Laser & Applications

Dispesion effect

Exercises' sheet No 3 June 2017

Exercise 1 *Short pulse propagating in fused silica*

Let us consider a 10 fs pulse from a Ti :Sa laser entering a plate of fused silica. The plate has a thickness of 1 mm. For simplicity the pulses is considered Gaussian and does not have any chirp. Considering that the GDD of fused silica at $\lambda = 800$ nm is 36.16 fs^2 calculate the pulse broadening at the output of the plate sue to dispersion.

Exercise 2 *broadening by self-phase modulation*

The self-phase modulation (SPM) is the result of the nonlinear Kerr effect that is described mathematically by

$$n = n_0 + n_2 I \tag{1}$$

where n_0 is the linear refractive index, n_2 the nonlinear one and I the intensity of the beam.

1. Show that the maximum spectral broadening due to SPM after a propagation over a distance L in a crystal with Kerr nonlinearity is

$$\Delta\omega_{\max} = \omega_{\max} - \omega_0 \simeq 0.86 \frac{n_2 \omega_0 I_0 L}{c\tau_0} \tag{2}$$

   where ω_0 is the central frequency of the pulse spectrum. We assume for this that the nonlinear medium does not yield any linear dispersion. Moreover the pulse is considered Gaussian

$$I(t) = I_0 \exp\left(\frac{-t^2}{\tau_0^2}\right) \tag{3}$$

2. Using the expression of $\Delta\omega_{rmmax.}$ calculate the spectral broadening of a 20 fs long pulse, 40 μJ energy, Gaussian pulse centered at $\lambda = 800$ nm, propagating in a capillary filled with 0.4 bar of Argon gas. The capillary is 60 cm and has an inner radius $a = 80$ μm.. We assume that the beam inside the capillary has a uniform intensity profile with an effective area $A_{\text{eff}} = \pi w^2$, where $w = 2a/3$ is the spot size of the laser. The nonlinear refractive index of argon is $(n_2/p) = 9.8 \times 10^{-24} \text{m}^2/(\text{W}\cdot\text{bar})$

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