Shaping triangular picosecond laser pulses for electron photoinjectors

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Outline

- Motivation for pulse shaping activity
- Theoretical model and results of numerical simulations
- Experimental results: achievements and drawbacks
- Conclusion

Motivation for laser pulse shaping at photoinjector

- Active control of parameters of generated electron bunches: emittance, distribution of spatial charge: shape and duration;
- Development new methods for control of laser pulse intensity distribution at ps region;
- Improvement of laser pulse and beam quality;
- Development new methods for laser beam diagnostics;

Intermediate outcome of the activity is a formation of cylindrical and ellipsoidal laser pulses

Formation triangular pulses: idea

For linearly chirped pulses at $T_{\text{pulse}} \gg T_{\text{fourier}}$

$$|A(t)|^2 \propto |S(\Omega)|^2 \quad \Omega \propto t$$

Control at frequency domain **linearly** corresponds to control at time

For formation triangular laser pulses it is necessary producing triangular spectral intensity distribution

Spectral shaper

SLM: Spatial Light Modulator

$$S_{\text{req}}(\Omega) = M(\Omega) \cdot S_{\text{in}}(\Omega) \xrightarrow{\text{FT}} A_{\text{req}}(t)$$

Optimal spectrum cutting

If $T/TF \sim 90$ The sharp spectral intensity distribution is a reason for oscillation on temporal shape

Optimal energy conversion is about 52%

The smoothed spectral masks can be used for minimizing oscillations on the temporal shape

The smoothed spectral mask

FIG.3. Initial spectrum and spectral distribution in the form of a smoothed triangle with $2N=6$ and $\delta\lambda/\Delta\lambda=0.1$ obtained from it (a), and temporal intensity distribution for unshaped spectral distribution and smoothed triangular distribution ($S \approx 210$) for $\delta\lambda/\Delta\lambda=0.1$, $2N=6$ (b), $\delta\lambda/\Delta\lambda=0.05$, $2N=8$ (c), $\delta\lambda/\Delta\lambda=0.17$, $2N=10$ (d)

FIG.4. Curves for PV versus $\delta\lambda/\Delta\lambda$ (a) and $\delta\tau/\tau$ versus $\delta\lambda/\Delta\lambda$ (b) when using super-Gaussian sections with $2N=4, 6, 8, 10, 12$.

Experimental setup

Spectral shaper

Experimental results

Spectral intensity distributions

Temporal intensity distribution

model

experiment

1ps-period intensity oscillations: pure spectral effect in SLM

→ The term explain the oscillations

The probable physical reason is dispersion of refractive index of liquid crystals

Conclusion

- We have demonstrated experimental implementation of picosecond chirped laser pulses with quasi-triangular intensity distribution in time.
- Shaping of quasi-triangular intensity distribution has been analyzed numerically, its basic principles and conditions for their optimal realization have been determined.
- We have revealed periodic distortions of the temporal intensity distribution profile at different experimental conditions associated with the SLM matrix. Such distortions are, evidently, caused by the molecular response of the NLCs used in the modulator to the laser radiation field.

Update of laser driver for electron photo injector at IAP RAS