01. The Rise of the Wave Theory of Light.

Buchwald (1989), Intro.

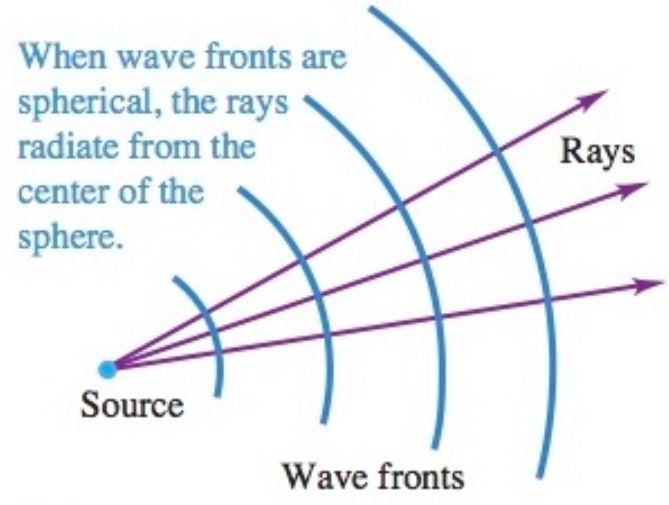
- *Emission theory*: Light consists of particles interacting *via* forces.
- *Wave theory*: Light consists of waves (in the "ether").

Some concepts:

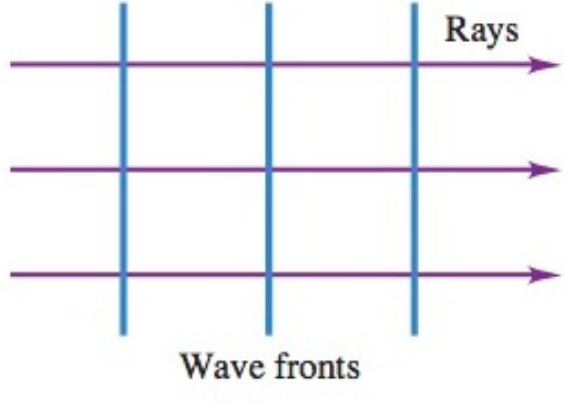
- *wave front* = locus of points at which the phase of vibration of a physical quantity associated with the wave is the same.
- *ray* = path of particle *or* imaginary line in direction of wave propagation.
- *beam* = bundle of rays.

Contemporary distinctions:

- *Geometric optics*: describes light propagation in terms of rays.
- *Physical optics*: describes light propragation in terms of waves.
- *Electrodynamics*: theory of electromagnetic phenomena (including light).



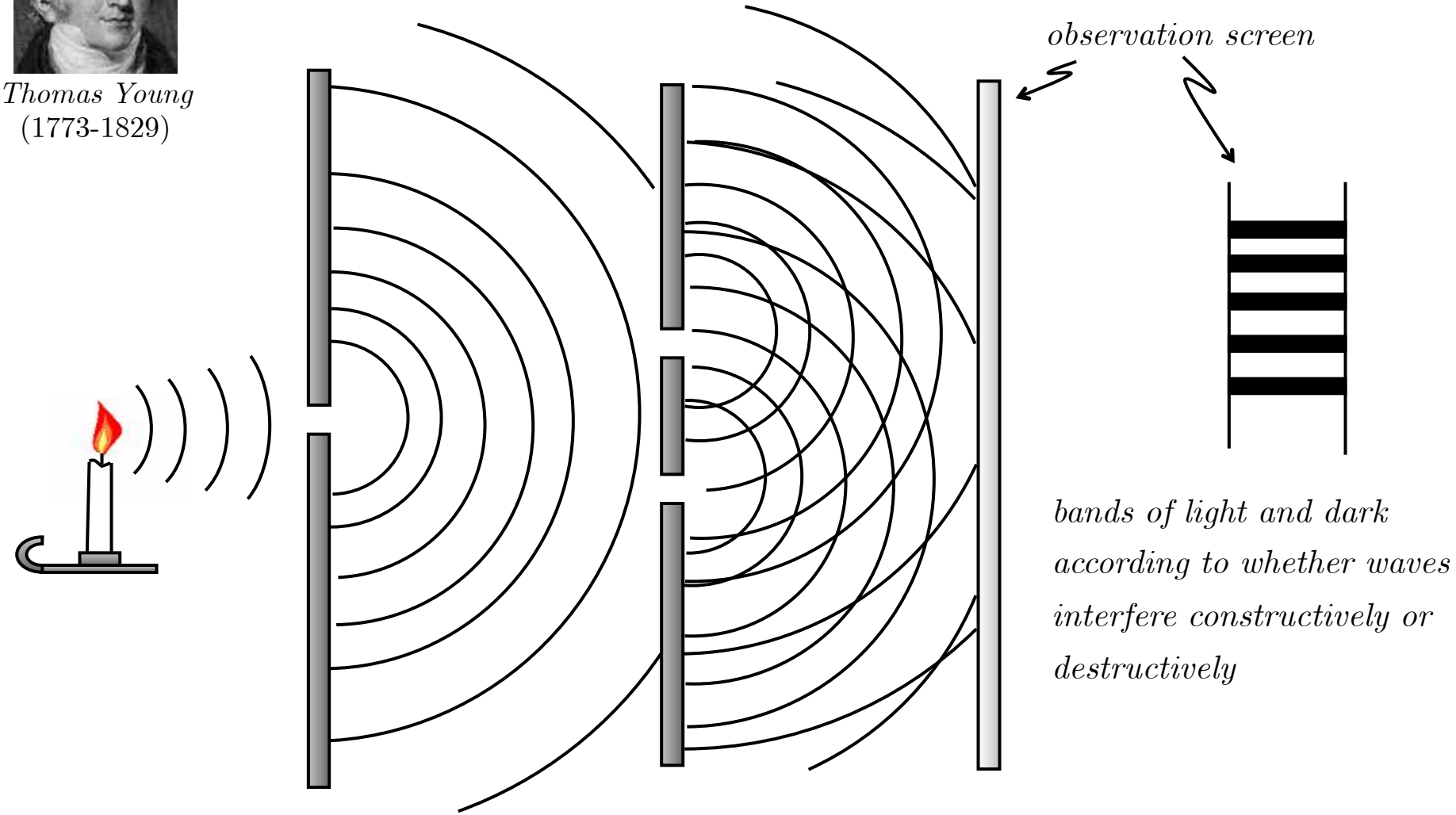
When wave fronts are planar, the rays are perpendicular to the wave fronts and parallel to each other.



- *Standard View*: Physics entailed mathematics. Adopting wave theory entailed using mathematics of waves to describe optical phenomena. 1830s successful wave descriptions of interference, diffraction and polarization.

Thomas Young
(1773-1829)

Young's 2-Slit Experiment (~1800)



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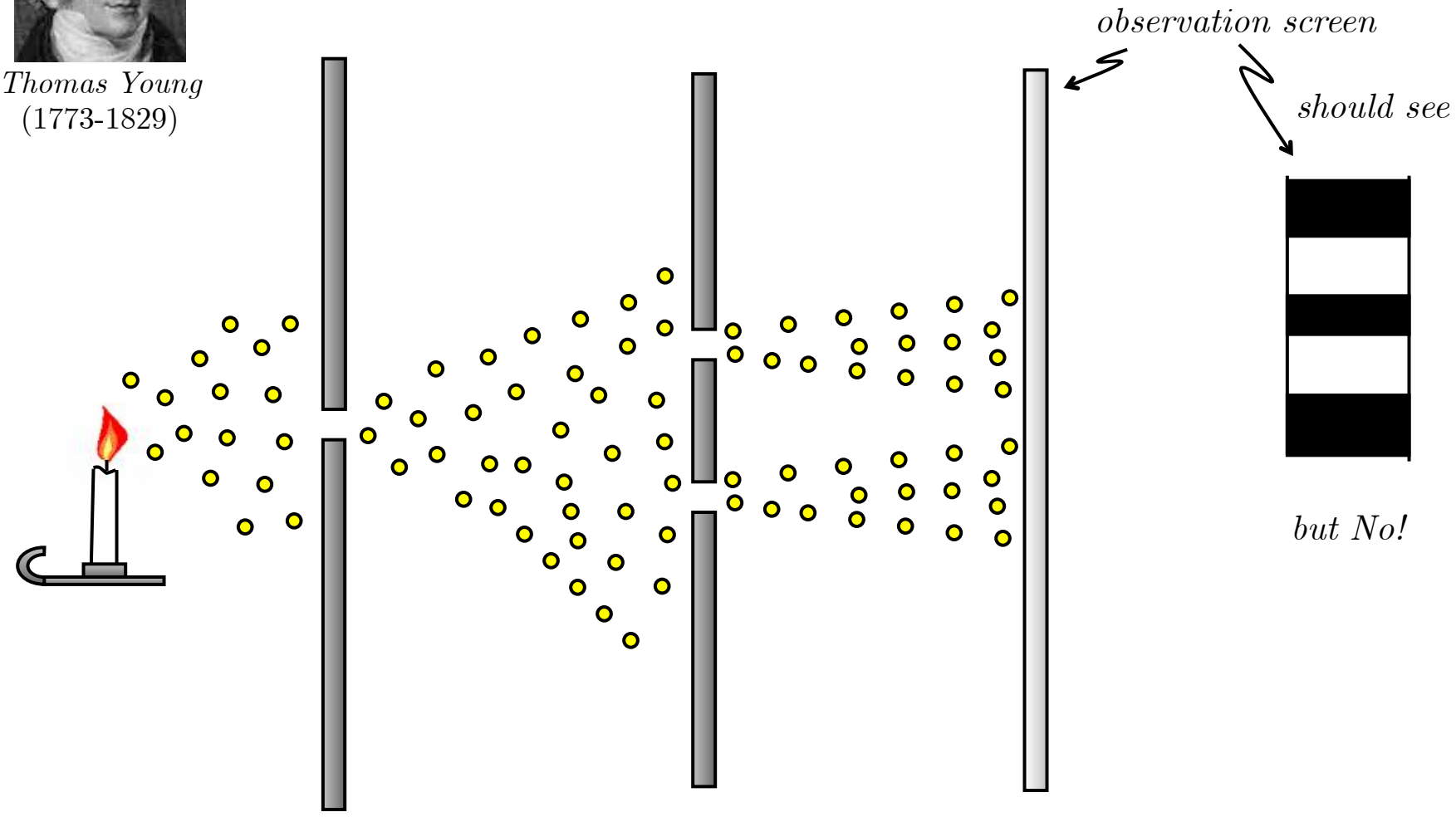
- If light consists of particles, should see...



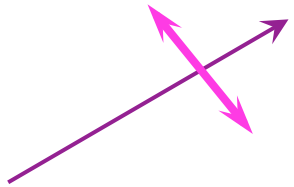
- *Buchwald's View*: Mathematics entailed physics. Rise of wave theory in 1830s involved mathematical use of *wave fronts* as opposed to *rays* as tools of analysis.
  - Distinction between *physical* and *mathematical* aspects of a given theory.
  - *Claim* 1: Fresnel's formulation of the mathematical wave theory made use of the physics possible.
  - *Claim 2*: One could discard emission theory but still retain its mathematics.

Augustin-Jean Fresnel (1788-1827)

Why? Emissionists and wave theorists had different concepts of a ray.

Emissionist understanding of a ray:

- Rays possess individual identities.
  - *Rays can be counted: #rays = intensity of beam.*
- Rays possess inherent asymmetry (like a stick with a cross-piece nailed to it at right angles).



Emissionist understanding of polarization:

- Polarization is a property of beams, not individual rays.
  - *A polarized beam made up of rays all with identically oriented cross-pieces.*
- Polarization comes in degrees.
- Polarization is relative to detectors.
  - *A beam can be polarized with respect to one detector, but partially polarized with respect to another.*

Selectionism = theory in which rays are selected by the apparatus (as in polarization filters).

Wave theorist understanding of a ray:

- Rays are mathematical abstractions: *they can't be counted.*

Wave theorist understanding of polarization:

- Polarization is a property of waves.
  - *Polarization refers to an asymmetry at a point in the wave front.*
  - *But*: *Every point in the wave front is associated with a unique ray.*
- *So*: Polarization can also be thought of as a property of individual rays.
- Polarization is absolute and not relative to detectors.

Misunderstandings between selectionists and wave theorists

- "It was apparently very hard for wave theorists to see that selectionists often needed only to count rays rather than to rely directly on the intricate details of particles and forces..." (Buchwald 1989, pg. xix.)
- "[In addition to the Standard View], one must also try to capture the effects of the more delicate and difficult distinctions between rays and waves, distinctions that usually remained just below the surface of scientific discourse, subtly affecting its texture and tone." (Buchwald 1989, pg. xx.)