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PULSE SHAPE EVOLUTION OF FELI FEL DUE TO CAVITY DETUNING

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Abstract

A 1.0% wavelength jitter (side band oscillation) of 11μm FEL at FELI was observed due to cavity detuning. Although an ordinary wavelength jitter of the FELI FEL is controlled within 0.05%, the spectral behavior was appeared during a cavity desynchronization, where the FEL output is given at about maximum power. Moreover, amplitude (pulse shape) of the macropulse is also observed to be modulated with some oscillation period at the same time. The spectral side-band and the power modulation can be explained as the phenomena when the FEL is oscillated as the spiking mode operation in a long-pulse FEL case.

1. Introduction

We have been studying optical property of Free Electron Laser (FEL) at Free Electron Laser Research Institute (FELI)[1,2,3]. Especially in ref. [3] we reported that the side-band is oscillated in spectrum due to the cavity detuning and that the spectral modulation is affected from the electron energy perturbation. Further experiment reveled that the side-band oscillation in the spectrum is associated with the macropulse shape evolution during the cavity detuning. On the contrary, the side-band oscillation and the macropulse shape modulation are observed in the CLIO, the LANL and the Stanford [4,5,6]. They explained the phenomena using the spiking mode theory. In this paper, we therefore try to discuss the amplitude (pulse shape) and frequency evolution of the macropulse caused from the cavity detuning of mid-infrared (MIR) FEL.

2. Cavity detuning

The MIR FEL facility of the FELI has a 165MeV S-band linac, a 6.72m-length optical cavity and a undulator (N=58, λu=34mm). The slippage length (Ls) and the electron bunch length are approximately 600μm and 3mm, respectively. Therefore a slippage parameter (μc) is about 0.2 and the FELI FEL is classified in a long pulse FEL like the CLIO and the LANL [4,5].

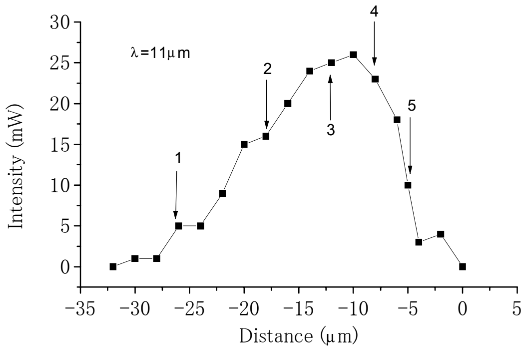

Fig. 1 Detuning curve of the 11μm FEL.

Fig. 1 shows the detuning curve of the 11μm FEL at the FELI, when the length of optical cavity (δL) are changed.

3. Amplitude modulation

Fig.2 shows the amplitude shapes of the FEL macropulse for various δL values (1~5) indicated in Fig.1. The time structures are measured with an MCT detector with 100ns rise time. The micropulse structure can not be seen in these macropulses. Although we unfortunately have not measured the duration of the FEL micropulse with an auto-correlation

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system, the CLIO result suggests that the time structure of the FELI FEL micropulse is also modulated in a theoretical slippage period (~2.1ps).

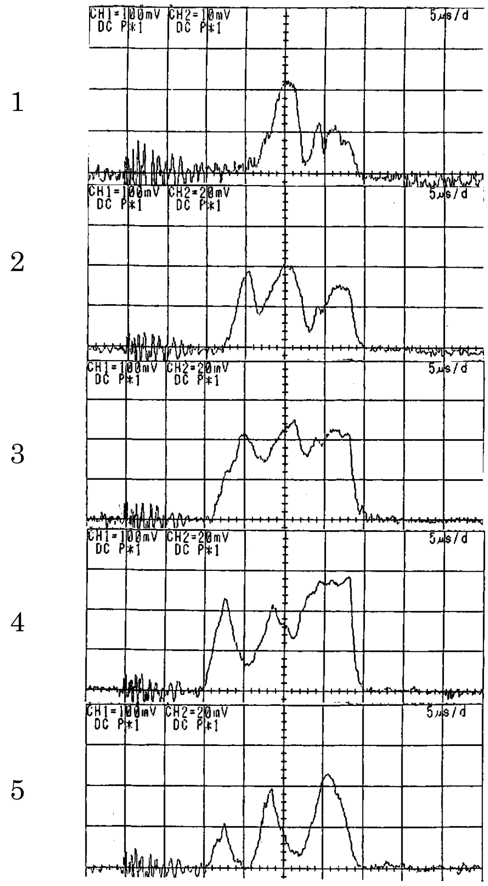

Fig. 2 Pulse evolution of the FEL macropulse due to cavity detuing.

Moreover, the modulations of the macropulse have double structure of 5□s and much shorter period. The 5□s period modulation is observed in all time structure corresponding to the cavity detuning. The modulation is unknown but is independent with the cavity detuning. The shorter period modulation, which is not clearer than the former modulation, is depended on the detuning length described in Fig. 3.

The LANL group reported that side-band oscillation which is decided in the following equation.

$$\tau = \frac{N \cdot \lambda}{2 \cdot \delta L} \cdot \frac{2L_c}{c}$$

Here τ is oscillation period of the side-band, N is the number of undulator period, λ is the FEL wavelength, δL is the detuning length (δL=0 when the FEL power is maximum.) and Lc is the cavity length. Fig.3 indicates our experimental results and the calculated oscillation period.

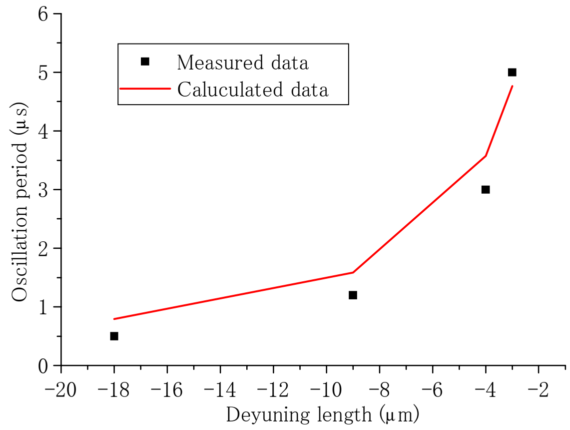

Fig. 3 Oscillation periods of the FEL macropulse of the side-band as a function of cavity detuning length.

4. Conclusion

We have discussed the shape evolution of the FELI FEL macropulse due to the cavity detuning. We found both the frequency modulation and the amplitude modulation are strongly dependent with the laser cavity detuning. The oscillation period of the amplitude modulation is good agreement with the calculated data. Further measurement of the miropulse duration will more clearly explains the phenomena.

References

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