UV Temporal Profile Measurement and Manipulation at the 100 fs Timescale

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Outline

- Cross-correlation technique
- First measurements of UV pulse width
- Technique improvements
- Femtosecond UV pulse shaping approaches
  - Temporal pulse clipper
  - Adaptative UV pulse shaping with micromirror arrays
- Conclusions
Investigation of beam quality due to laser pulse-shape using PARMELA

\[ \lambda = 2 \cdot \lambda_{\text{cutoff}} \]

"Flattop"

\[ \lambda = \lambda_{\text{cutoff}} / 2 \]

"Gaussian"
PARMELA results for the interaction point

**Near-Ideal**

For $\sigma_r = 1.0$ mm and $\sigma_{r_{cut}} = 0.5$ mm

and $\sigma_t = 0.8$ ps and $\sigma_{t_{cut}} = 0.4$ ps:

$X_{\text{min}} = 16.6$ mm at 211.1 cm

$Y_{\text{min}} = 10.4$ mm at 211.4 cm

$\sigma_x = 0.74$ pi-mm mR

$\sigma_y = 0.76$ pi-mm-mR

**Gaussian**

For $\sigma_r = 0.25$ mm and $\sigma_{r_{cut}} = 0.5$ mm

and $\sigma_t = 0.2$ ps and $\sigma_{t_{cut}} = 0.4$ ps:

$X_{\text{min}} = 25.9$ mm at 215.4 cm

$Y_{\text{min}} = 19.3$ mm at 214.0 cm

$\sigma_x = 1.1$ pi-mm mR

$\sigma_y = 1.1$ pi-mm-mR
Why cross-correlation….

UV temporal profile for a flat top pulse has a high degree of complexity, which makes it unsuitable for analysis by many techniques (FROG, Single Shot Autocorrelation, SPIDER, etc.)

$$\text{Complexity} = \frac{\text{Duration}}{\text{Detail}} \geq 10$$
Basic Concept

- A well characterized ultrashort IR pulse is mixed with a longer, unknown UV pulse
- Asymmetric UV pulses may be characterized by recording during one scanning delay direction only
- A spectrogram may be inferred from spectral measurements of the correlation signal at different delays
Scanning cross-correlation device overview
Single-shot autocorrelation measures IR pulsewidth

1 mJ, 800 nm @ 1 kHz

2nd Harmonic Intensity (a.u.)

Delay (a.u.)

47 fs
UV Pulse Width Measurement

UV Crosscorrelation 10% conversion efficiency

FWHM = 37.2 fs
Pulse width measurement after 1.5 cm fused silica

Broadening from 1.5 cm Fused Silica

- Measured values
- Theoretical broadened

Calculated FWHM = 418 fs
Measured FWHM = 383 fs
Tilt and vertical displacement enable piecewise linear spatial phase modulation while retaining capability to produce discontinuities for pulse shaping applications. Like a spatial light modulator based pulse shaper, there is no net spatial beam steering.
Stepped Pixel vs. Piecewise Linear SLPM (Quadratic Phase Modulation)
Micromirror array design layout

Four micromirrors with both tilt and vertical motion

Folded Spring

Upper Actuator

Stationary Mirror

Movable Comb Teeth

Lower Actuator

Movable Mirror
SEM images of micromirror array
Conclusions

• We have demonstrated the ability to measure UV pulse widths at a resolution of 100 fs using a scanning cross-correlation technique

• MEMS Micromirror arrays may be a promising solution to pulse shaping in the ultraviolet

• A fixed amplitude mask UV “pulse clipper” will be implemented in the short term while larger arrays of micromirrors are developed

• Both high damage threshold UV coatings for the micromirrors as well as high efficiency UV gratings will be needed
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