Tel: +886-3-6662123
www.hcphotonics.com
service@hcphotonics.com

Dispersion:

Q: Group delay dispersion in Lithium Niobate?

A:

Group velocity dispersion is the phenomenon that different wavelength traveling in different group velocity when they transmit into a dispersive medium. Figure 1 illustrates the dispersion of an ultrashort pulse, in which the different frequency components are separated and the entire pulse are stretched.

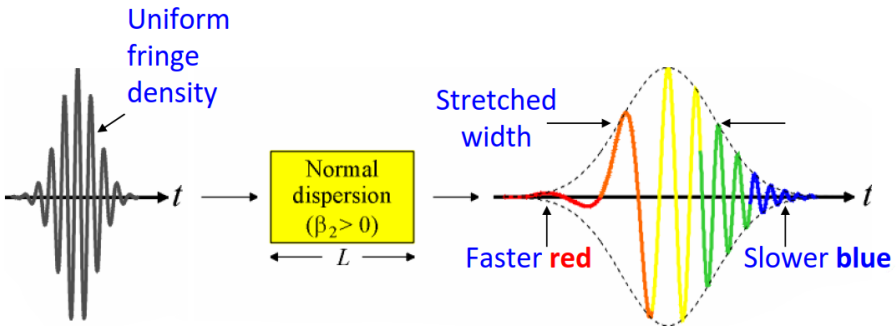

Fig. 1 An illustration of pulse stretching by a dispersive medium.

The effect is insignificant when the length of medium is relatively short or the incident pulse is near monochromatic, but become a serious issue in ultrafast optics. The equation for the group velocity dispersion is shown below [1]:

$$GVD = \frac{d^2k}{d\omega^2}$$

Where k is the wave vector, ω is the angular frequency. The unit of GVD is (s^2/m), which means the group velocity difference per unit time at the specific wavelength.

As figure 1 shows, the wide bandwidth of an ultrashort pulse will result in significant GVD, stretching the entire pulse into a broader pulse. In some applications, people need a way to quantitatively estimate the dispersion and directly estimate the output pulse duration, so one can interpret above GVD formula into another way by:

$$D_\lambda = -\frac{2\pi c}{\lambda^2} \times GVD = -\frac{2\pi c}{\lambda^2}\frac{d^2k}{d\omega^2}$$

The unit of D_λ is usually in ps/nm/km, and the pulse width can be easily estimated by simple multiplication of spectral bandwidth and medium length:

$$t_{out} = D_\lambda \times \Delta\lambda \times L$$

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With the progress of ultrafast technology, people do care the pulse broadening even in a short crystal. In this article we calculate the dispersion in format of GVD and D of the 5% MgO doped lithium niobate, and results are shown below:

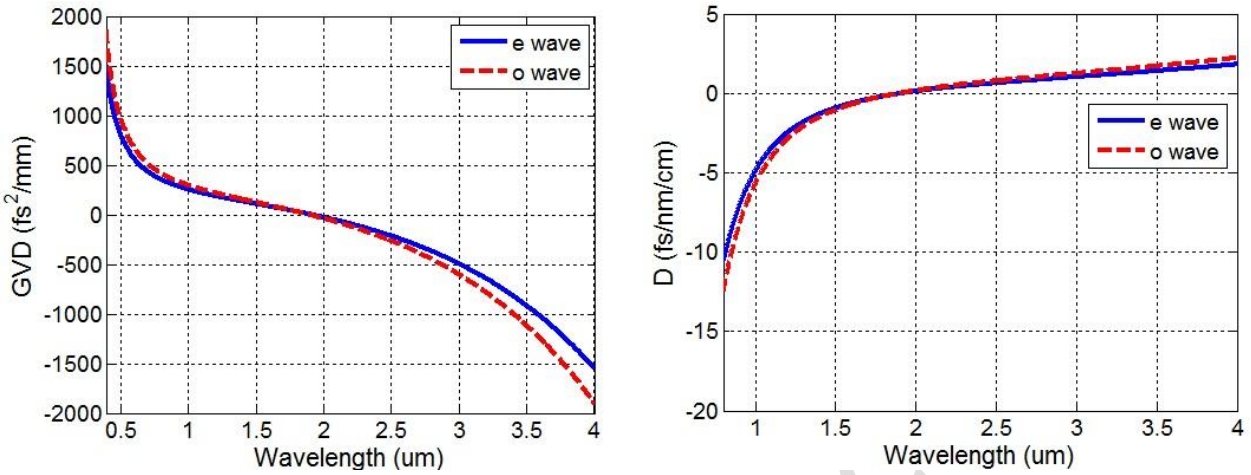

Fig. 2(a) Calculation of group velocity dispersion for lithium niobate via Sellmeier equation [2]. (b) Dispersion parameter D of lithium niobate.

Reference:

[1] RP Photonics. https://www.rp-photonics.com/group_velocity_dispersion.html

[2] Shang-Da Yang (2017 Fall) “Ultrafast Optics” lecture slides.

[3] O. Gayer, Z. Sacks, E. Galun, A. Arie, " Temperature and wavelength dependent refractive index equations for MgO-doped congruent and stoichiometric $LiNbO_3$" Appl. Phys. B: Lasers Opt. **91**, 343 (2008)