Supercontinuum generation in a nonlinear optical fiber

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Goals

Explore spectral supercontinuum generation via propagation of ultrashort laser pulses in a nonlinear medium

Supercontinuum – intense spectral broadening of light

→ governed by Generalized NonLinear Schrodinger Equation (GNLSE)[1]

Disperive effects: Group velocity dispersion (GVD), Third order dispersion (TOD)

Nonlinear effects: Selfphase modulation, Self steepening, Raman scattering

$$\frac{\partial u}{\partial z} + \frac{i\beta_2}{2}\frac{\partial^2 u}{\partial \tau^2} - \frac{\beta_3}{6}\frac{\partial^3 u}{\partial \tau^3} = i\gamma\left[|u|^2 u + \frac{i}{\omega_0}\frac{\partial}{\partial \tau}(|u|^2 u) - T_R u \frac{\partial |u|^2}{\partial \tau}\right] \quad (1)$$

→ u- pulse envelope

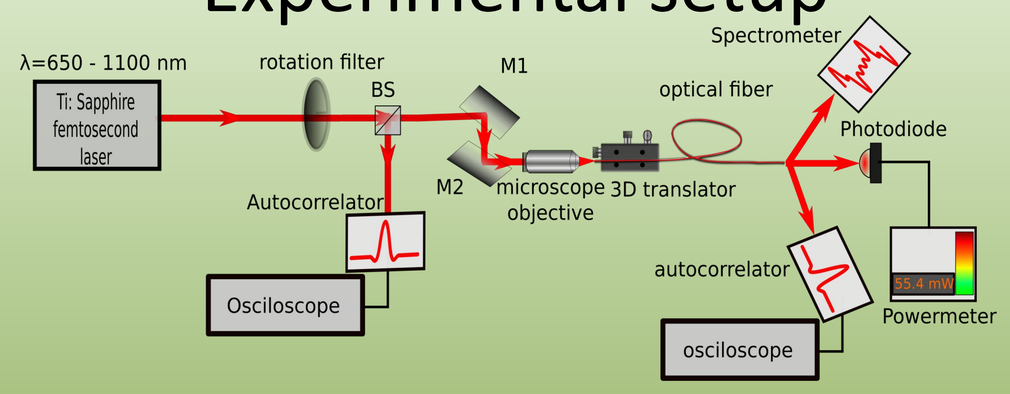
→ β_i- Taylor coeffiecients of propagation constant β(ω)

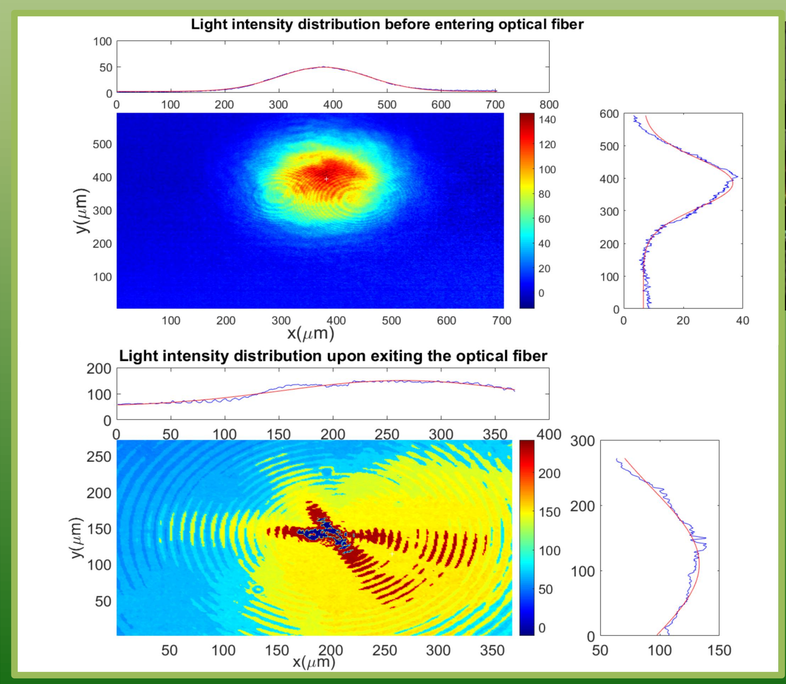
→ γ- nonlinear coeffiecient

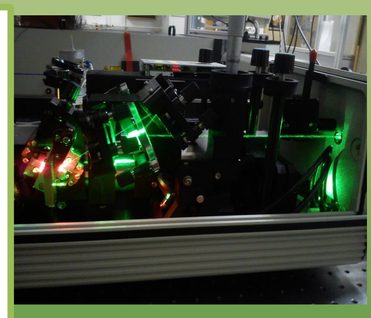
Behaviour of supercontinuum is examined against:

- Pulse average power
- Pulse wavelength
- Pulse width

Experimental setup





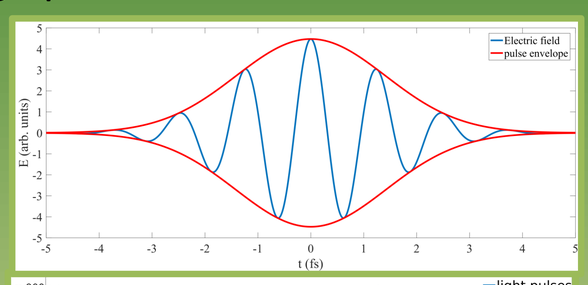


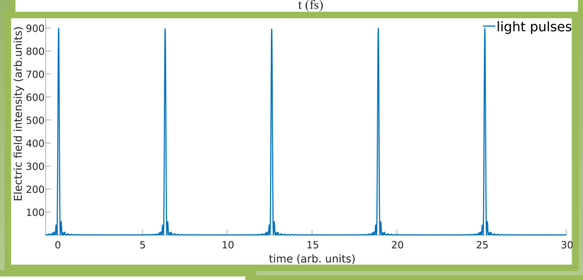
Femtosecond pulses

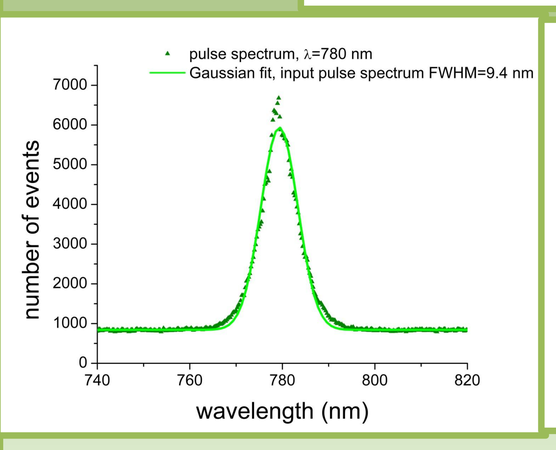
→ generated via mode-locking technique in a femtosecond pulse laser[2]

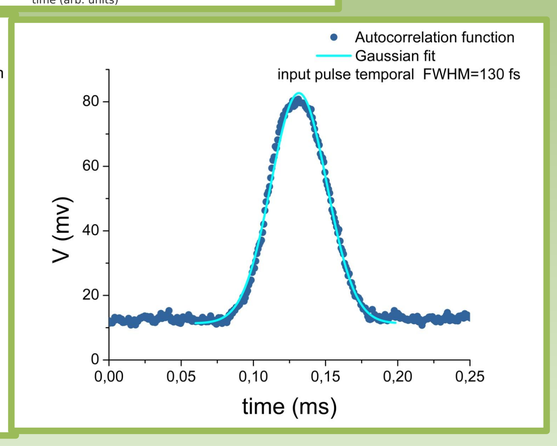
Pulse parameters:

- Wavelength
- Pulse width (extracted from autocorrelation function)
- Pulse average power

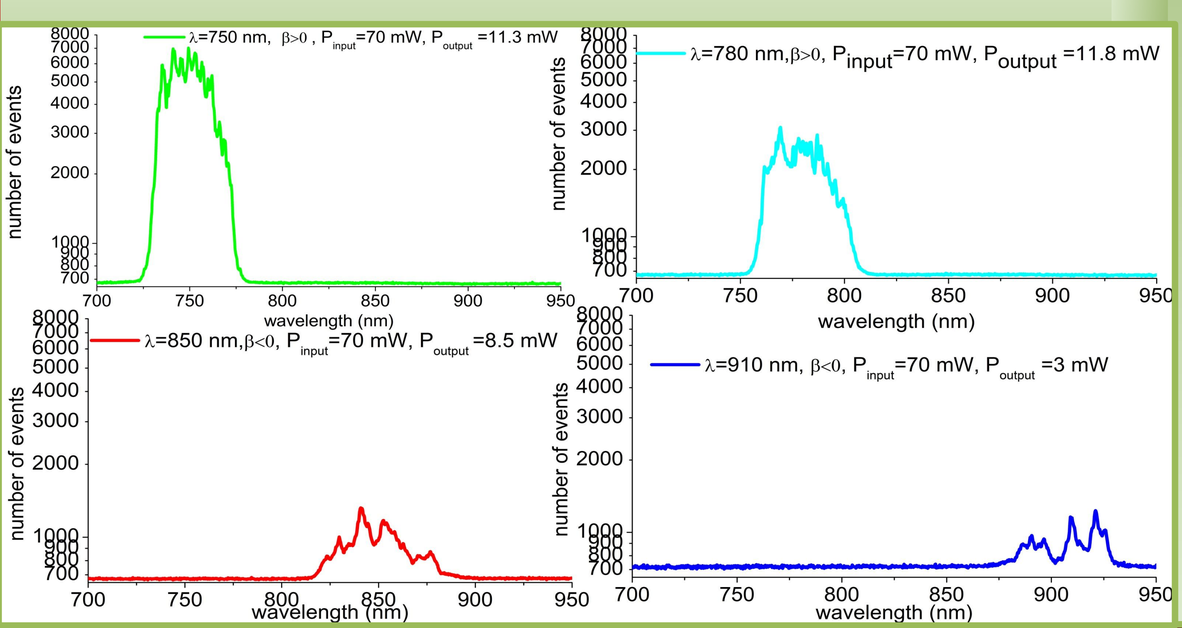






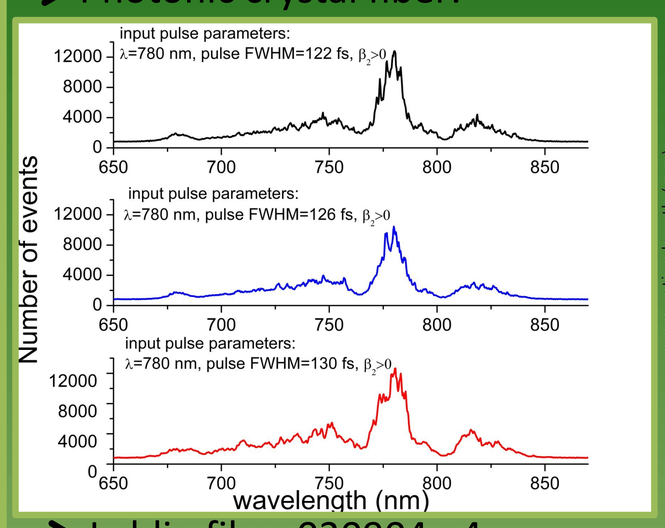


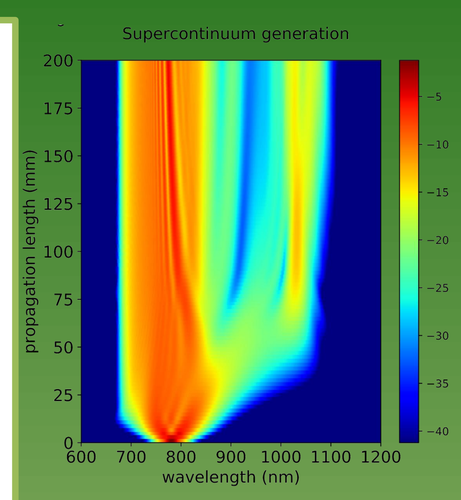
→ Supercontinuum behaviour for $\beta_2>0$ and $\beta_2<0$



Experimental results and numerical simulations

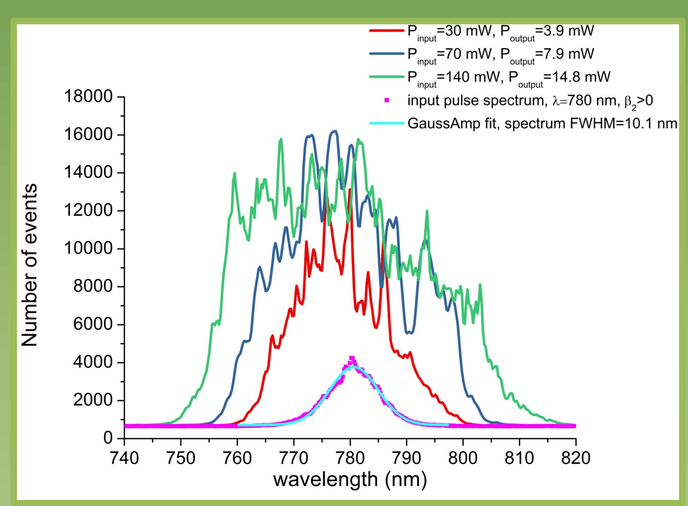
→ Photonic crystal fiber:

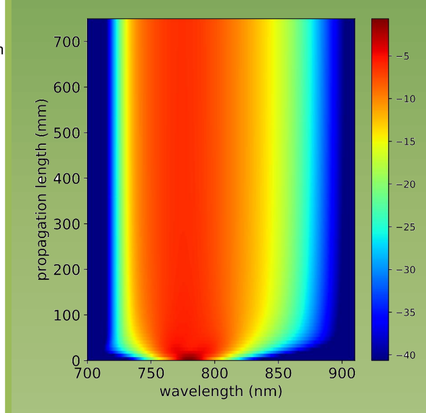




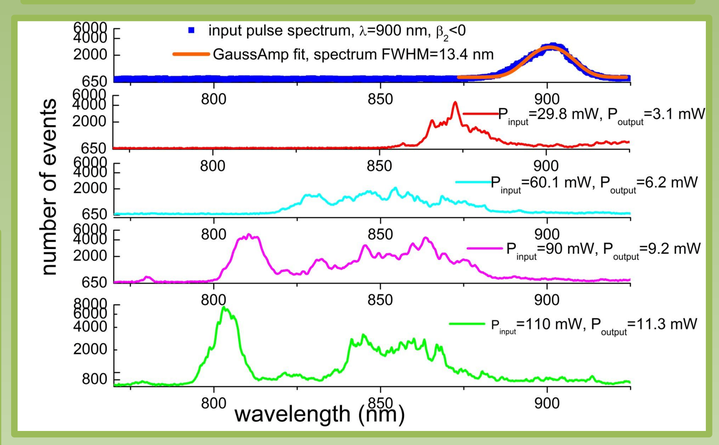
simulation parameters:
input pulse FWHM= 130 fs
input pulse λ= 780 nm
pulse avg. power= 70 mW
β_2=8 ps^2/km
β_3=0.05 ps^3/km
γ=50 (Wkm)$^{-1}$
fiber length L=200 mm

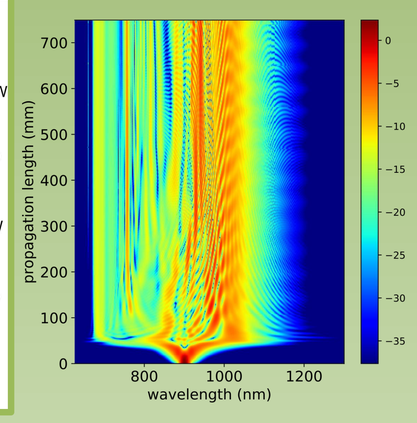
→ Lublin fiber 030904 p4:





simulation parameters:
input pulse FWHM= 130 fs
input pulse λ= 780 nm
pulse avg. power= 70 mW
β_2=15 ps^2/km
β_3=0.05 ps^3/km
γ=10 (Wkm)$^{-1}$
fiber length L=750 mm





simulation parameters:
input pulse FWHM= 186 fs
input pulse λ= 900 nm
pulse avg. power= 60 mW
β_2=-5 ps^2/km
β_3=0.05 ps^3/km
γ=50 (Wkm)$^{-1}$
fiber length L=750 mm

References:
[1] Nonlinear Fiber Optics, Govind P. Agrawal
[2] Femtosecond Optical Frequency Comb: Principle, Operation, and Applications, Jun Ye and Steven T. Cundiff