Interferometers

- Can use interference effects to precisely measure distance
- First example Michelson Interferometer
- Have 2 mirrors (M_1 & M_2) placed on arms at 90 degrees
- Splitting mirror O (half silvered mirror) at intersection
- Splitter mirror – reflects part (~50%) of light 90^o

Lets part pass directly through

- Of a thin film of Aluminium ~100 nm, not full absorbing
- Monochormatic & coherent light source along path of one arm
- Detector at other arm
- Light to M_1 is reduced, reflected by M_1 then by splitter to detector
- Light at splitter reduced but reflected to M_2
- The passed through splitter O to detector

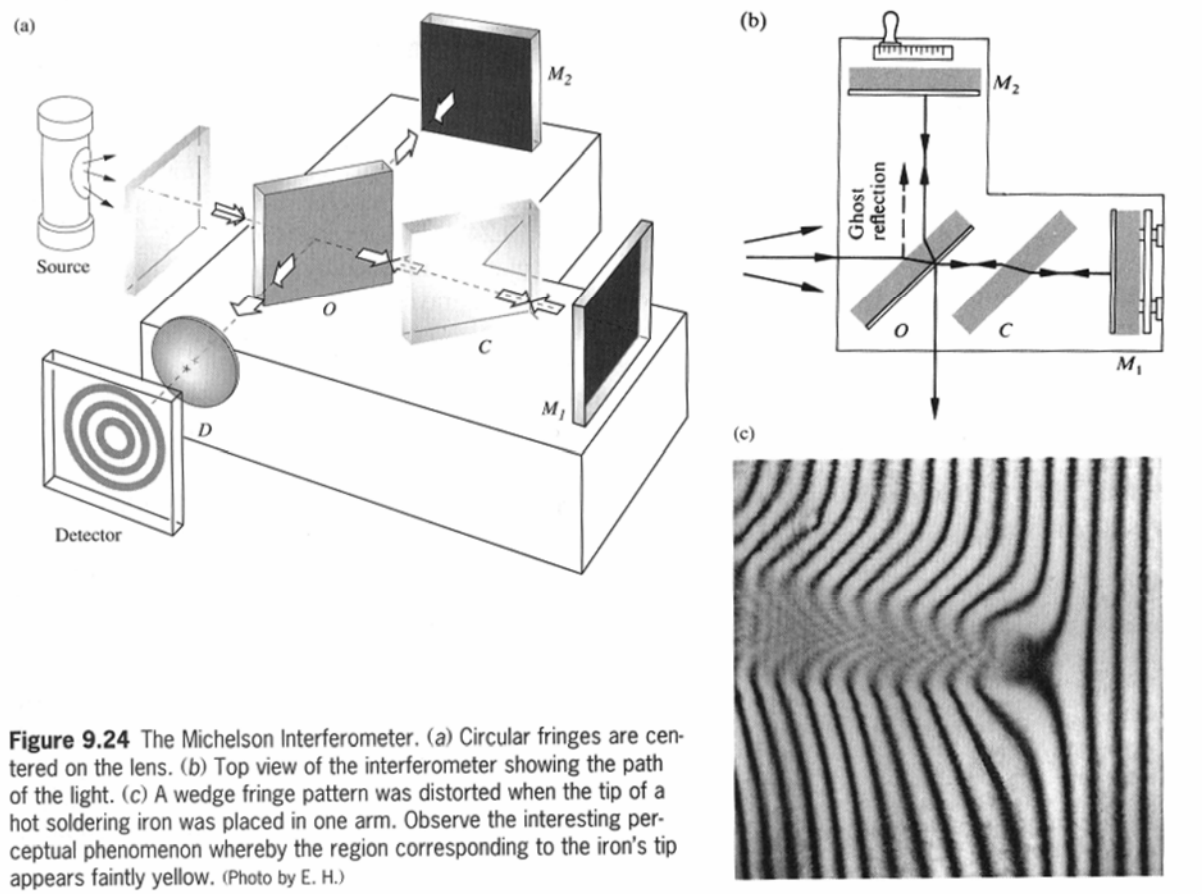


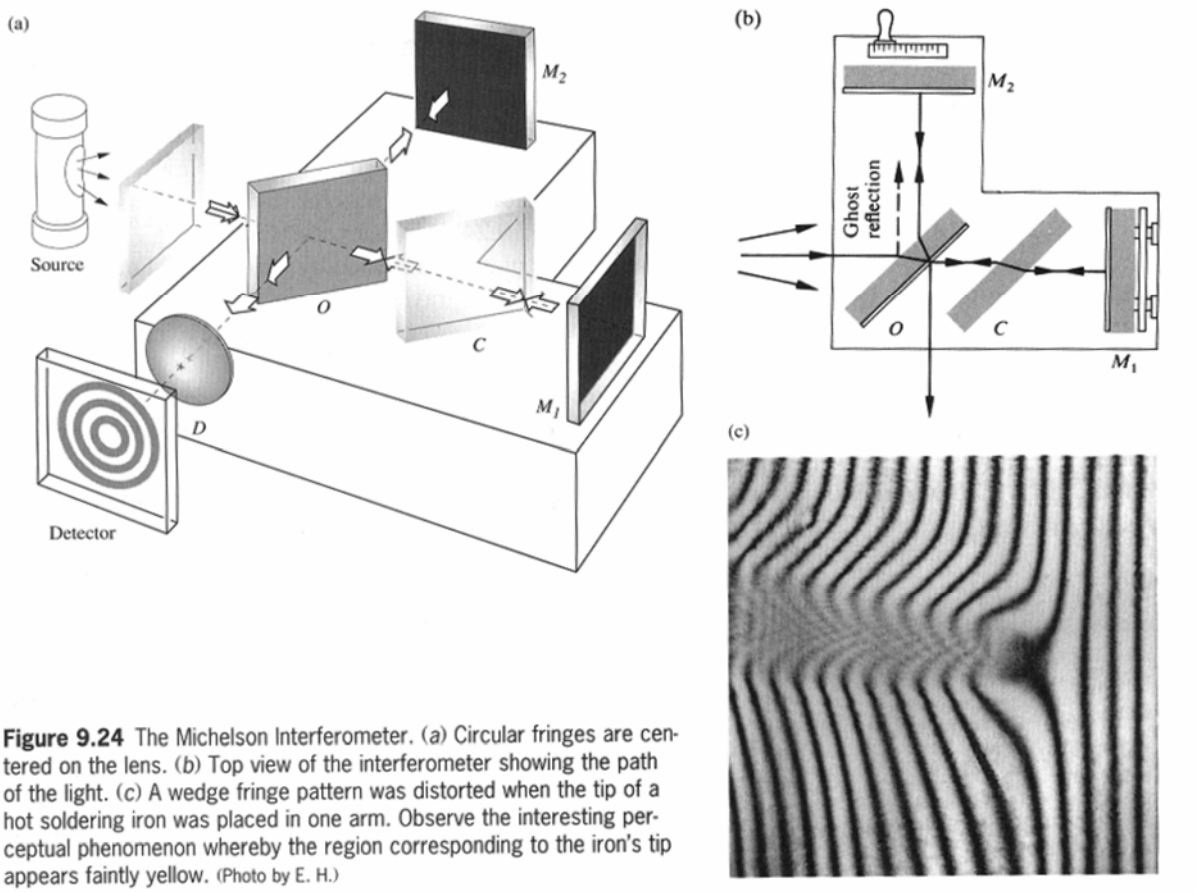
Figure 9.24 The Michelson Interferometer. (*a*) Circular fringes are centered on the lens. (*b*) Top view of the interferometer showing the path of the light. (*c*) A wedge fringe pattern was distorted when the tip of a hot soldering iron was placed in one arm. Observe the interesting perceptual phenomenon whereby the region corresponding to the iron's tip appears faintly yellow. (Photo by E. H.)

Michelson Interferometer

- At detector two beams combine to create interference
- Let path length difference be Δl
- Then if $\Delta l = N\lambda/2$ get constructive interference – bright
- Dark if

$$\Delta l = \frac{2N+1}{4}\lambda$$

- Now can measure very small distance changes
- Eg if put glass plate C in can see small defects in glass
- Interferometers used in measuring distance
- Digitize light level and measure changes – can get $\lambda/64$ or 256
- Measure 2 nm distance
- Need extremely stable laser



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Michelson Interferometer

- Actually see circular interference at the detector
- Reason distance from detector to splitter is d
- The angle θ at the detector when destructive interference is

$$2d\cos(\theta_m) = m\lambda$$

- Result is rings of interference

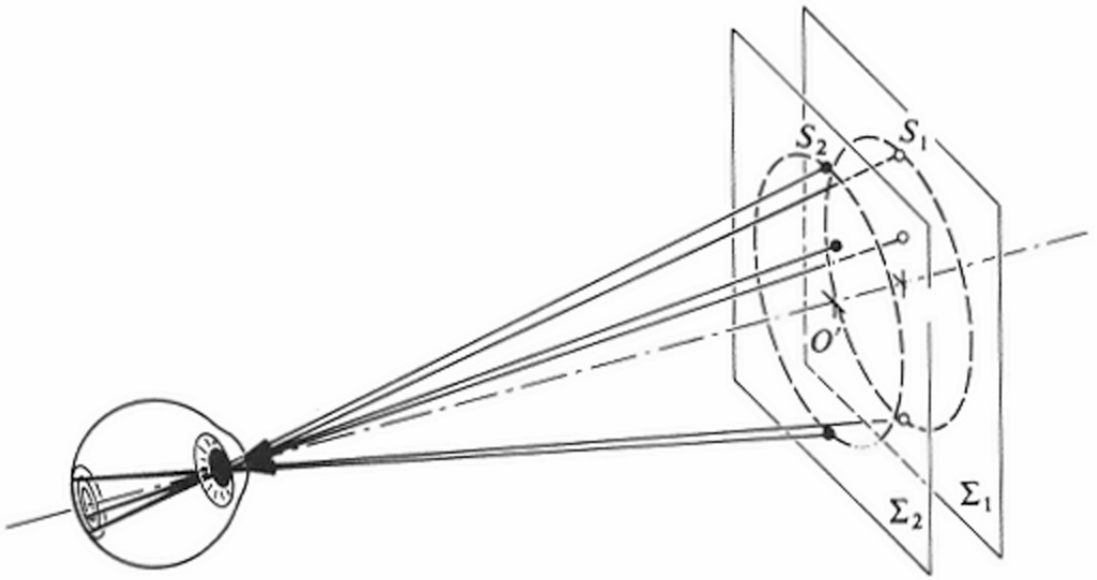
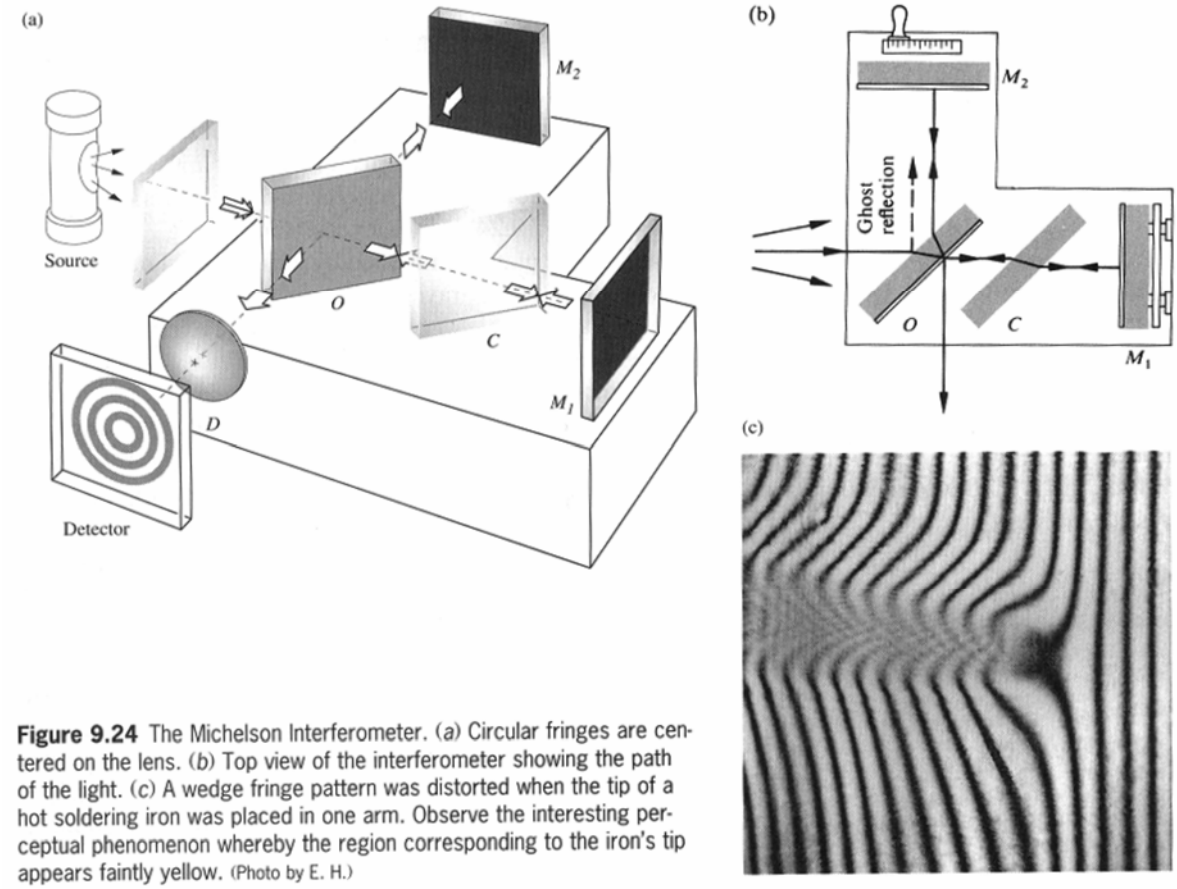


Figure 9.26 Formation of circular fringes.

Michelson Morley Experiment

- Use Michelson interferometer
- Put on path along direction of earth around sun
- Other path at along radius to sun
- Then rotate by 90 degrees
- Classic physics: Along the path in direction of motion
- light should arrive sooner to addition of velocities
- But no difference found – first indication of relativity



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Mach- Zehnder & Sagnac Interferometer

- Mach- Zehnder Interferometer
- 2 splitters and 2 mirrors
- Detects small changes in one path relative to other
- Used to detect small events in one path
- Sagnac is a ring interferometer
- Used to small deviations in both directions

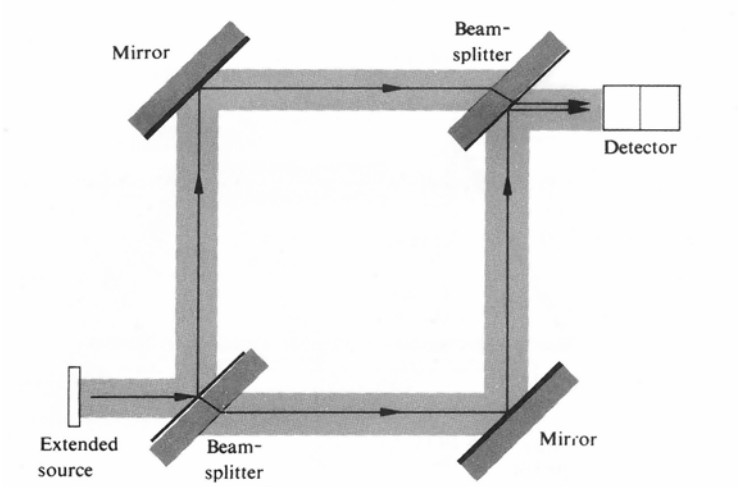

Figure 9.27 The Mach–Zehnder Interferometer.

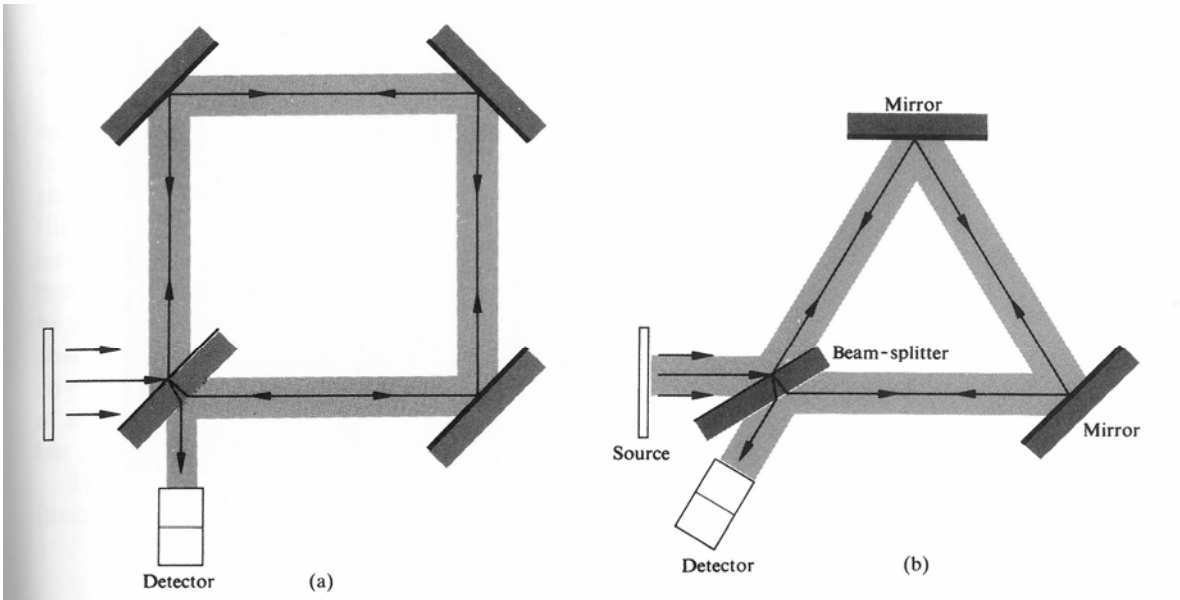

Figure 9.29 (***a***) A Sagnac Interferometer. (***b***) Another variation of the Sagnac Interferometer.