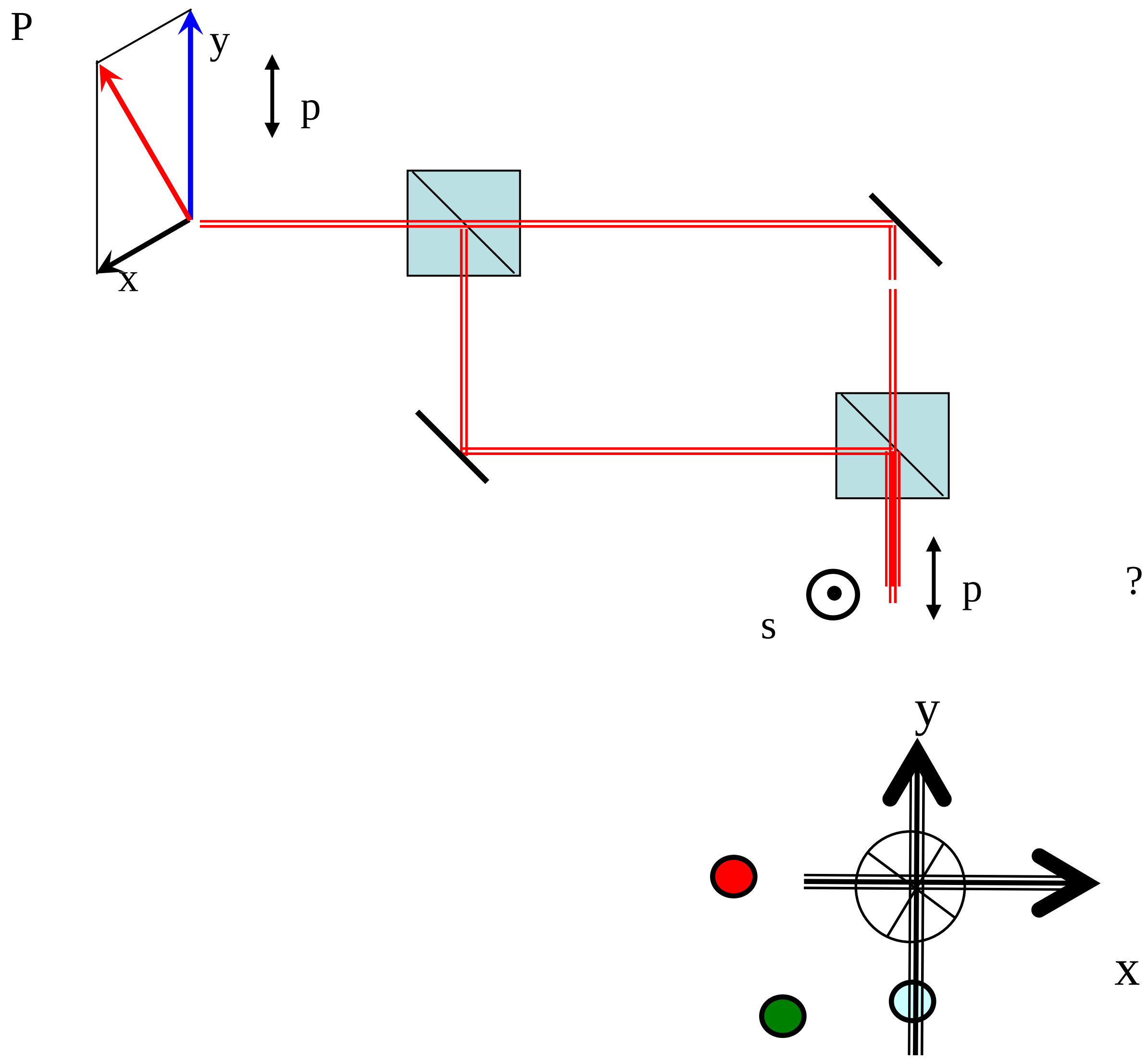
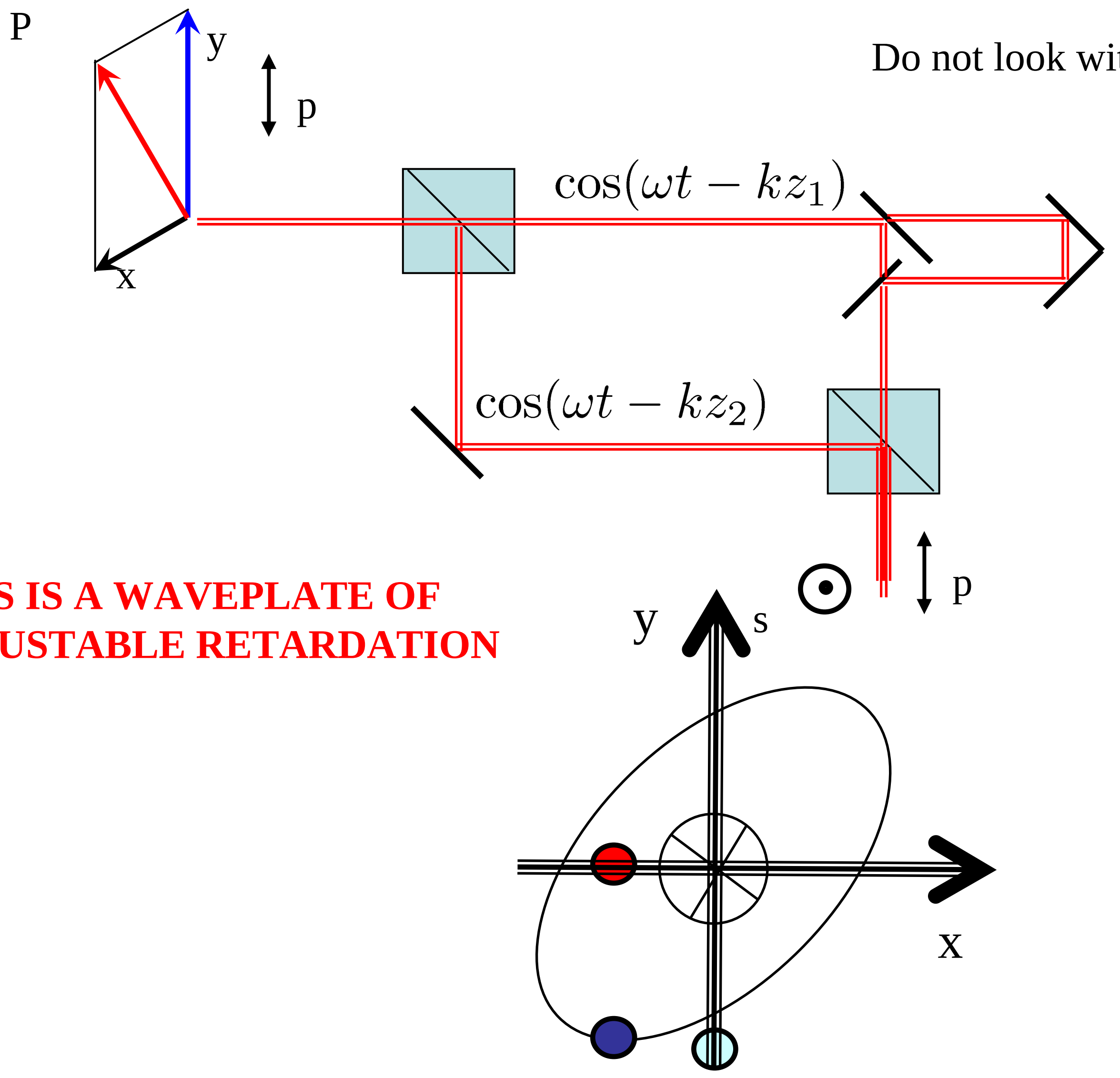
The rich man polarization manipulator



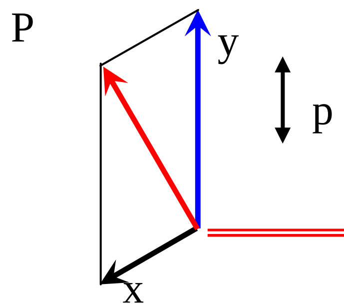
The rich man polarization manipulator

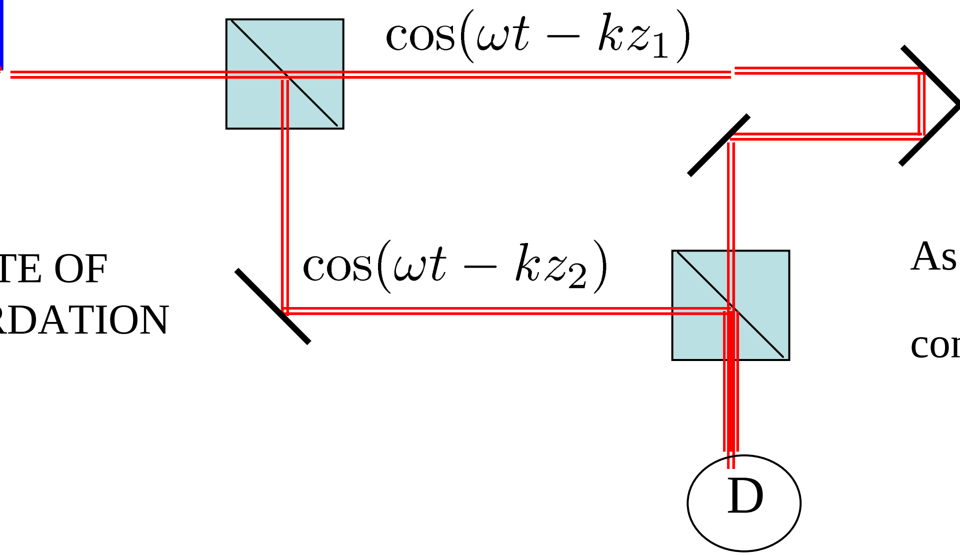
Do not look without animation!



THIS IS A WAVEPLATE OF ADJUSTABLE RETARDATION

Mach Zehnder versus polarization manipulator



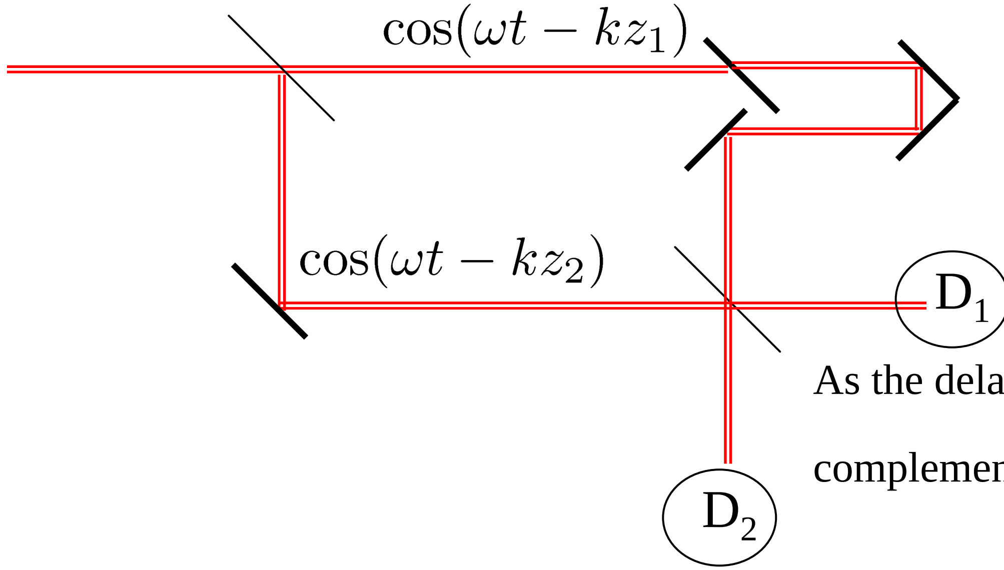


THIS IS A WAVEPLATE OF ADJUSTABLE RETARDATION

As the delay is scanned,

constant signal on D.

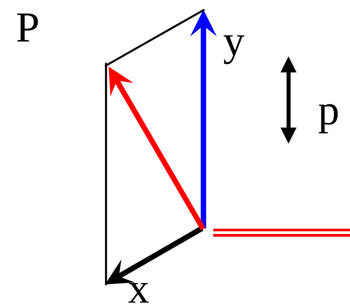
MACH ZEHNDER



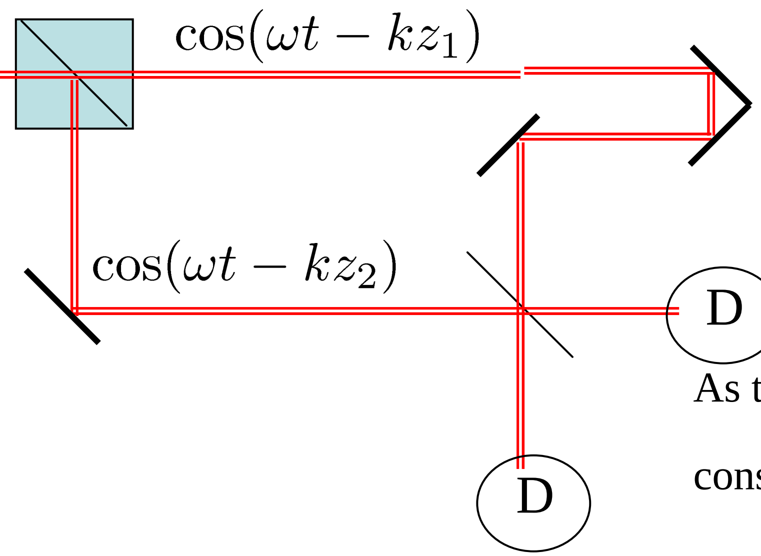
As the delay is scanned,

complementary fringes on D1 and D2

What is the difference between these two devices?



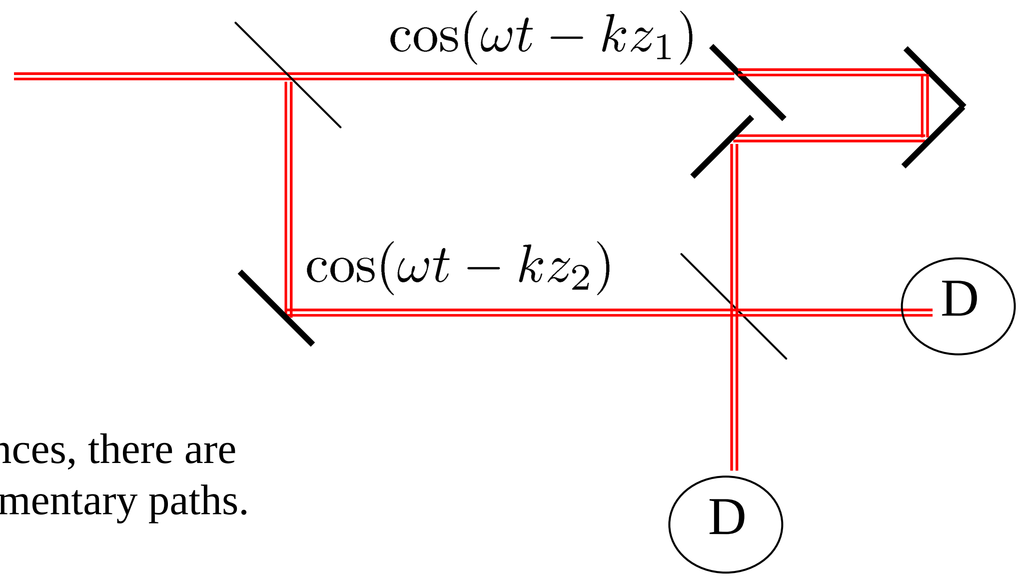
Orthogonal polarizations do not interfere



As the delay is scanned,

constant signal on D's.

MACH ZEHNDER

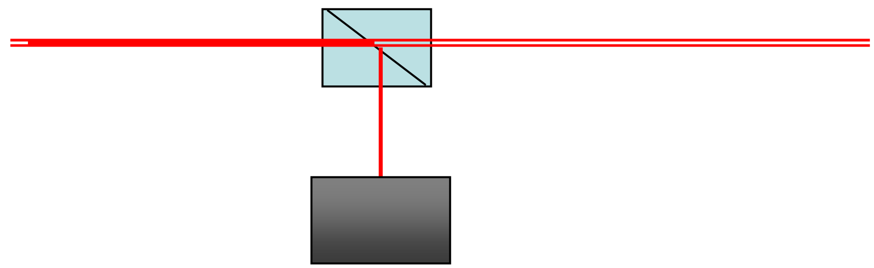


If there are interferences, there are
ALWAYS 2 complementary paths.

If there are interferences, there are ALWAYS 2 complementary paths.

The second path may be well hidden, as in the example of a polarizing sheet

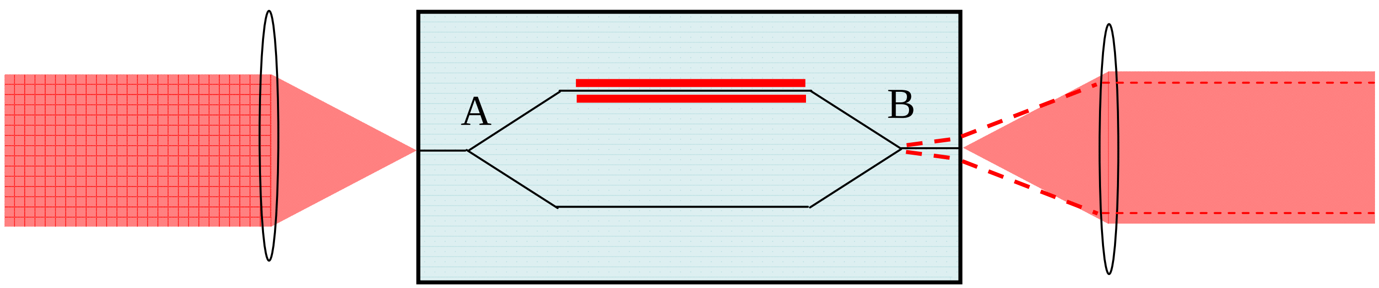
A sheet polarizer can be viewed as a cmbination of a polarizing beam splitter and an absorber:



Other example: Mach Zehnder amplitude modukator used with fibers in communication:

A 50/50 splitter in A, 2 equql paths before recombining in B – constructive interference into the waveguide, output collected by a lens. The interference become destructive in B when a voltage is applied to one branch. Where does the light power go? Out of the waveguide, (dashed line). If the waveguide after B is too short, it might be collected by the output lens.

A 50/50 split

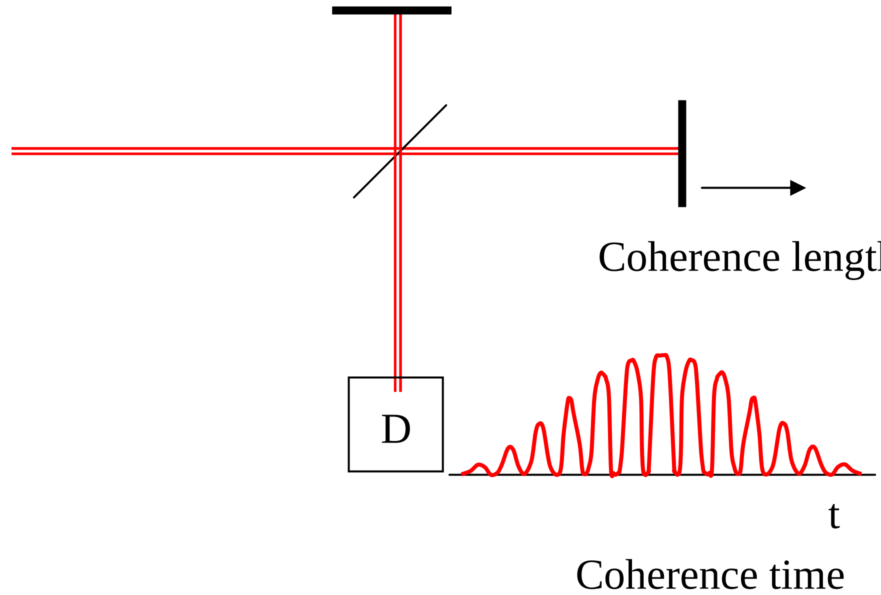


Coherence

Pedrotti Chapter 9

Coherence time, coherence length

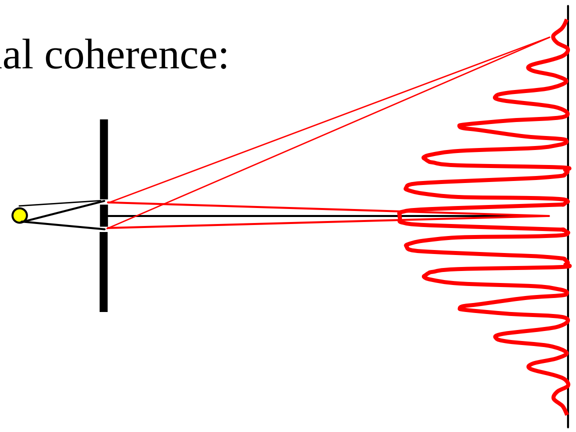
Michelson



Sodium doublet

588.9950 and 589.5924 nm

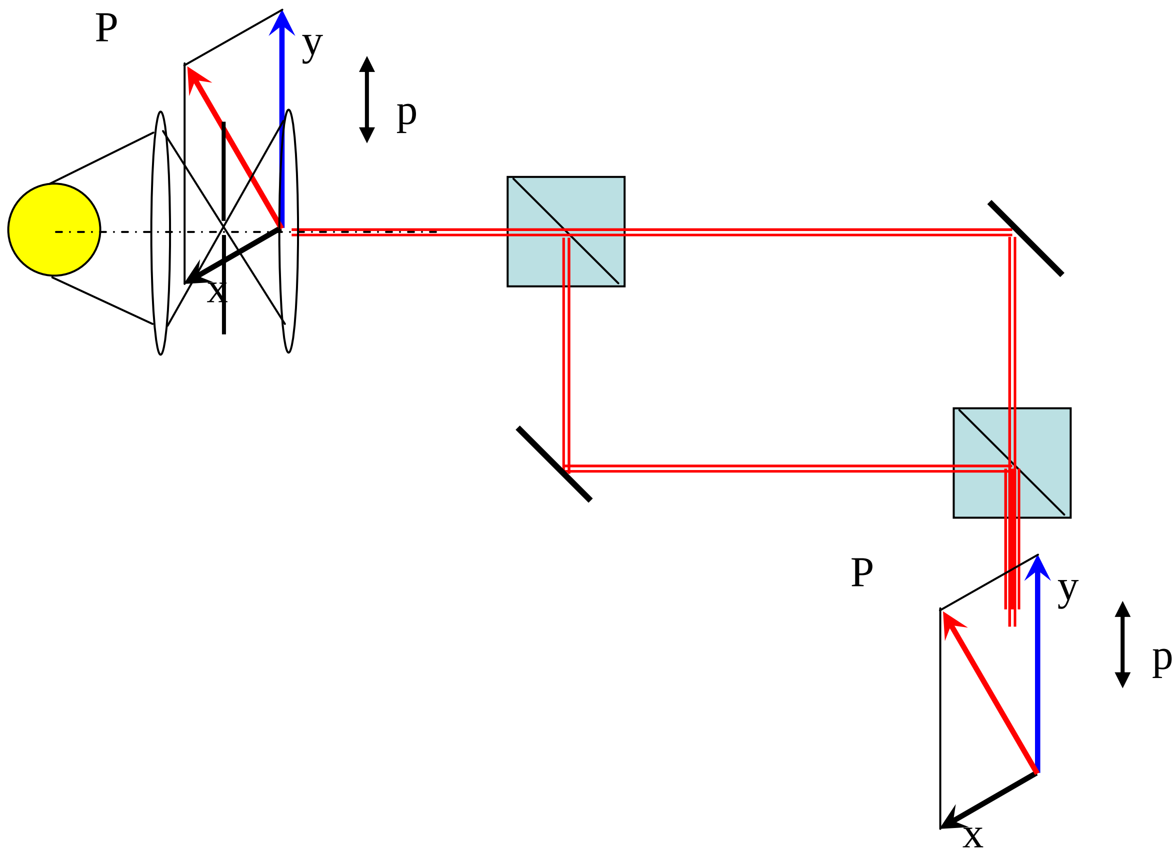
Spatial coherence:



If there are interferences, there are ALWAYS 2 complementary paths.

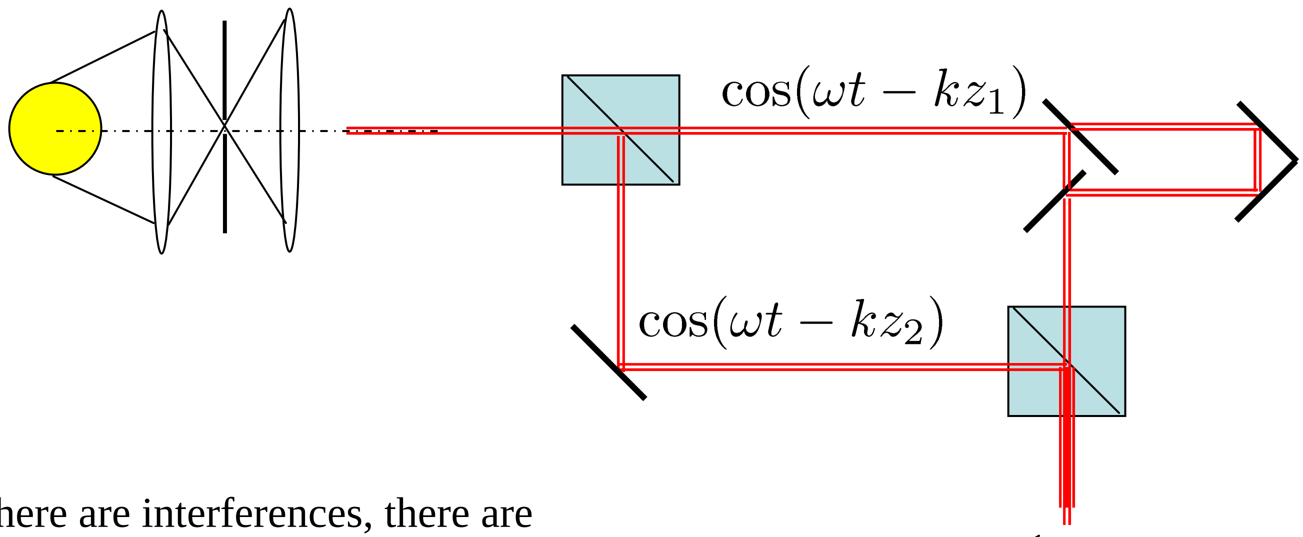
Polarization and coherence

Is there something such as "polarization coherence"?

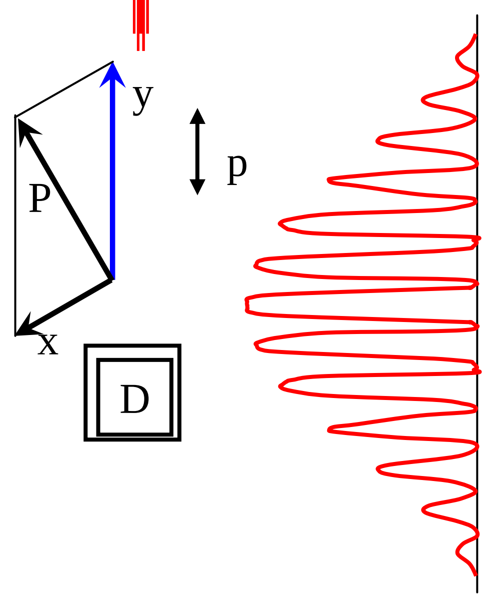


Polarization and coherence

Do not look without animatio!



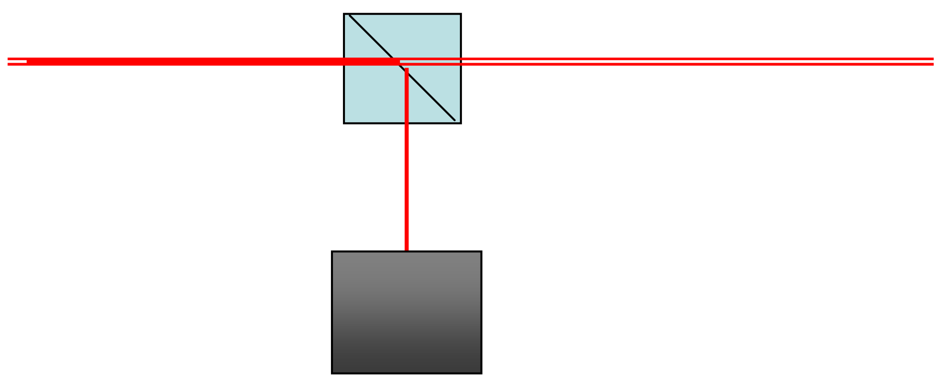
If there are interferences, there are ALWAYS 2 complementary paths. Where are they?



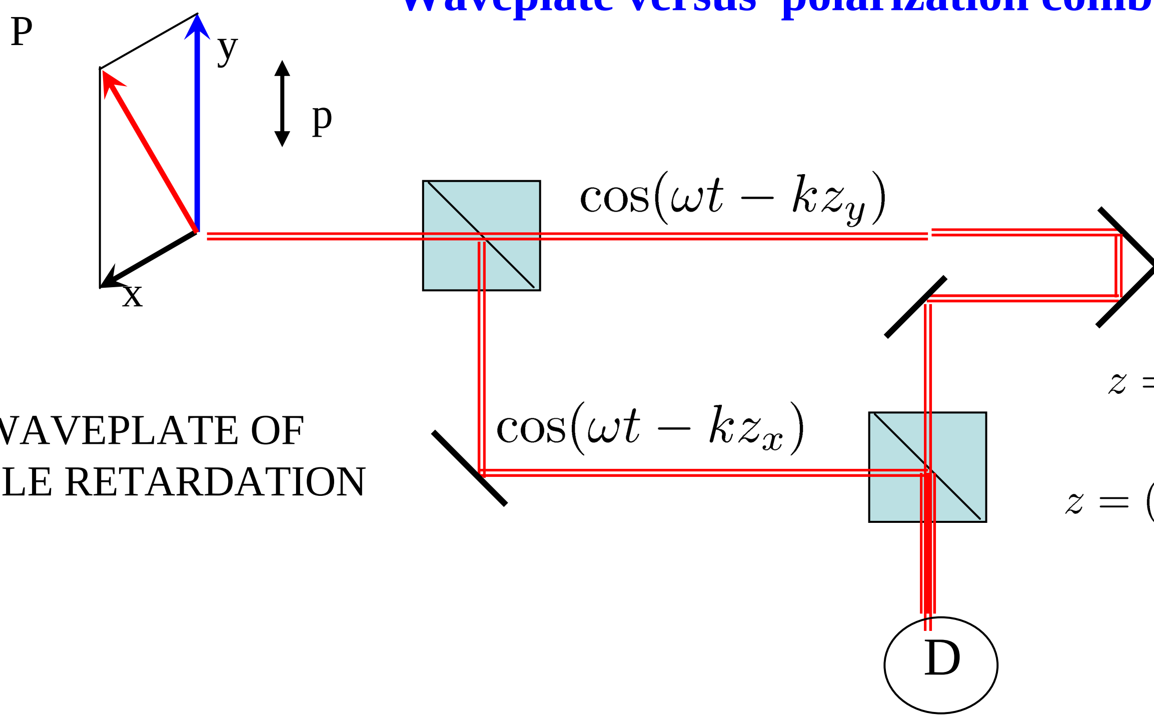
2 orthogonal polarizations cannot interfere.

By projecting them with a polarizer at 45^o, they become parallel and can interfere

A sheet polarizer is a polarizing beam splitter + an absorber:



Waveplate versus polarization combiner



$$z = z_y - z_x$$

$z = N\lambda$ 0 wave

$z = (2N+1)\frac{\lambda}{2}$ Half wave

$z = (2N+1)\frac{\lambda}{4}$ Quarter wave

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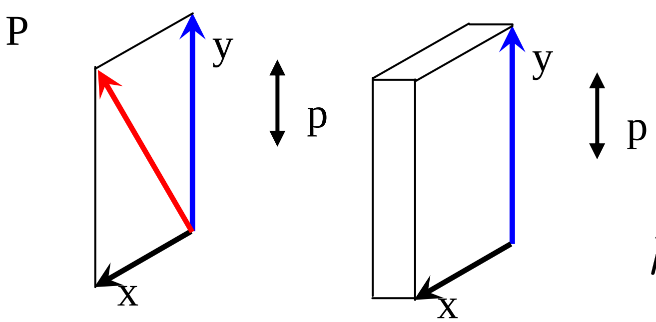


$\cos(\omega t - k_y z)$

$z =$ plate thickness not adjustable

$k_y - k_x =$ material property not adjustable

$\cos(\omega t - k_x z)$

Another polarization gate

Other than the polarization gate using a multiple order $\lambda/4$ wave plate plus a zero order $\lambda/4$ wave plate. Another version will be a multiple order full λ wave plate plus a zero order $\lambda/4$ wave plate.

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

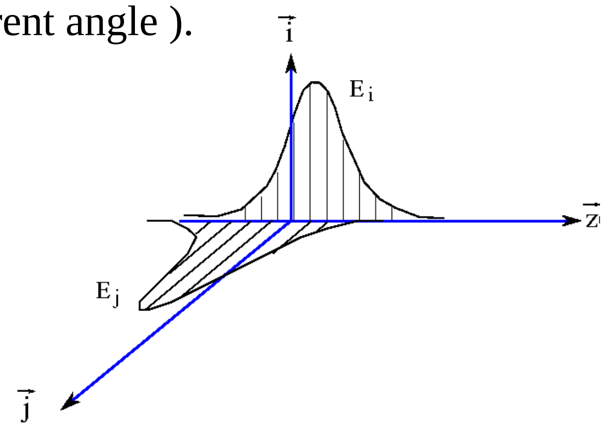
The electric field is first incident on a multiple full wave plate with its polarization axis at 45° with respect to the fast axis of the wave plate.

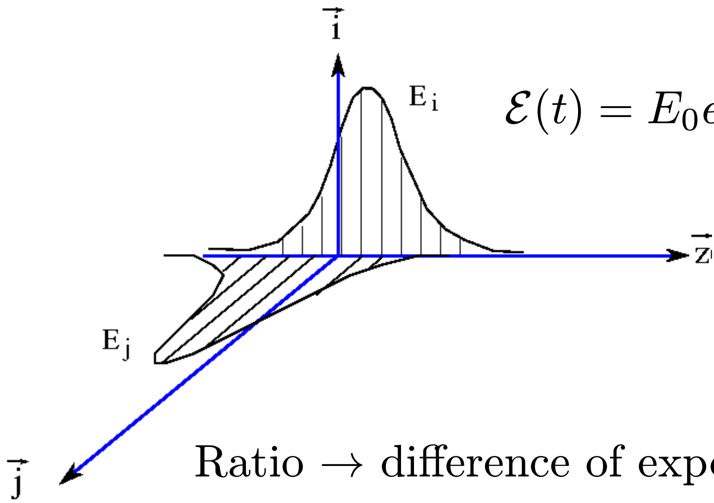
The wave plate introduces a group delay of 6.2 fs between its e and o components

$$E(t) = \sqrt{2}[E_0^-(t')\hat{i} + E_0^+(t')\hat{j}]\cos(\omega t')$$

Fast axis   slow axis

This is a linear polarized pulse with time dependent polarization angle θ w.r.t axis $\hat{j}$ (i.e. different portion of the pulse in time are polarized at different angle).

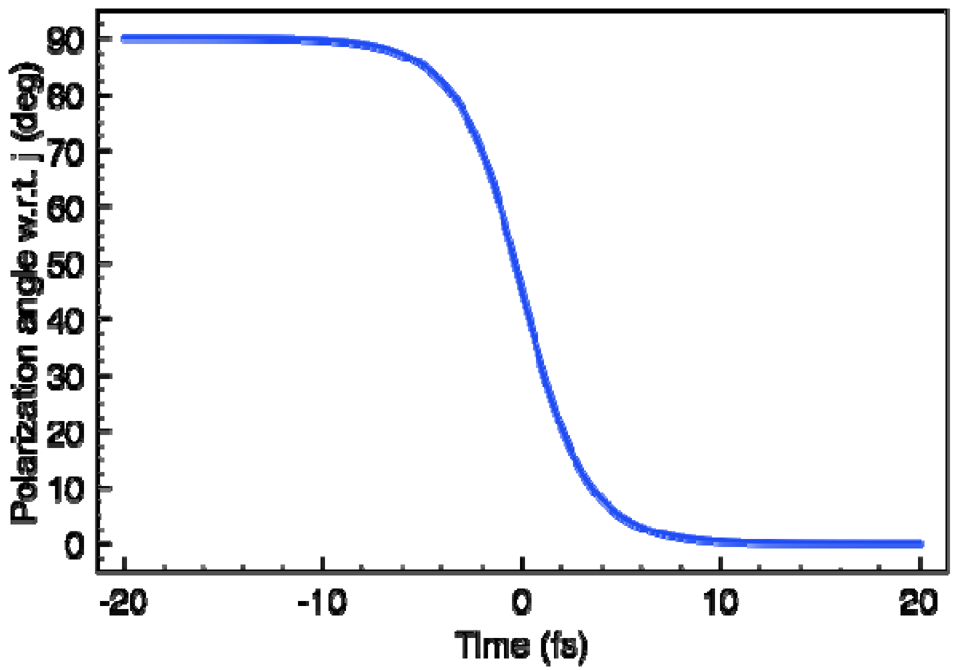




$$\mathcal{E}(t) = E_0 e^{\frac{-t^2}{t_p^2}}$$

$$\theta(t') = \tan^{-1}\left[\frac{E_0^+(t')}{E_0^-(t')}\right] = \tan^{-1}\left(e^{-\frac{2\tau t'}{\tau_p^2}}\right)$$

Ratio $\rightarrow$ difference of exponents $\rightarrow \frac{1}{\tau_p^2}\left[(t^2+\tau^2-2t\frac{\tau}{2})-(t^2+\tau^2+2t\frac{\tau}{2})\right]$



A zero order $\lambda/4$ wave plate is placed at an angle θ_2 with respect to the full wave plate.

Project the electric field onto the F.A. and S.A (x' and y')) of the zero-order $\lambda/4$ wave plate.
After the $\lambda/4$ wave plate, the electric field becomes:

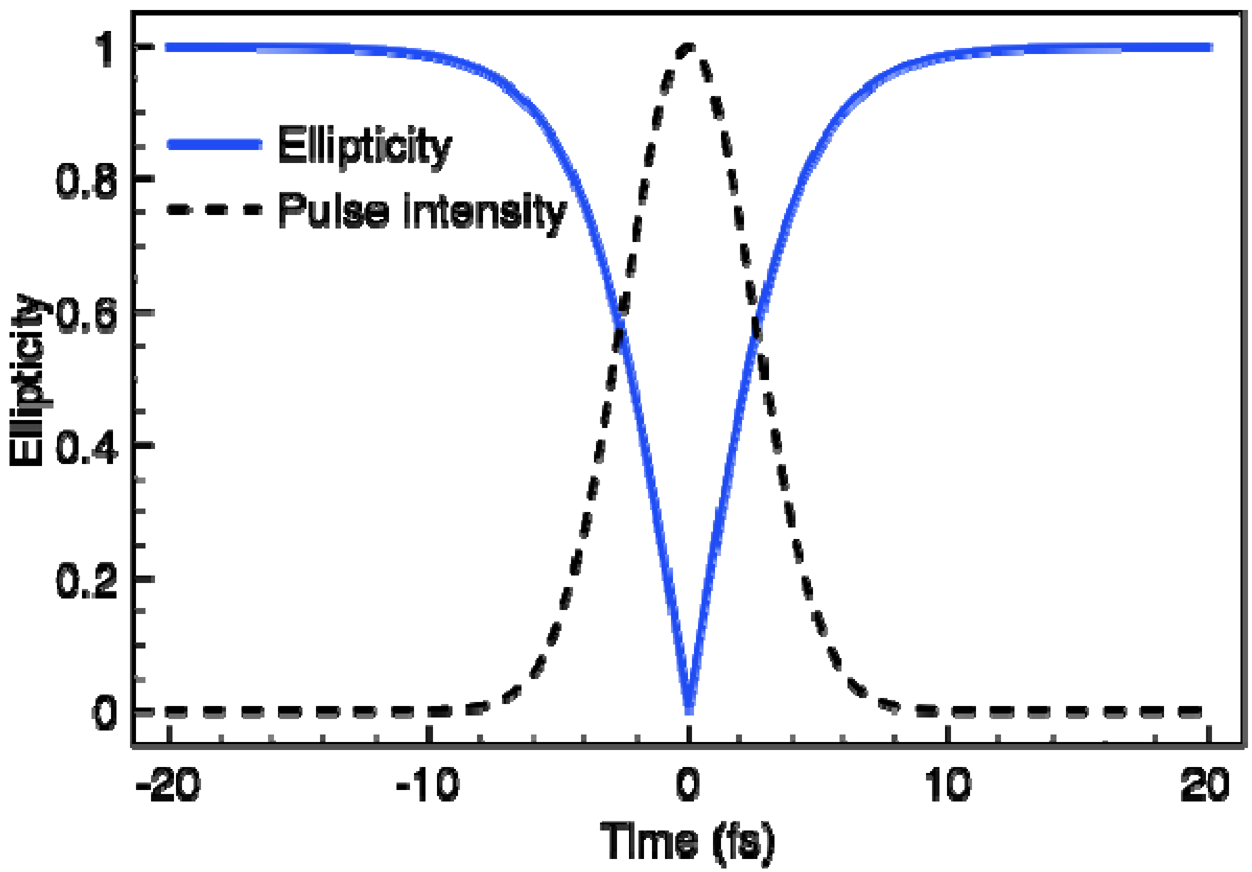
$$E_{x'}(t') = \sqrt{2}\cos(\omega t)[E_0^-(t')\cos\theta_2 + E_0^+(t')\sin\theta_2]$$
$$E_{y'}(t') = -\sqrt{2}\sin(\omega t)[E_0^+(t')\cos\theta_2 - E_0^-(t')\sin\theta_2]$$

This is a elliptical polarized pulse with its major and minor axis on x' and y'. Its ellipticity is:

$$\epsilon(t') = |\frac{E_0^-(t')\sin(\theta_2) - E_0^+(t')\cos(\theta_2)}{E_0^-(t')\cos(\theta_2) + E_0^+(t')\sin(\theta_2)}|$$

With $\theta_2 = 45^o$ the ellipticity is:

$$\begin{aligned}\epsilon(t') &= |\frac{E_0^-(t') - E_0^+(t')}{E_0^-(t') + E_0^+(t')}| \\ &= |\frac{e^{\frac{2\tau t'}{\tau_p^2}} - 1}{e^{\frac{2\tau t'}{\tau_p^2}} + 1}|\end{aligned}$$



Ellipticity
Pulse intensity
Ellipticity
1
0.8
0.6
0.4
0.2
0
-20
-10
0
10
20
Time (fs)