode generation with the narrowest classical spectrum has been obtained for sufficiently large detuning .**

I. INTRODUCTION

Sideband instability was carefully studied both theoretically [1] and experimentally [2] because of the influence of the phenomenon on the main FEL parameters. The instability decreases the monochromaticity of FEL radiation by the appearance of sideband modes. The shift between the sideband modes is equal to the bounce frequency of electron oscillations in potential well of the electromagnetic wave. A spiking structure of the light pulse with a period close to a slippage length or somewhat larger than it is also a result of the instability.

II. EXPERIMENTAL RESULTS

In typical regimes of our FEL, sideband instability appears as some not large additional part on the left side of the frequency spectrum. The negative detuning of the electron bunch repetition frequency damped the instability. However in the regime that differs only by a twice longer pulse the instability was especially clearly visible due to a better separation of the sideband modes. Thus, here we present this regime to illustrate strong sideband instability. Our main experimental results are listed below:

a) The sideband instability is the strongest for the positive detuning of the electron bunch repetition frequency. Up to six sideband modes are generated simultaneously for the detuning (Fig.1).

b) Negative frequency detuning decreased the number of sideband modes and single-mode generation with the narrowest classical spectrum has been obtained for sufficiently large detuning (Fig.1, 2).

c) Mode competition and mode switching appear when the detuning is changed. The main mode for some detuning can be one of the sideband modes (Fig.1).

d) The spiking structure of the light pulse for strong instability and the sideband harmonic beating appear in unstable regime (Fig.2a ÷ 2d). This structure is transformed in the classical Gaussian-like pulse for damped sideband instability (Fig.2f).

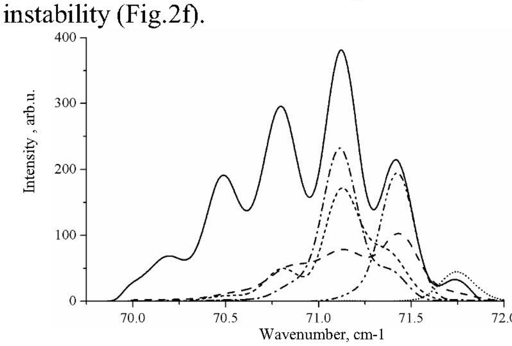

Fig.1. Spectrums in the long-pulse regime for different relative electron bunch frequency detunings: $3.3\cdot10^{-6}$ (solid, increased by 100 times), $5.5\cdot10^{-7}$(dash), $-2.2\cdot10^{-6}$(short dash), $-7.8\cdot10^{-6}$(dash-dot), $-1.3\cdot10^{-5}$(dash-dot-dot), $-2.4\cdot10^{-5}$(dot).

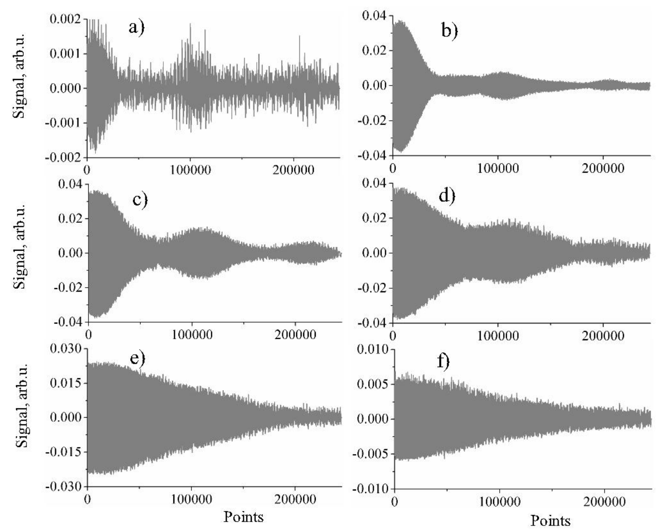

Fig. 2. Interferograms in the long-pulse regime for different relative electron bunch frequency detunings: $3.3\cdot10^{-6}$(a), $5.5\cdot10^{-7}$(b), $-2.2\cdot10^{-6}$(c), $-7.8\cdot10^{-6}$(d), $-1.3\cdot10^{-5}$(e), $-2.4\cdot10^{-5}$(f). Interferograms in the IFS-66v device are shifted down for symmetry; one point is equal to 316.4 nm of the total difference of interferometer branches; a detector noise is present in the interferogram (a).

REFERENCES

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