Isolated terawatt attosecond X-ray Free Electron Laser
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Abstract: Micro-bunching instability (MBI) is considered as a critical obstacle for the realization of the isolated terawatt attosecond XFEL. To make high a peak current, the distribution of the electron beam in the phase space should be uniform. The micro-bunching instability will twist the distribution which results in very low peak current value. The effect by MBI has been investigated and a proposal is provided to overcome the obstacle. This will pave a way to the realization of a terawatt level, isolated attosecond pulse at X-ray region.

I. Introduction

The simplest method to generate a tera-watt (TW) attosecond X-ray from a single spike current without any optical mirrors or magnetic components in the undulator line has been proposed [1]. However, it was soon recognized that the proposal cannot be realized due to the micro-bunching instability (MBI) of the electron beam. The MBI is unavoidable in the operation of the XFEL. In this presentation, we will propose a method to overcome this MBI to realize the isolated TW attosecond XFEL.

II. TW-as XFEL generation with single spike

The distribution of the electron beam in the phase space is shown in Fig. 1.

![Energy distribution of the electron beam at end of linac in the PAL-XFEL for the two cases of (a) laser heater OFF and (b) laser heater ON with peak laser power of 30 kW.](image)

The distribution in Fig. 1 is too noisy to make a single peak current with a chicane-type bunch compressor. With the distribution, we cannot make high peak current spike. If we try to make high a peak current, the energy spread in the peak current area will be very high.

The current spike generated with Fig. 1(b) is shown in Fig. 2.

![Current spike and energy spread.](image)

As shown in Fig. 2(a) and (b), the energy spread in the peak current spike is too high to get the saturation in the FEL process. We have to decrease the peak current value. However, weak current-spike will give us very low photon power. To solve this situation, we adopt the multi current spike method [2]. In Fig. 3, the multi-current spike generated with the micro-bunching effect is shown.

![Multi-current spike with energy spread.](image)

With the multi-current spikes shown in Fig. 3, we can produce the radiation power of over 1 TW with a pulse duration of less than 100 attoseconds, as shown in Fig. 4.

![Multi-current spike with energy spread.](image)

The peak FEL power is over 1 TW and the pulse duration is only 73.38 as in the FWHM.

III. Summary

The simple method was proposed to overcome the micro-bunching instability, which is a critical problem to realize the TW-as FEL.

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REFERENCES