Recent progress of the femtosecond laser researches at APRI in Korea

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Introduction
Advanced Photonics Research Institute (APRI) has started to build an ultrahigh intensity laser facility from 2003. This facility will be served as an international user facility for Asian and International ultrahigh intensity laser community. By the year of 2009, a Petawatt-class ultrashort laser facility will be established. Followings are some of our recent results of the femtosecond laser researches at APRI.

APRI 25-TW laser system
Currently, a 25-TW, 30-fs Ti:sapphire laser system including a multi-purpose target chamber is established. Using this laser facility, x-ray generation, electron and ion acceleration experiments are scheduled in this year. In this talk, the performance of the 25TW laser system, the target chamber, and the plans for the power upgrade of the facility will be presented.

Fig. 1. Output pulse width and contrast ratio of the system

A mirror dispersion controlled sub-10 femtosecond laser oscillator
The generation of light pulses in the few-optical-cycle regime promises to be a powerful tool for many advanced applications, such as time-resolved spectroscopy, optical coherence tomography, and nonlinear X-ray optics. We constructed a high average power, stable, compact and sub-10 femtosecond Ti:sapphire laser oscillator without intra-cavity prism pair. An average output power of 560 mW at 5.6 W pump power, amplitude jittering of 0.05%, and pulse duration of 8.5 fs were obtained.

Fig. 2 Autocorrelation signal and Wigner distribution of sub-10 fs laser oscillator

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Carrier envelope phase locking by the direct locking method in the time-domain

In the few-cycle regime, the phase difference between the carrier wave and its pulse envelope, called the carrier-envelope phase (CEP) is an important parameter of the laser pulse. We demonstrated the carrier envelope phase locking by use of a novel phase-locked loop method operating in the time-domain. By adopting appropriate waveplates and polarizers in the two homodyne detection arms, we could eliminate the fluctuation noise and locked the absolute phase within the phase jitter of 0.37 rad.

![Fig. 3 CEP stabilization using the direct locking method.](image)

Single subattosecond pulse generation from few-cycle laser driven electrons

Development of femtosecond lasers also triggered the opening of a new era of scientific researches in the attosecond regime, facilitated by the attosecond pulses generated by the interaction between high-intensity femtosecond lasers and matter. We propose an alternative way based on the relativistic nonlinear Thomson scattering of high-intensity few-cycle lasers by electrons. The interaction between a free electron and a high-intensity laser serves as a basic physical process wherein fundamental light-matter interaction can be studied. We show that, for the case of laser pulses in the few-cycle regime, when a proper detection angle is selected, isolated single pulses can be generated and their pulse duration can be shorter than 1 attosecond for certain laser parameters.

![Fig.4 Radiation power as a function of time for a circularly polarized, 5 fs laser pulse with intensity $2\times10^{20}$ W/cm$^2$ and carrier envelope phase (a) $-\pi/2$ and (b) $\pi/2$, observed in the direction $\theta=16^\circ$ and $\phi=0$.](image)