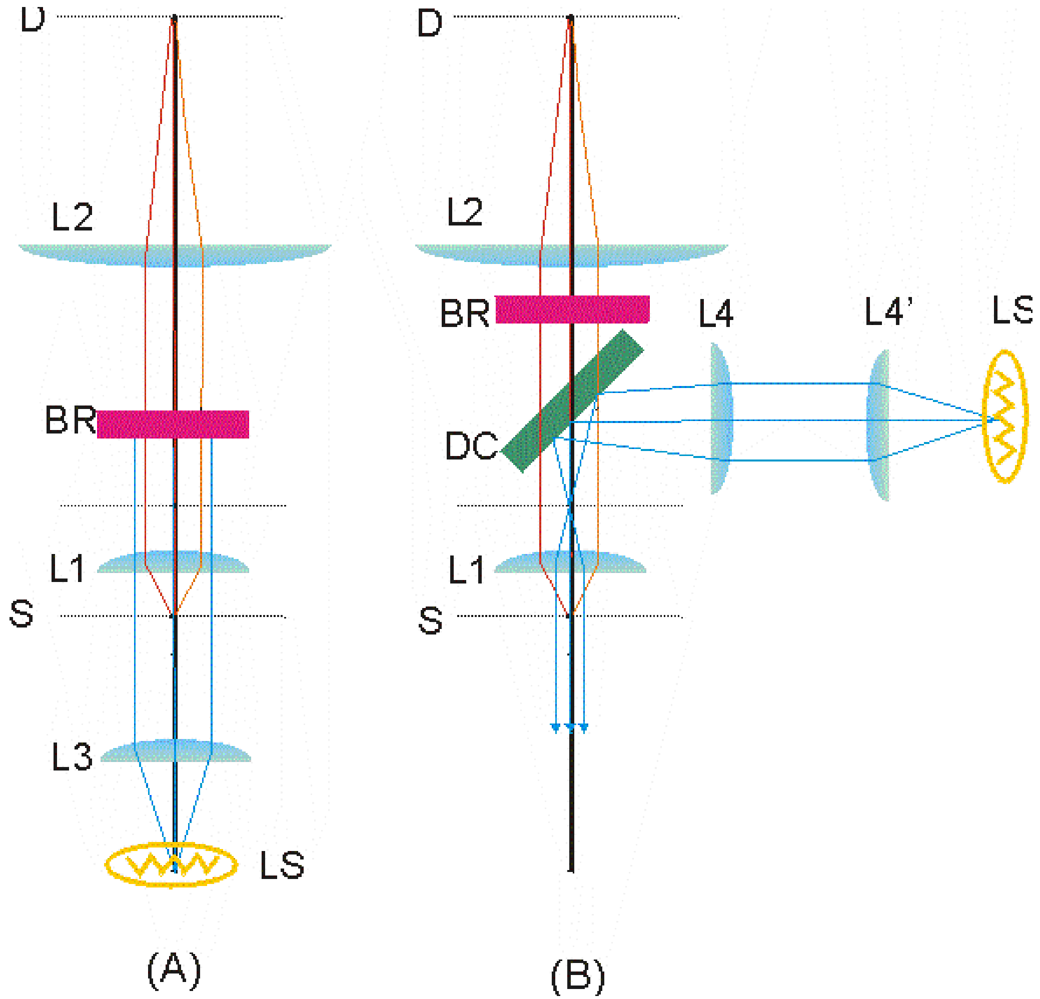
# Optics & Microscopy II



# What have we learned last lecture:

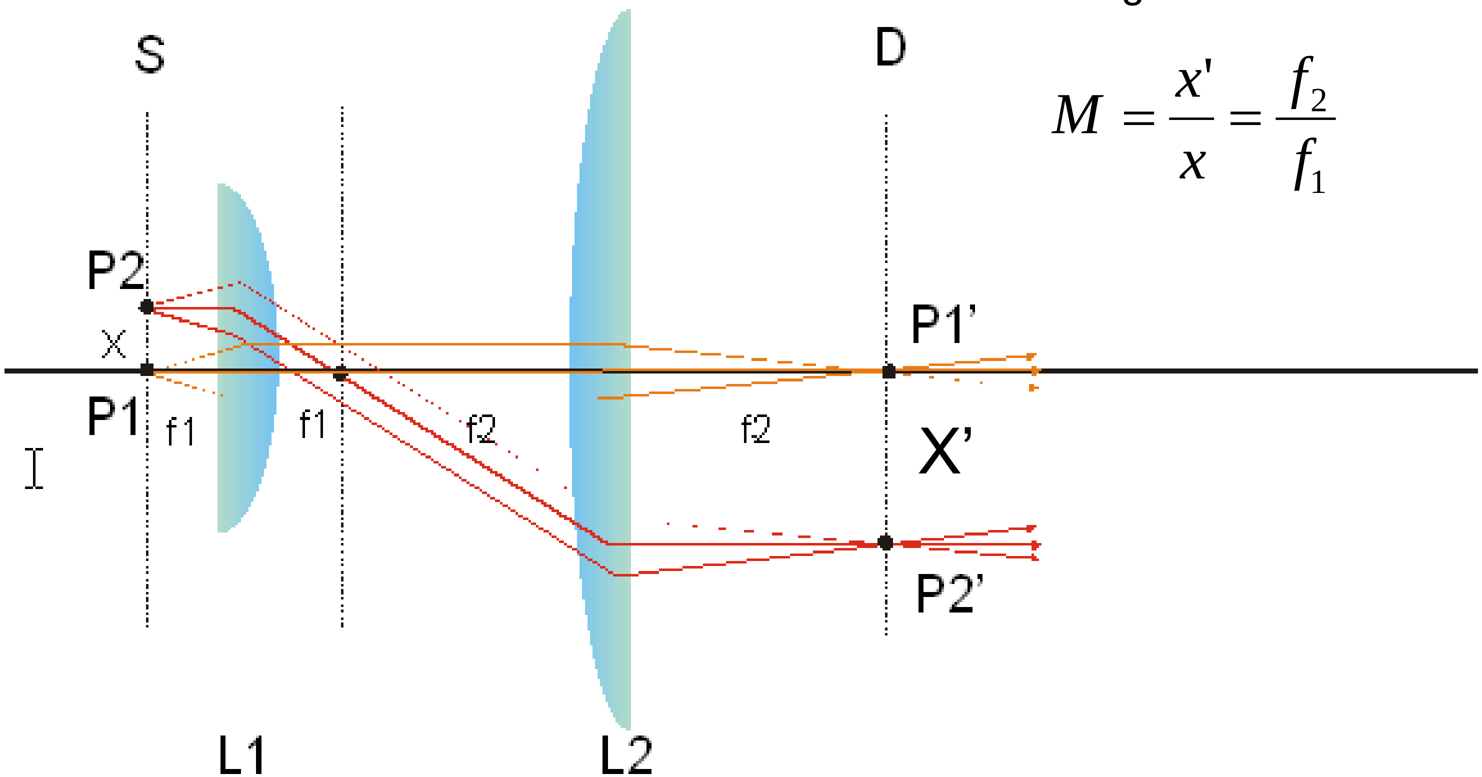
1. Maxwell’s equations and wave equations
2. Law of Reflection and Snell’s Law
3. Lens Maker’s Equation
4. Ray tracing rules
5. Basic microscope design

# Optical Microscopy

Detection path of an optical microscope.  Note that at the detector, the magnification is the ratio of the focal length of the objective and the tube lens.

Magnification

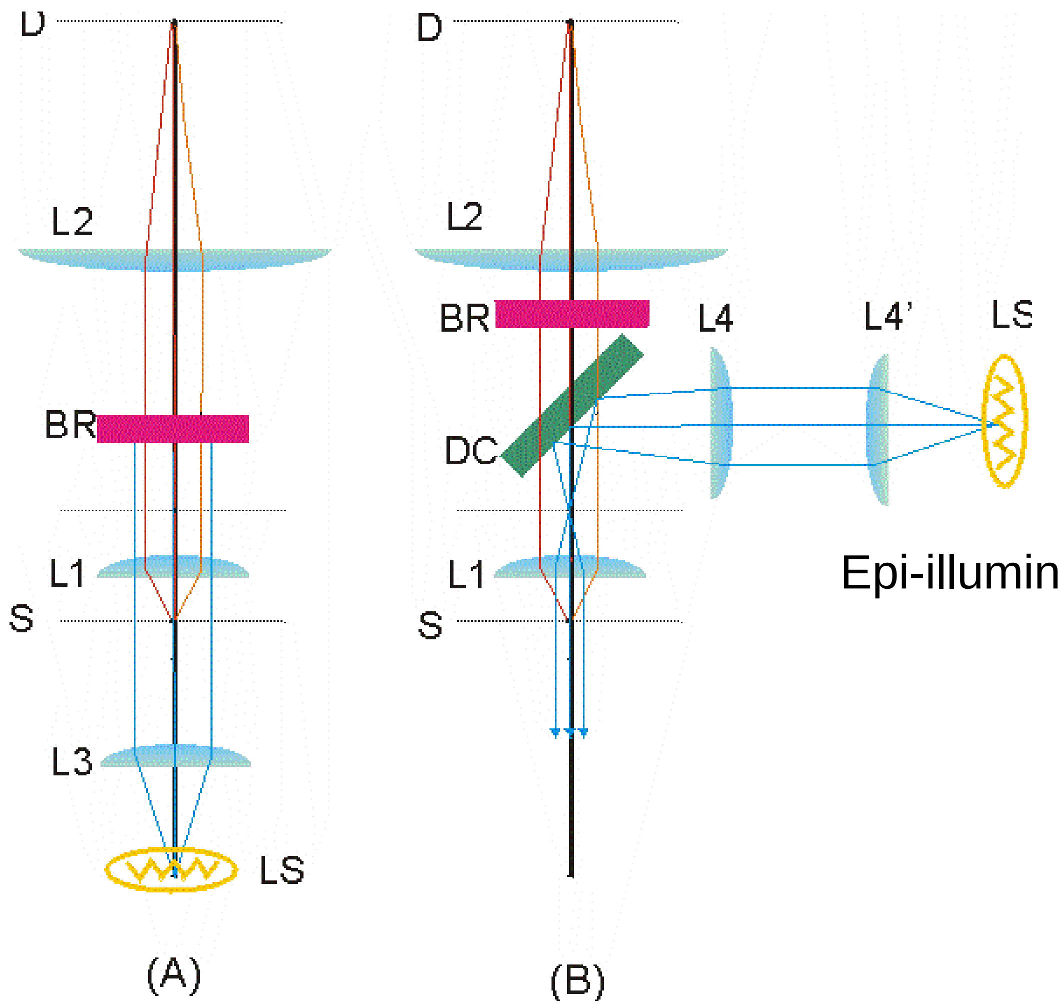
$$M = \frac{x'}{x} = \frac{f_2}{f_1}$$



# Optical Microscopy

Kohler illumination ensure that the structure of the light source (such as the filament of lamp) is not imaged at the specimen.

Trans-illumination




Epi-illumination

# Aberration and Microscope Objectives

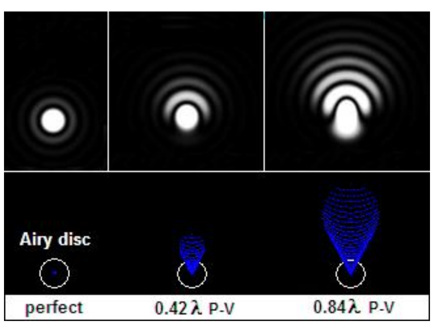
The lens marker equation, $\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$ , is based on the assumption that:

$$\sin\alpha = \alpha + \frac{\alpha^3}{3!} + \cdots..$$

What happen if we accounts for the higher order terms? Aberration

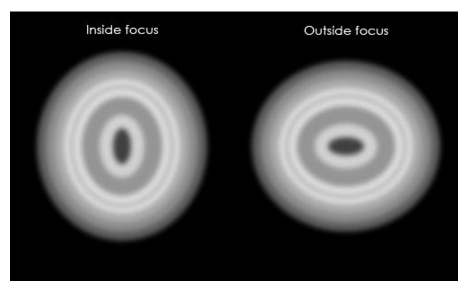
Monochromatic ones:

Coma

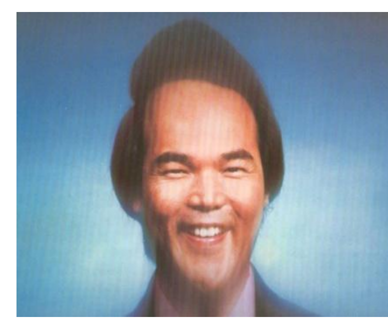



www.telescope-optics.net

Astigmatism



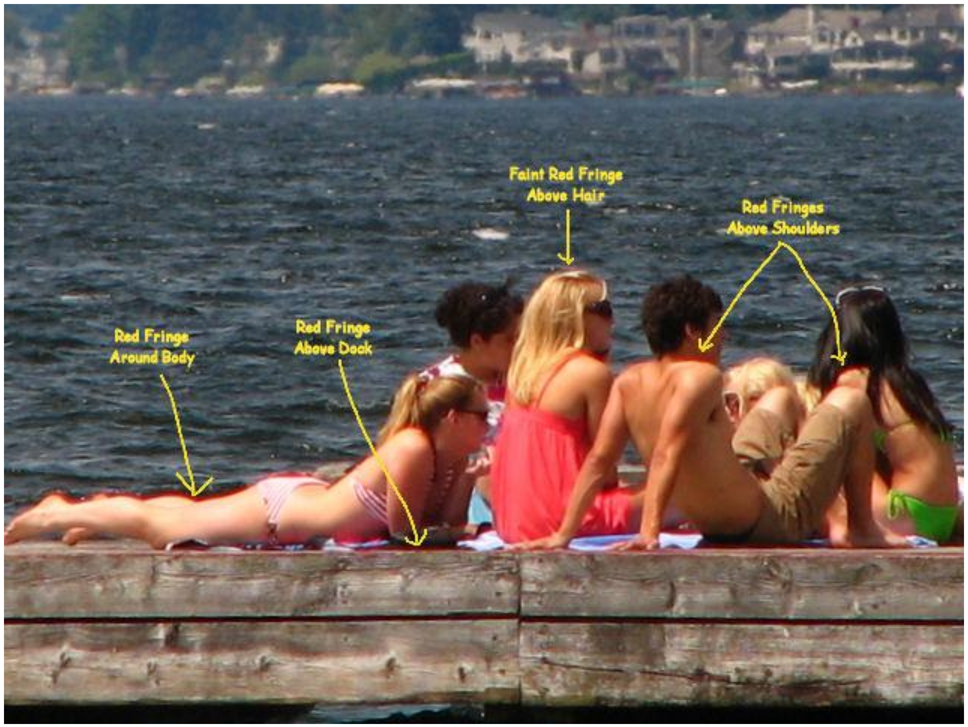

Starizona.com



culloeyecenter.com

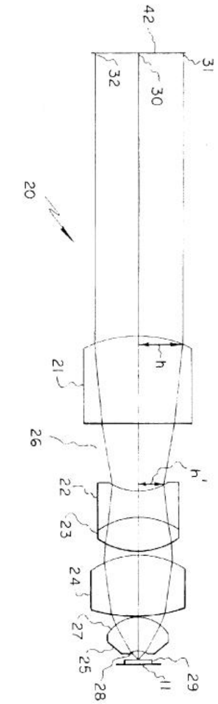
# Aberration and Microscope Objectives

## Chromatic aberration




www.askimo.com

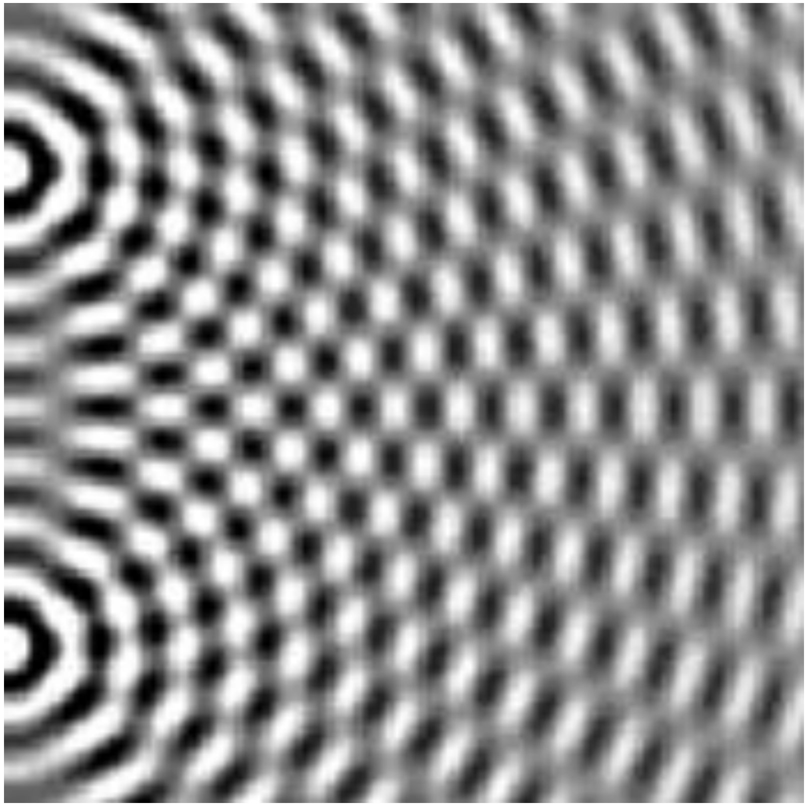
## Real microscope objective



United States Patent 6914728

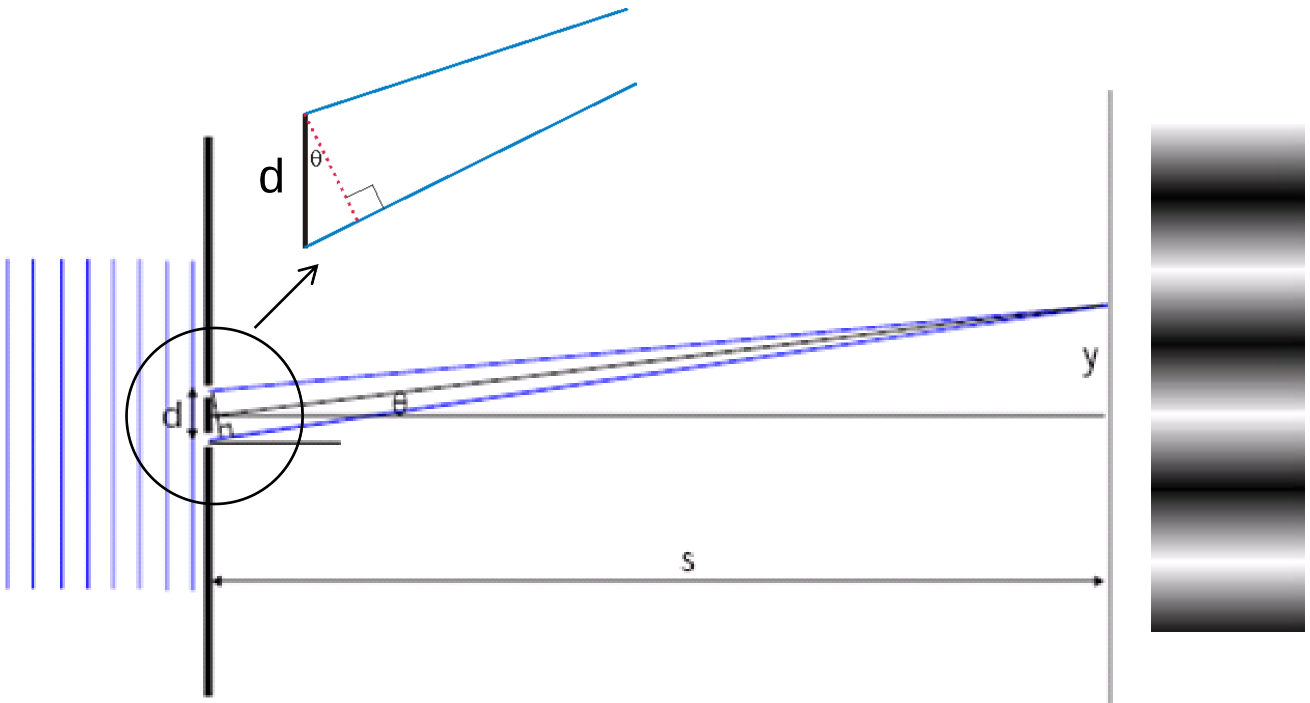
# Wave Nature of Light -- Interference

Huygen



# Interference

Consider two thin slits separated by d. What is the intensity of light at a screen distance s away at a position y?




Constructive

$$\delta = 0, 2\pi, 4\pi, \cdots$$

$$d\sin\theta = m\lambda$$

Destructive

$$\delta = \pi, 3\pi, 5\pi \cdots$$

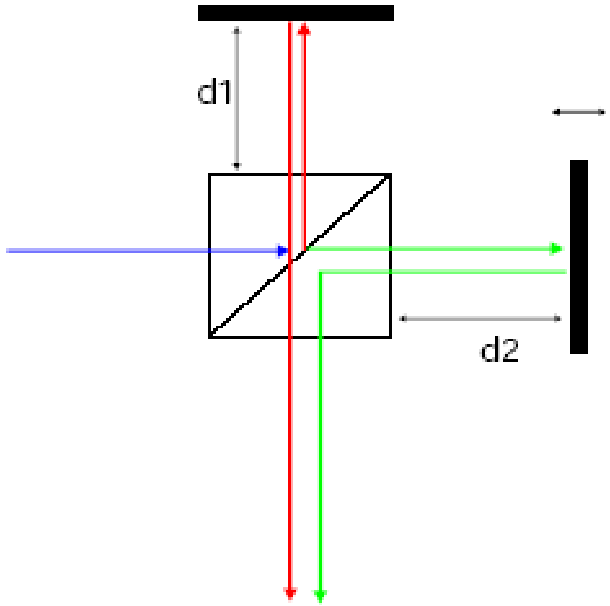
$$d\sin\theta = (m + \frac{1}{2})\lambda$$

$$\tan\theta = y / s$$

$$\delta = kd\sin\theta = \frac{2\pi d\sin\theta}{\lambda}$$

What happen if we have many slits with separation d?
Implications in the photonic crystal experiment?

Optical application of interference – Michaelson Interferometer




One of the most common use of interference is in the construction of interferometers (device that generate interference). They are a class of instrument that has provide some of the most precise measurement of distance and the wavelength of light.

Let's consider what is the interference effect of the red & green light rays:

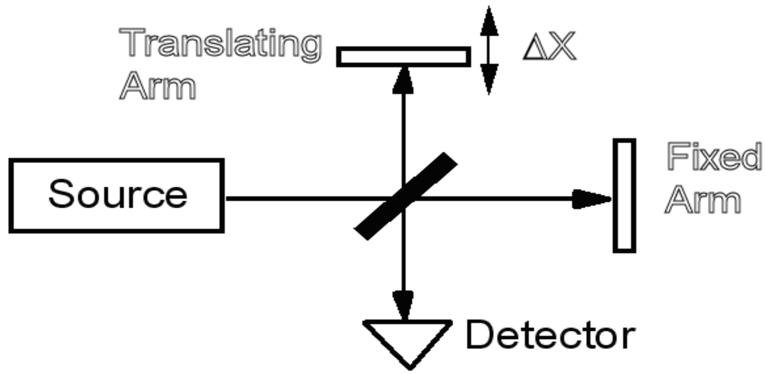
$$I_T = (E_R + E_G)^2 = 2I[1 + \cos(\frac{2\pi}{\lambda} 2(d_1 - d_2))] =$$

If we keep one mirror constant, we will see intensity variation with the travel of the second mirror as:

$$d_1 - d_2 = \frac{(n-1)\lambda}{2}; \text{ n=1,2,3... maxima}$$

$$d_1 - d_2 = \frac{(2n+1)\lambda}{4}; \text{ n=0,1,2... minima}$$

# Fourier Transform Spectroscopy




For single frequency

$$E(k) = A(k)\exp[ik(x-ct)]$$

$$E_1(k) + E_2(k) = A(k)(\exp[ik(x-ct)] + \exp[ik(x+\Delta x-ct)])$$

For a “sum’ of frequency

$$I_{ac}(\Delta x) \propto \int \left|A(k)\right|^2 \cos(k\Delta x)dk$$

Spectrum is Fourier transform of intensity at different x