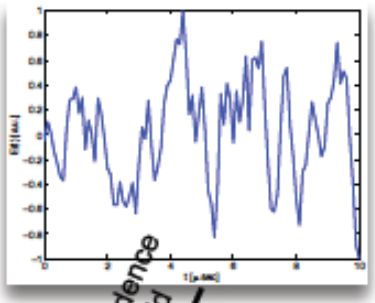
Temporal coherence

Michelson interferometer

random illumination
(not single color anymore)

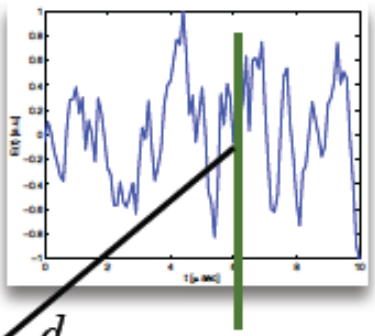


temporal dependence of emitted field

point source

detector

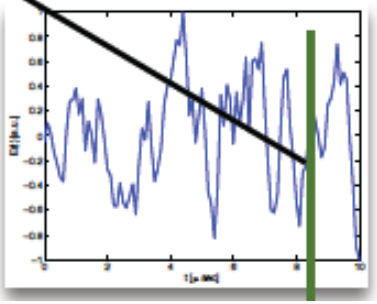
waveform from path 2, time delay t_2=const+$2d_2/c$



d_2

d_1

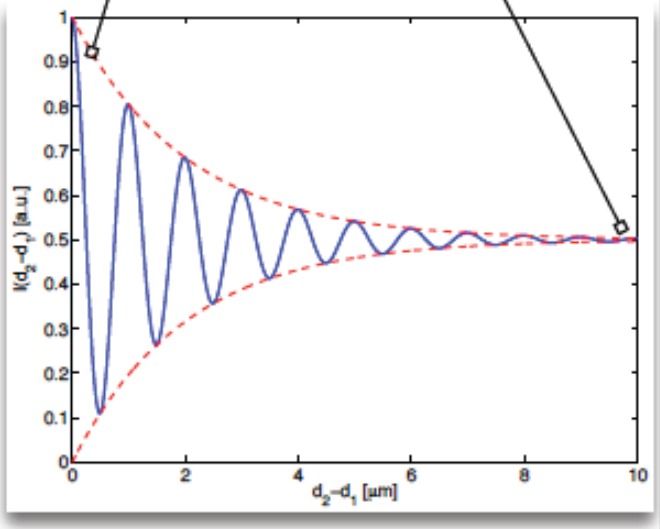
waveform at mirror 1, time delay t_1=const+$2d_1/c$



If paths 1 & 2 are matched, then the recombined waveforms at the detector are *correlated* so they produce interference fringes. However, as the difference d_2-d_1 increases, the degree of correlation decreases and so does the contrast in the interference pattern.

interference (fields add *coherently*)

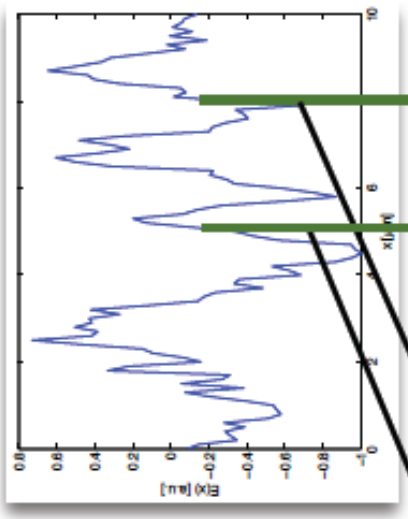
no interference (fields add *incoherently*)



Reference: MIT course website

Spatial coherence

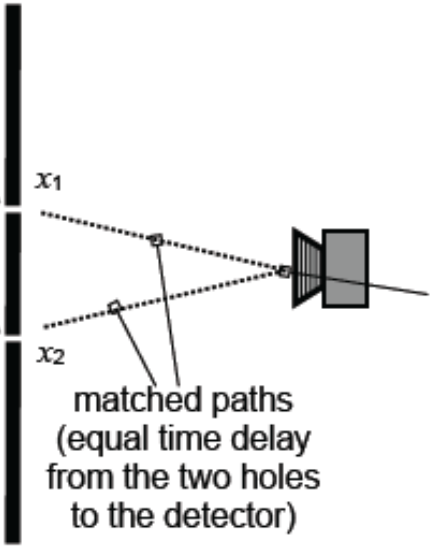
Young interferometer



waveform from hole 1, location x_1

waveform from hole 2, location x_2

random waveform



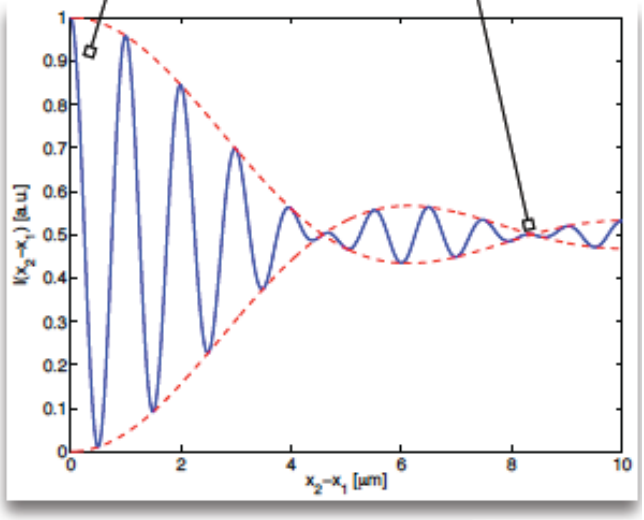
matched paths (equal time delay from the two holes to the detector)

interference recorded near the bisectrix (almost matched paths)

If holes 1 & 2 are coincident, or very closely spaced, then the recombined waveforms at the detector are *correlated* so they produce interference fringes. However, as the difference x_2-x_1 increases, the degree of correlation decreases and so does the contrast in the interference pattern.

interference (fields add *coherently*)

no interference (fields add *incoherently*)



Coherent and incoherent sources and measurements

Temporally incoherent; spatially coherent

- White light lamp (broadband; e.g., thermal) spatially limited by a pinhole
- White light source located very far away (i.e. with extremely small NA) e.g. sun, stars, lighthouse at long distance
- Pulsed laser sources with extremely short (<nsec) pulse duration; supercontinuum sources

Temporally & spatially coherent

- Monochromatic laser sources e.g. doubled Nd:YAG (best), HeNe, Ar^+ (poorer)
- Atomic transition (quasi-monochromatic) lamps (e.g. Xe) spatially limited by a pinhole

Temporally & spatially incoherent

- White light source at a nearby distance or without spatial limitation

Temporally coherent; spatially incoherent

also referred to as **quasi-monochromatic spatially incoherent**

- Monochromatic laser sources (e.g. HeNe, doubled Nd:YAG) with a rotating diffuser (plate of ground glass) in the beam path
- Atomic transition (quasi-monochromatic) lamps (e.g. Xe) without spatial limitation

Optical instruments utilizing the degree of coherence for imaging

- Michelson interferometer [spatial; high resolution astronomical imaging at optical frequencies]
- Radio telescopes, e.g. the Very Large Array (VLA) [spatial; astronomical imaging at RF frequencies]
- Optical Coherence Tomography (OCT) [temporal; bioimaging with optical sectioning]
- Multipole illumination in optical lithography [spatial; sub-μm feature patterning]

NOTE : In order to get a high visibility in an interference fringe, both the temporal and spatial coherences must be good.

How to make an incoherent light COHERENT?