第九次习题课：Interference in Optics

This part contains subjects on superposition of waves, interference (2 beam interference)

1. Superposition of waves

（1）Hecht's problem 7.29

An ionized gas or plasma is a dispersive medium for EM-waves. Given that the dispersion equation is

$$\omega^2 = \omega_p^2 + c^2 k^2$$

where w_p is the constant plasma frequency, determine expressions for both the phase and group velocities and show that $vv_g = c^2$.

（2）Given a Femto-second (10^{-15} s) laser pulse, (i.e. the duration of pulse in time, or temporal width) estimate its spectral width, i.e. the width in frequency domain. Given the central wavelength of the spectral distribution is 500 nm, what is the spectral width in wavelength? Was it able to excite Sodium transition around 580 nm?

2. calculate interference pattern given the arrangement of sources.

（1）Calculate the interference pattern generated by 3 points as instead of two used in Young's experiment. The 3 points (A, B, C) are on a straight line and equal spaced (AB=BC), the receiving plane is parallel with ABC and at distance D. The A, B, C have same amplitude and initial phase. (As illuminated by a broad laser beam).

（2）Two *plane* waves with same frequency, wavelength and initial phase travel with an angle 2θ between them. Let's arrange the coordinate system as following: Wave A forms angle θ with +Z axis, and wave B forms an angle of $-\theta$ with +Z; the wave vectors k of both waves lie in the Y-Z plane; the amplitude are A_0 for both waves and along the X direction.

1) Please write out the wave form for A and B.(in terms of k, w, A_0, θ and y, z)   2) On an observing screen of x-y plane at z=0, what is the interference pattern? (i.e. intensity distribution), and what is the spacing between the adjacent maxima.

(3) Fresnel Bi-prism:
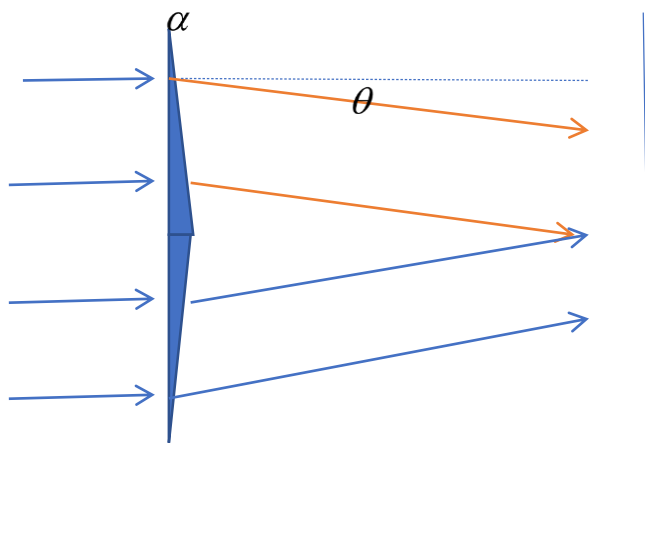
For the given setup, the incoming light is a monochromatic coherent plane wave, shine at normal angle to the input face. There will be overlap by the light beams refracted by the upper and lower half of the biprism (the prism has a small apex angle α, and this overlap will create interference pattern on the screen, determine the expression of this interference pattern, and find out the spacing between the interference fringe(spacing between maximum). (prism has index refraction n, either side is air n=1)

## 3. Use interference pattern (such as equal thickness or equal inclination pattern) to do measurement:

（1）In the two-slits Young's experiment, the distance to screen is 2 m and the wavelength of light used is 600 nm, and the spacing of the slits is 1mm. Now we insert a thin plate of glass (n=1.5) of thickness 0.05 mm is placed

over one of the slits, what is the resulting lateral fringe displacement at the screen?

*2. 块规是机加工里用的一种长度标准，它是一钢质长方体，它的两个端面经过磨平抛光，达到相互平行。附图中 G_1，G_2 是同规号的两个块规，G_1 的长度是标准的，G_2 是要校准的。校准方法如下：把 G_1 和 G_2 放在钢质平台面上，使面和面严密接触，G_1，G_2 上面用一块透明平板 T 压住。如果 G_1 和 G_2 的高度（即长度）不等，微有差别，则在 T 和 G_1，G_2 之间分别形成尖劈形空气层，它们在单色光照射下各产生等厚干涉条纹。

（1）设入射光的波长是 5893Å，G_1 和 G_2 相隔 5 cm（即图中的 l），T 和 G_1，G_2 间干涉条纹的间距都是0.5mm，试求 G_2 和 G_1 的高度之差。怎样判断它们谁长谁短？

（2）如果 T 和 G_1 间干涉条纹的间距是0.5mm，而 T 和 G_2 间的是0.3mm，则说明什么问题？
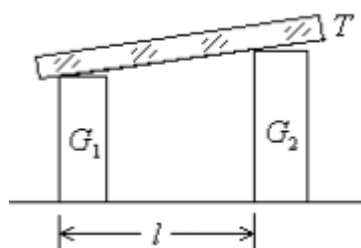
6. 肥皂膜的反射光呈现绿色，这时膜的法线和视线的夹角约为35°，试估算膜的最小厚度。设肥皂水的折射率为1.33，绿光波长为5000Å。