Simulation of interaction of the femtosecond laser pulses with chirped mirror

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Outline

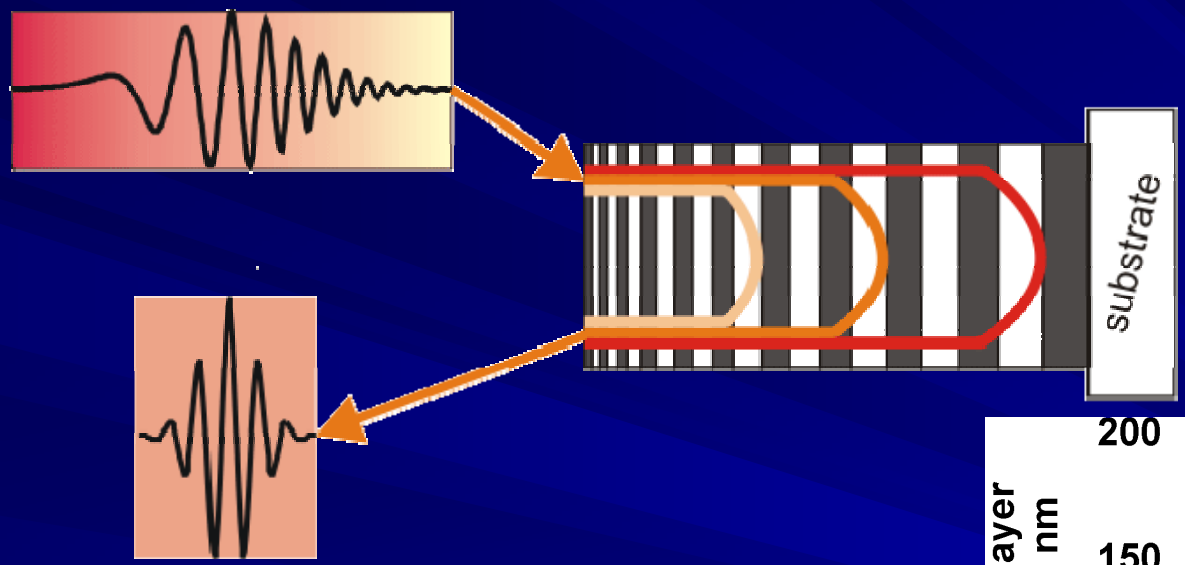
- Introduction
- Model description
- Result discussion
- Conclusion

Chirped Mirrors and femtosecond generation

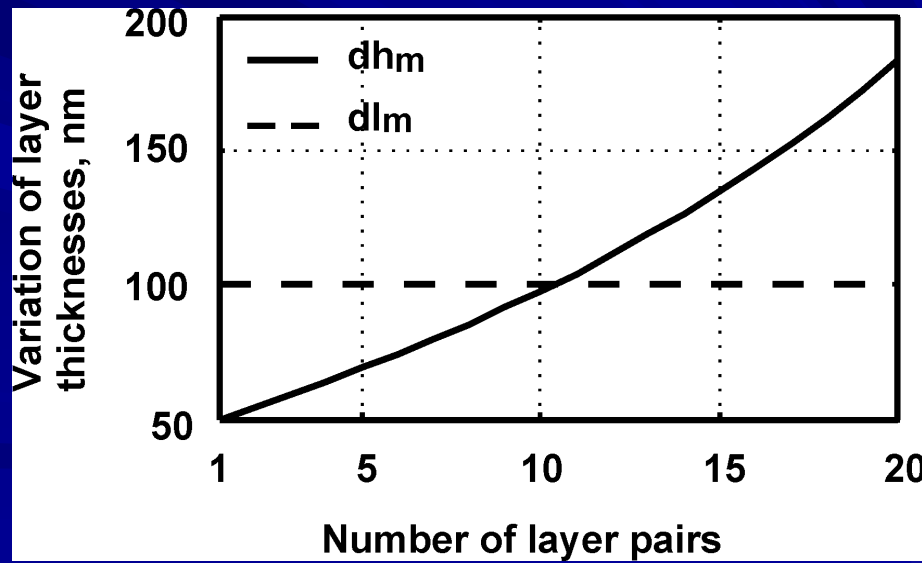
- Dispersion effect is one of the limiting factor of ultrafast generation
- Chirped mirrors permit to control the net intracavity dispersion
- The goal of design methods is to obtain structure for optimal dispersion compensation

Chirped mirrors and pulse compression

SiO_2/TiO_2

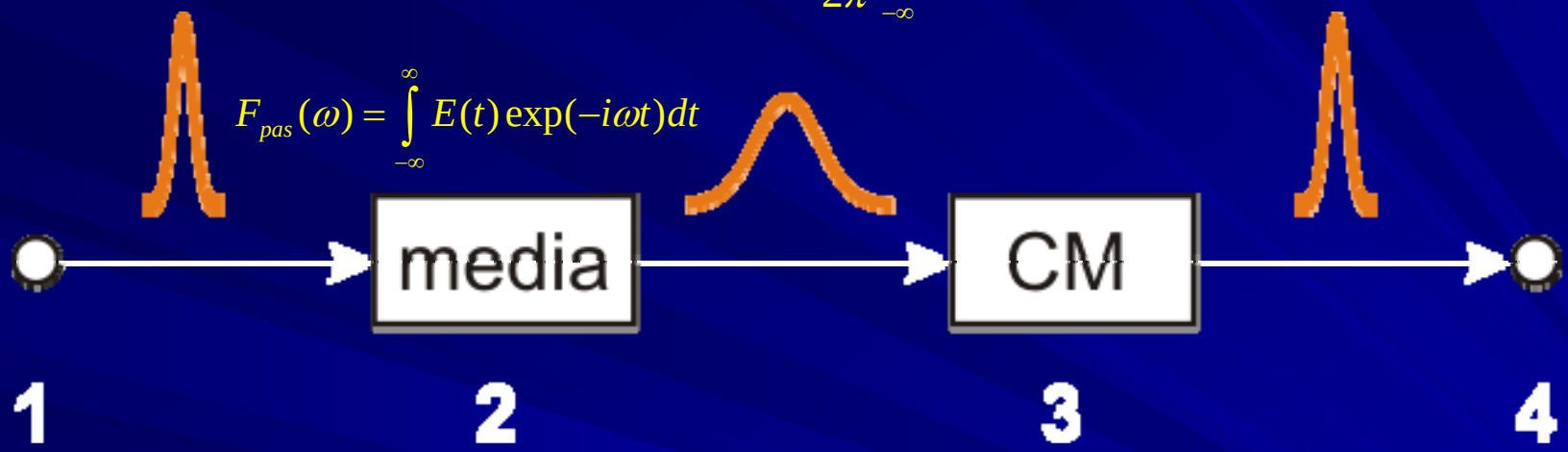


$n_l = 1.5 \quad n_h = 2.5$



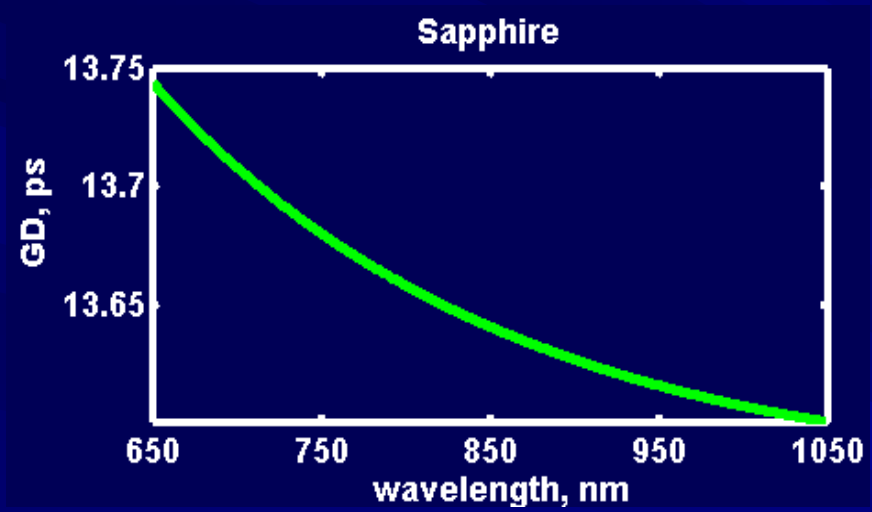
Model's description

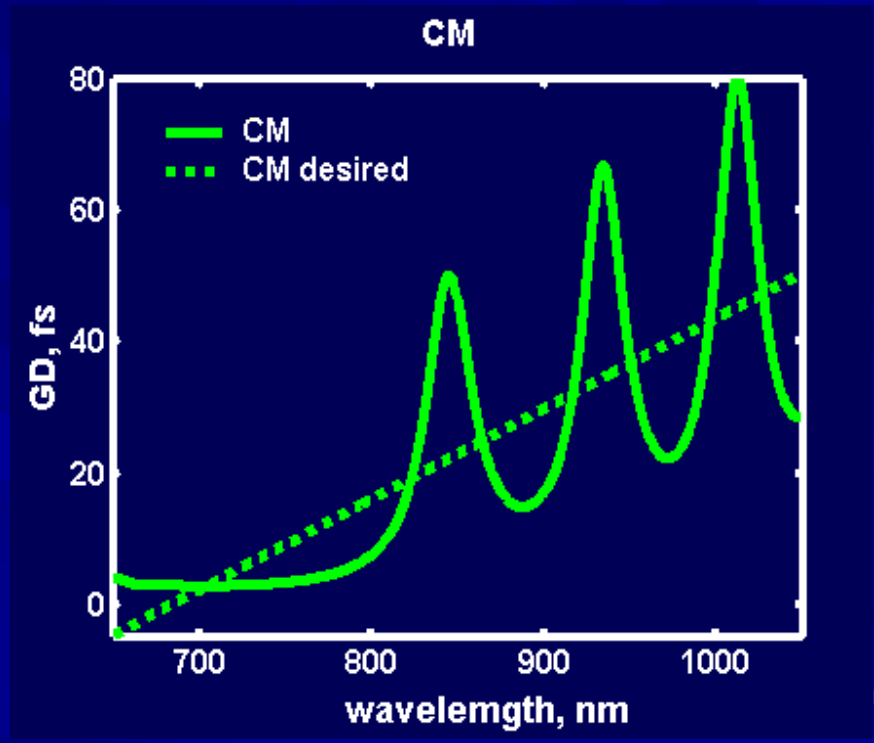
$$E_{pas}(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} F_{pas}(\omega)\exp(i\omega t)\exp[-i\varphi(\omega)]d\omega$$



1. **Input transform limited pulse** $E(t) = E_0 \exp\left(-2\ln 2\frac{t^2}{\tau_0^{\,2}}\right)\exp\left(i\omega_0 t\right)$
2. **Broadened pulse (chirp) (Sellmeier equation)** $\varphi(\omega) = \frac{\omega n(\omega) L_m}{c}$
3. **Chirped mirror reflectivity (Transfer matrix eq)** $r_M = \sqrt{R}\exp(i\Phi)$
4. **Compressed pulse after reflection** $E_{ref}(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} F_{pas}(\omega)\exp(i\omega t)\cdot r_M(\omega)d\omega$

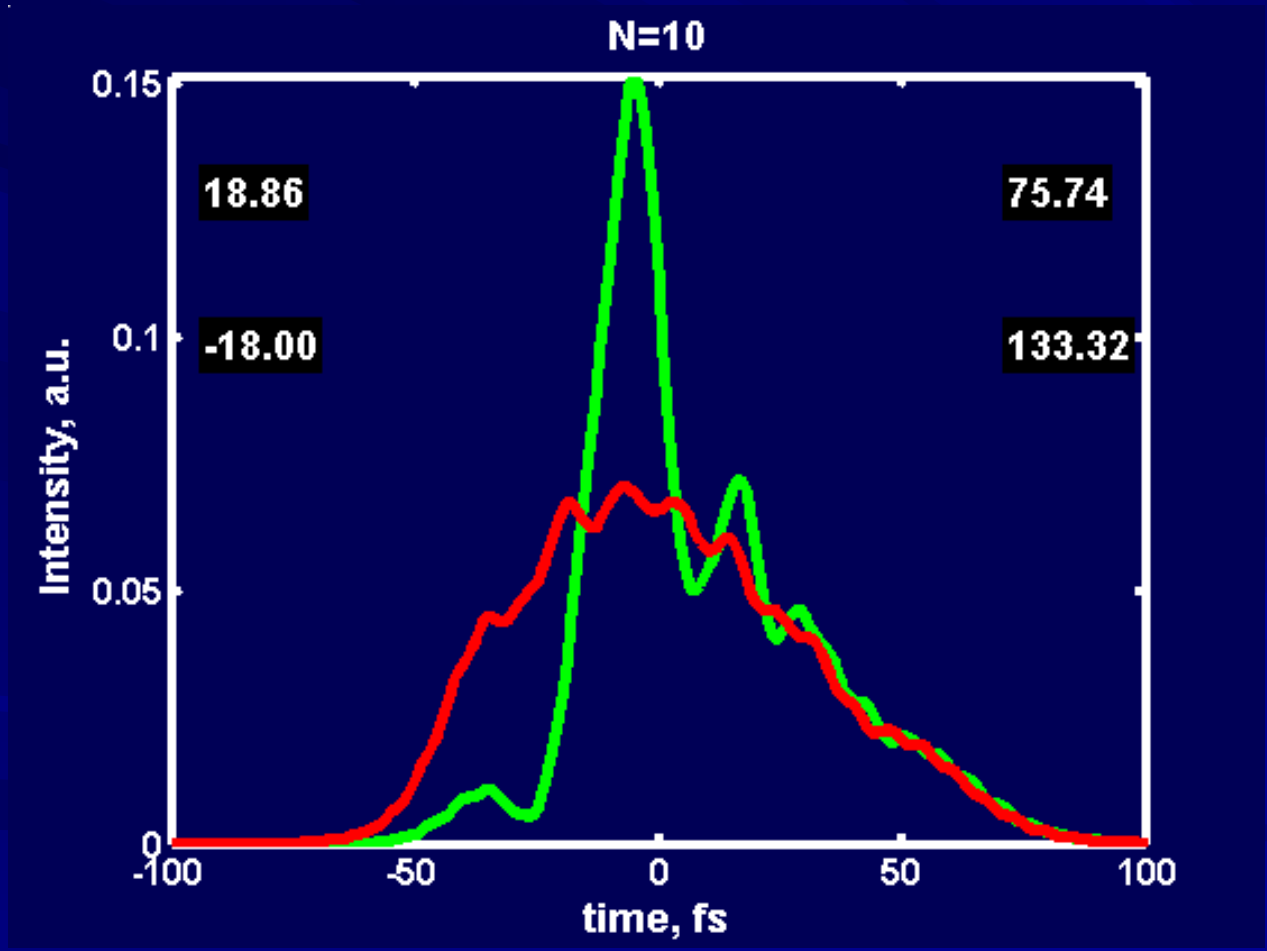
Dispersion compensation





$$GD(\omega) = \frac{d\varphi(\omega)}{d\omega}$$

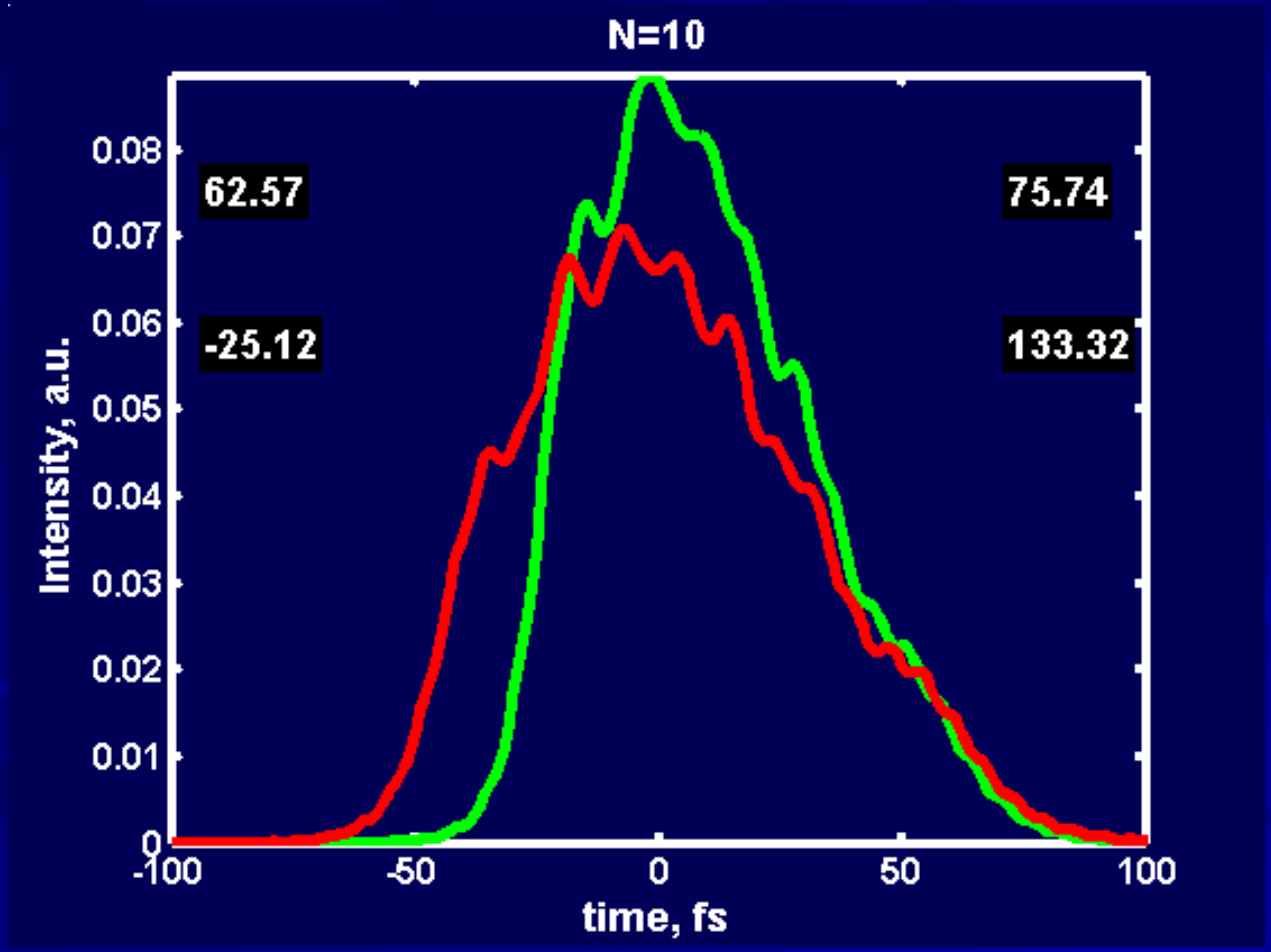
Pulse compression in CM with GD oscillations



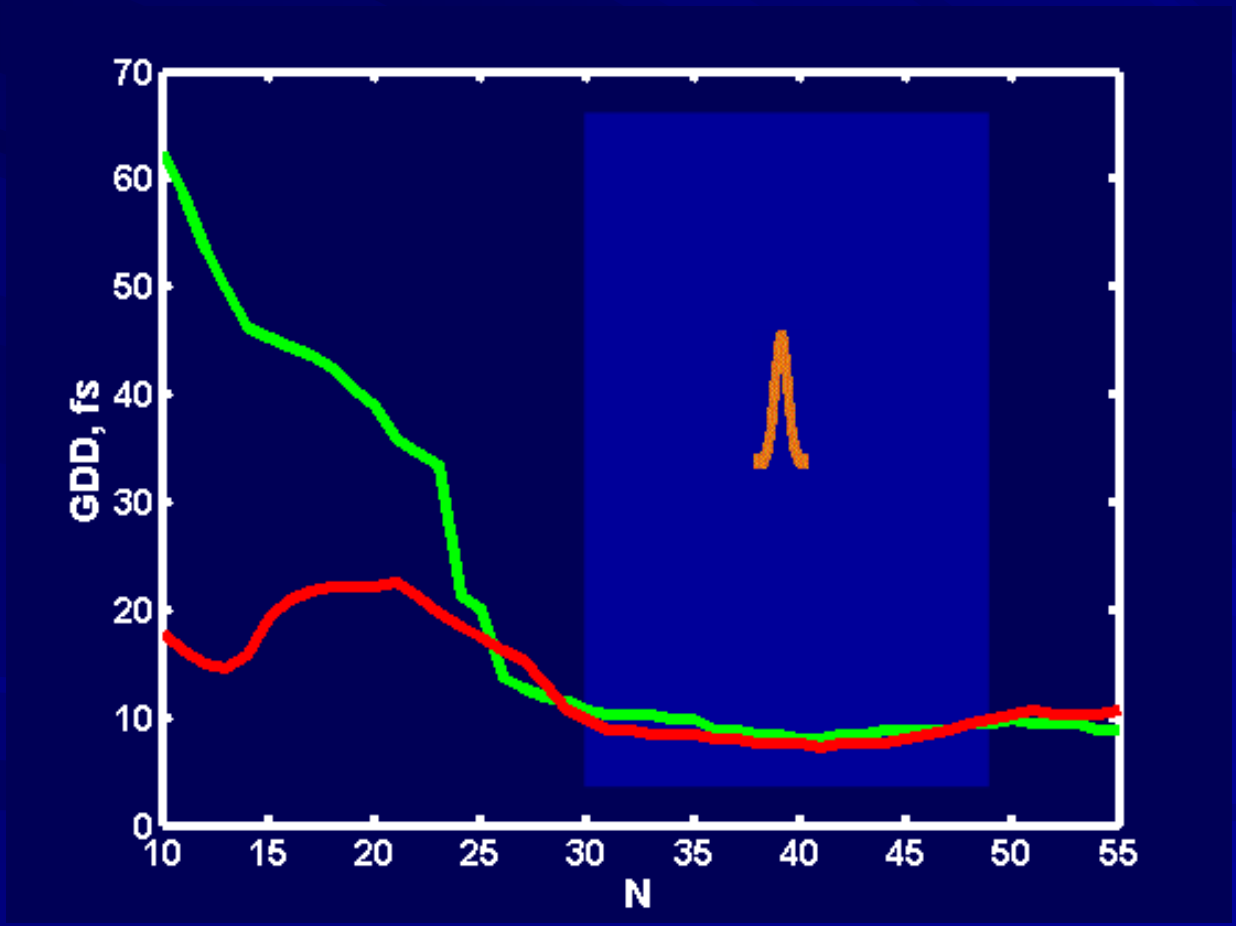
broadened pulse

compressed pulse

Pulse compression in CM with desired GD



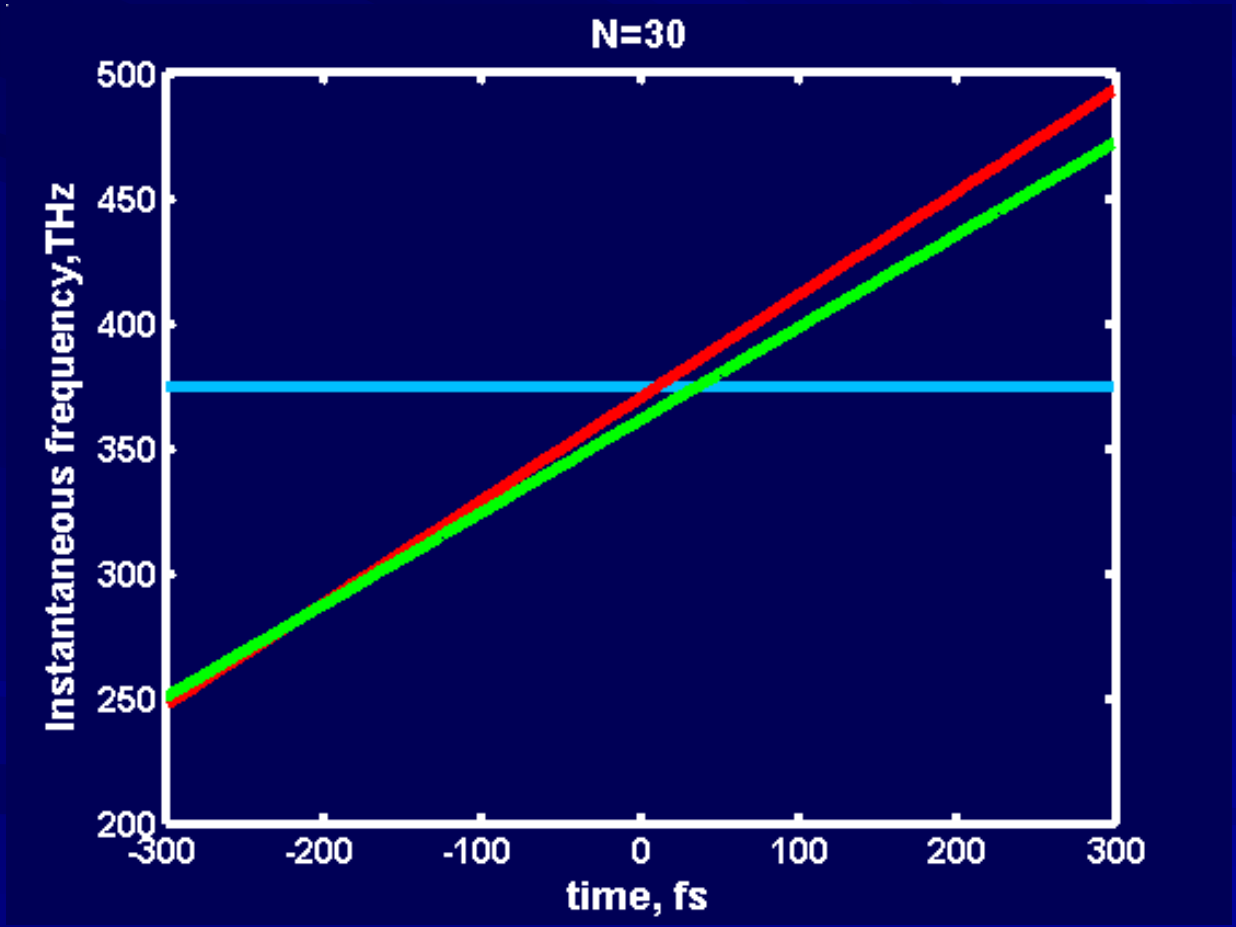
Pulse compression stages



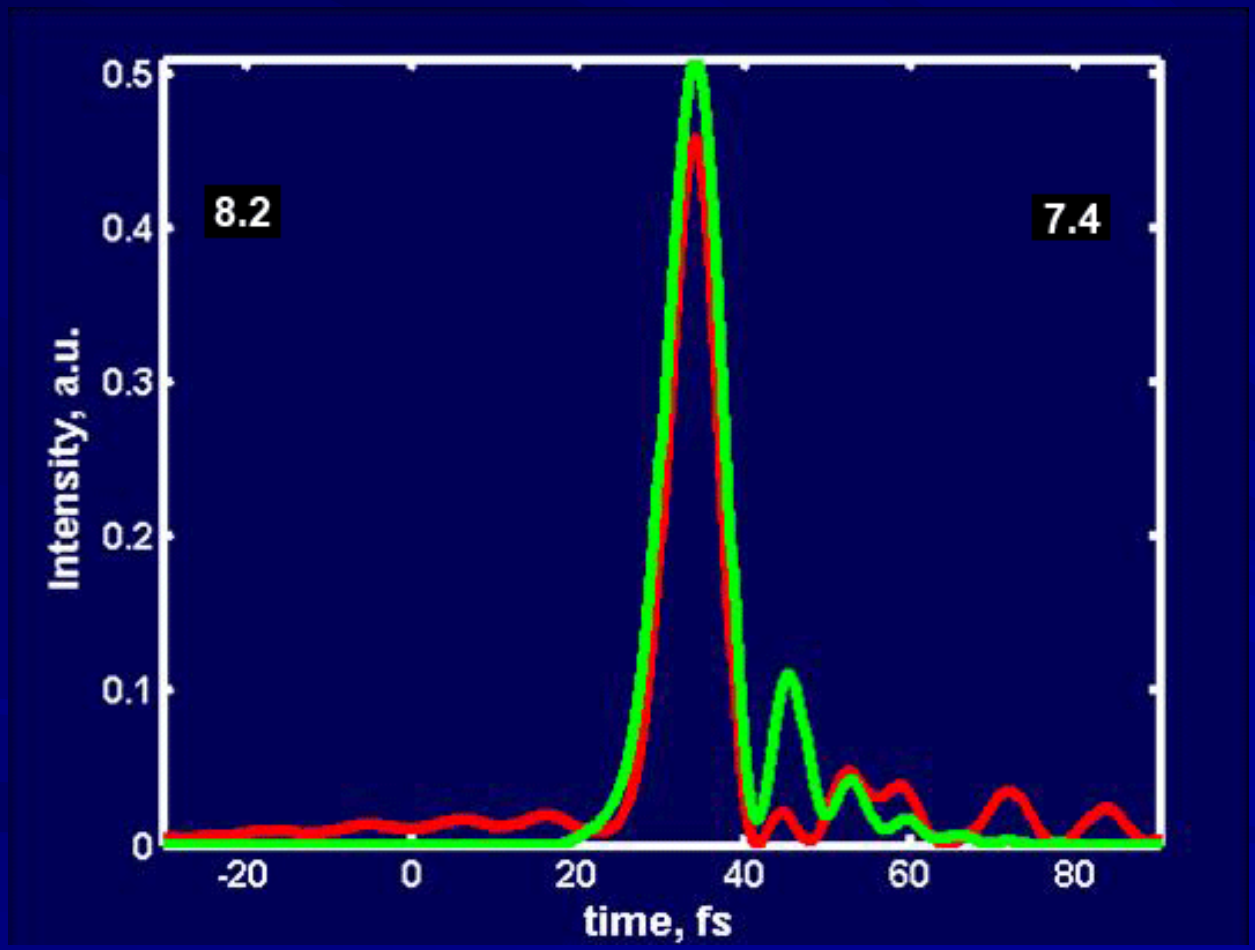
compression in CM with GD oscillatons

compression in CM with desired GD

Chirp compression



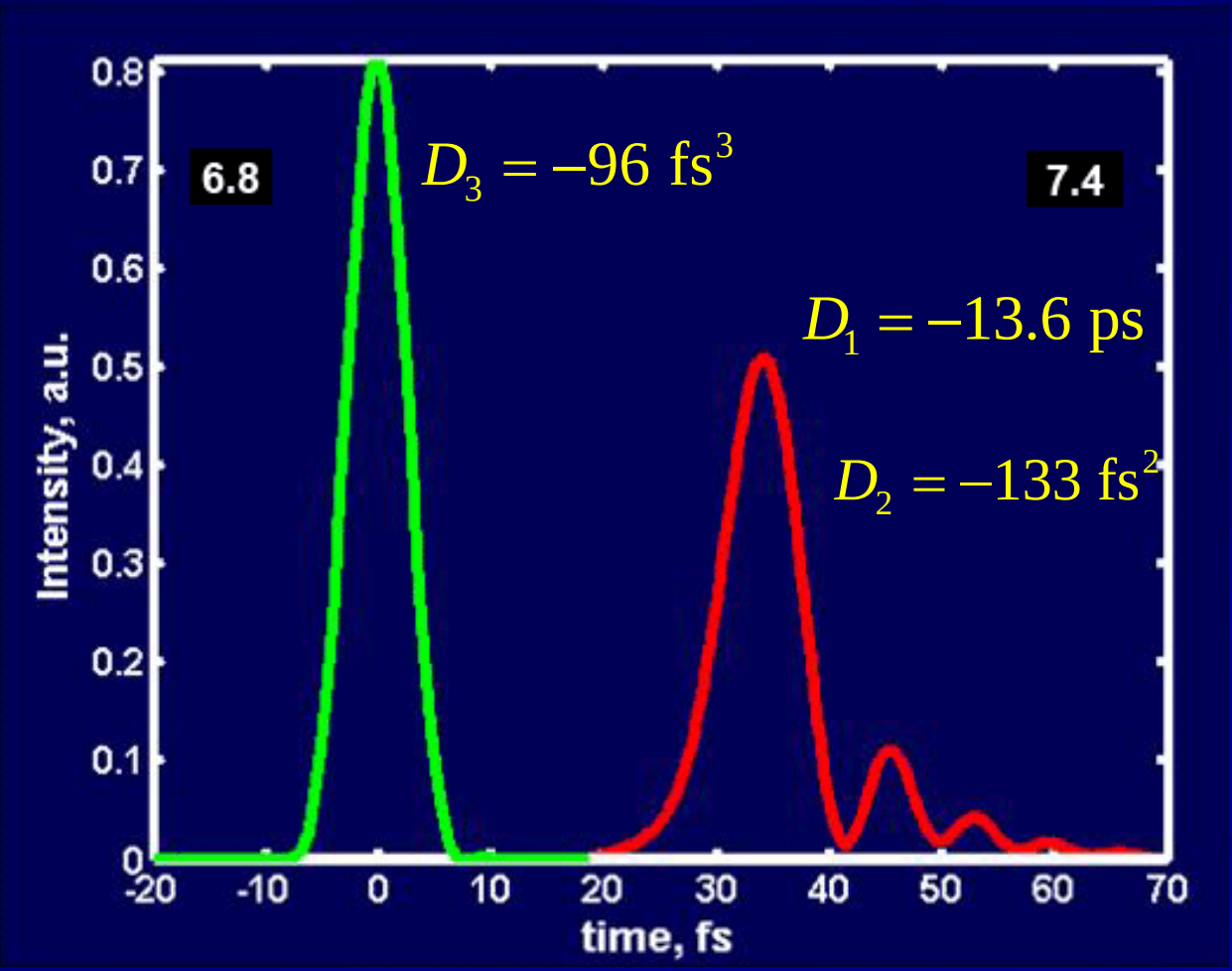
GD oscillations distort pulse profile



compressed pulse in CM with GD oscillatons

compressed pulse in CM with desired GD

TOD compensation



Phase shift

$$\phi(\omega) = \phi(\omega_0) + D_1 \cdot (\omega - \omega_0) + \sum_{n=2}^{\infty} \frac{1}{n!} D_n (\omega - \omega_0)^n$$

- compressed pulse in CM with desired GD
- compressed pulse with compensated TOD

Conclusions

- The model of interaction of femtosecond laser pulses with chirped mirror is developed
- Developed model allows improving chirped mirror design with purpose of obtaining better reflected pulse quality.
- It was revealed the reflected pulse profile drawbacks caused by chirped mirror design imperfection and the way to eliminate it.