Nonlinear Optics — Homework 2

Due Monday, February 12, 2024

Polarization gate

Other than the polarization gate using a multiple order $\lambda/4$ wave plate plus a zero order $\lambda/4$ wave plate that we discussed in the class, another version will be a multiple order full λ wave plate plus a zero order $\lambda/4$ wave plate.

Start with an electric field of

$$E(t) = 2\mathcal{E}(t)\cos(\omega t) \tag{1}$$

$\mathcal{E}(t)$ is the envelope of the ultra shot pulse. Assume that the envelope has a Gaussian shape, i.e.

$$\mathcal{E}(t) = E_0 e^{\frac{-t^2}{t_p^2}} \tag{2}$$

$\tau_p = 5$ fs is the pulse width.

1. The electric field is first incident on a multiple full wave plate with its polarization axis at 45^o with respect to the fast axis of the wave plate. Describe the electric field in time and plot its time dependent polarization angle, assuming the wave plate introduces a group delay of 6.2 fs between its e and o component at the central wavelength of the input pulse.

The derivation is similar to the one made in class, except that the full wave plate gives a phase retardation of 2π. Derive an expression for the electric field after the wave plate, showing that, after the wave plate, the pulse is linearly polarized pulse with time dependent polarization angle θ with respect to the axis $\hat{j}$ (i.e. different portions of the pulse in time are polarized at different angles). Find an expression for the angle $\theta(t')$ and plot..

2. A zero order $\lambda/4$ wave plate is placed at an angle θ_2 with respect to the full wave plate. Describe the electric field and its time dependent ellipticity after the $\lambda/4$ wave plate. Plot the ellipticity as function of time at $\theta_2 = 45^o$.

3. Suppose the threshold ellipticity to create the 25th harmonics is 0.12, calculate the polarization gate width.