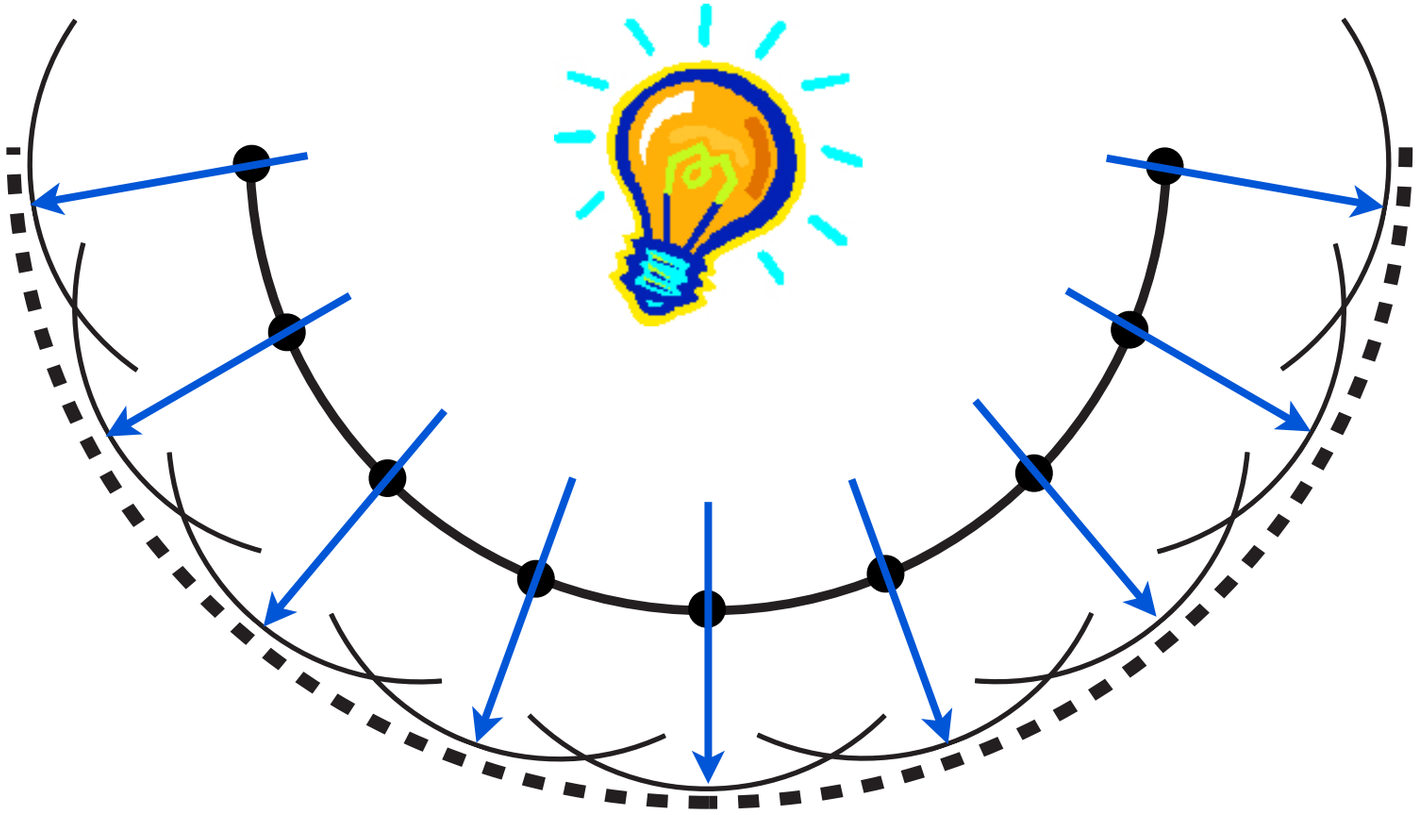
Light as a wave

- Huygen's wave theory
- Newton's corpuscular theory
- Young's double slit experiment
- Double slit interference
- Diffraction
- Single slit interference

- The electromagnetic nature of light
- The electromagnetic spectrum
- Light as electromagnetic radiation

Huygen's wave theory

- **"Light travels as a wave and each point on the existing wave-front acts as a source."**
- This helps to explain some of the wave properties of light: Reflection at an equal angle & refraction at a change of medium.

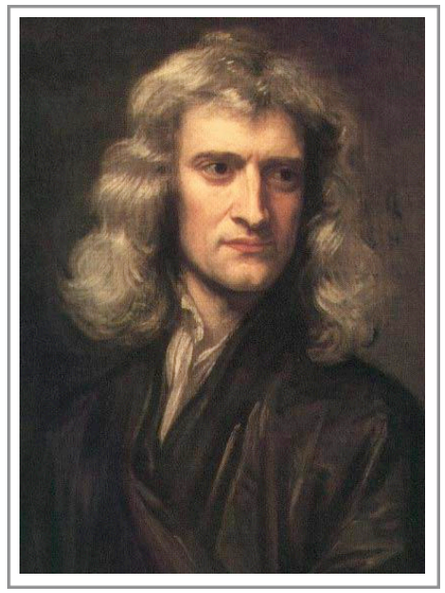


Problems with the theory:

- **Sound waves diffract around an object but light will cast a distinct shadow behind an object. Why no diffraction?**
- **What material transmits the waves? Ether?**

Huygen's Principle

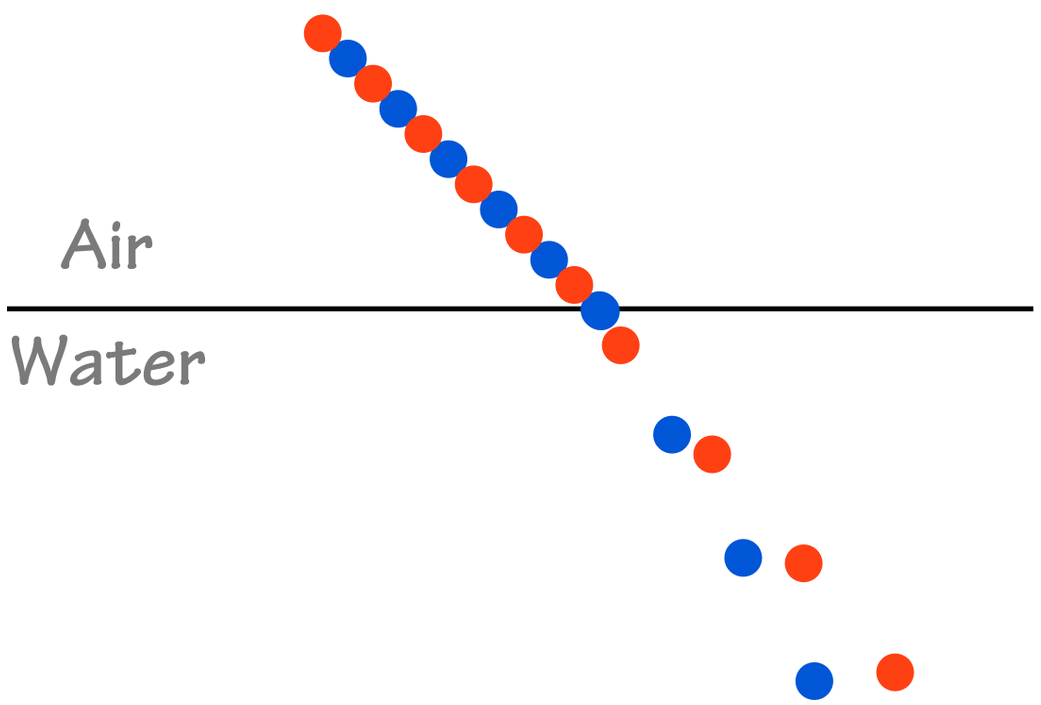
Newton's corpuscular theory



"Light is a stream of small particles"

This helps to explain:

- Travelling through space.
- Reflection of light -conservation of momentum.
- Refraction - attraction of particles to medium.
- Dispersion - red particles are heavier & refract less.
- Lack of diffraction of light around an obstacle.

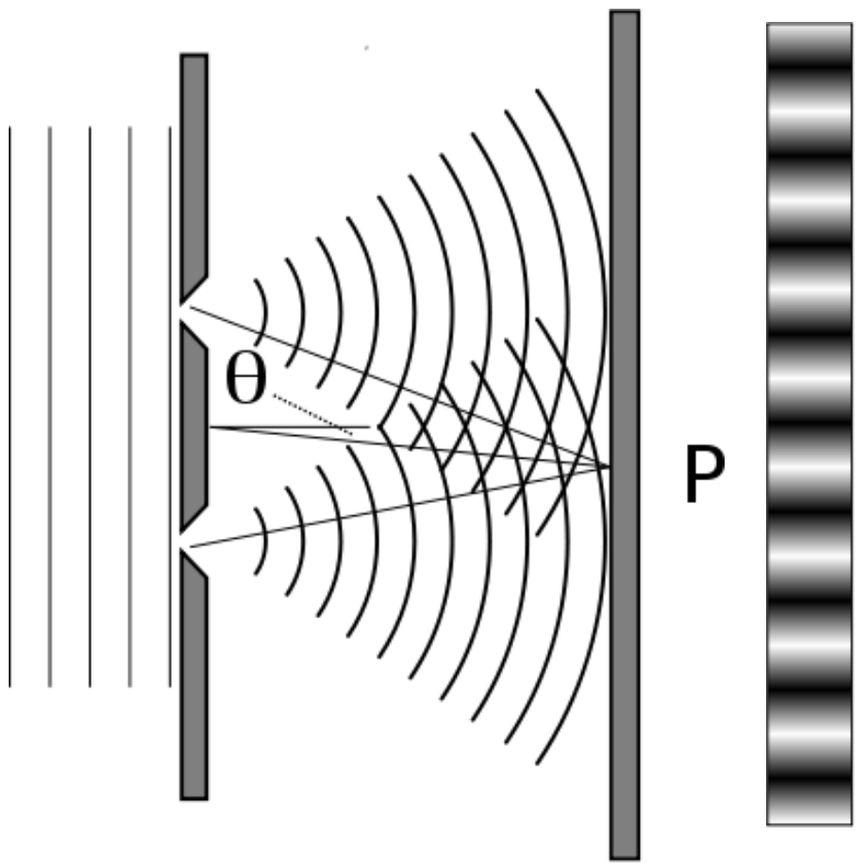


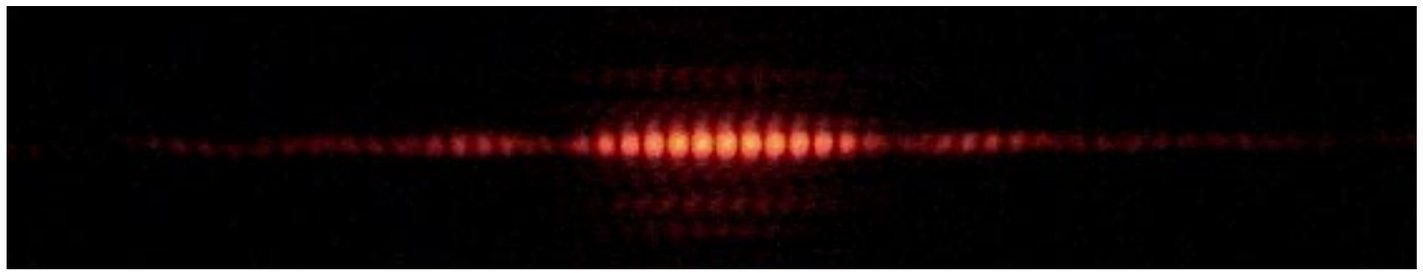
Problems with the theory:

- Particles must speed up entering a denser medium - this was later disproved by Focault.
- Later knowledge of the nature of light explains diffraction (λ/d) - the wavelength is too small to diffract around large objects.

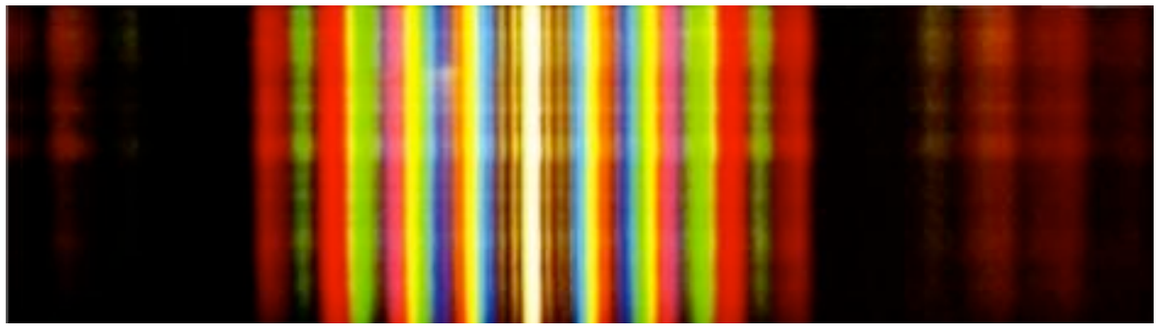
Young's double slit experiment

- Thomas Young set up a converging lens with light directed through two vertical slits.
- Expected from particle theory: two vertical lines.
- Actual result: a distribution of light and dark regions.
- Conclusion: maxima and minima are from wave interference (same as sound waves!)



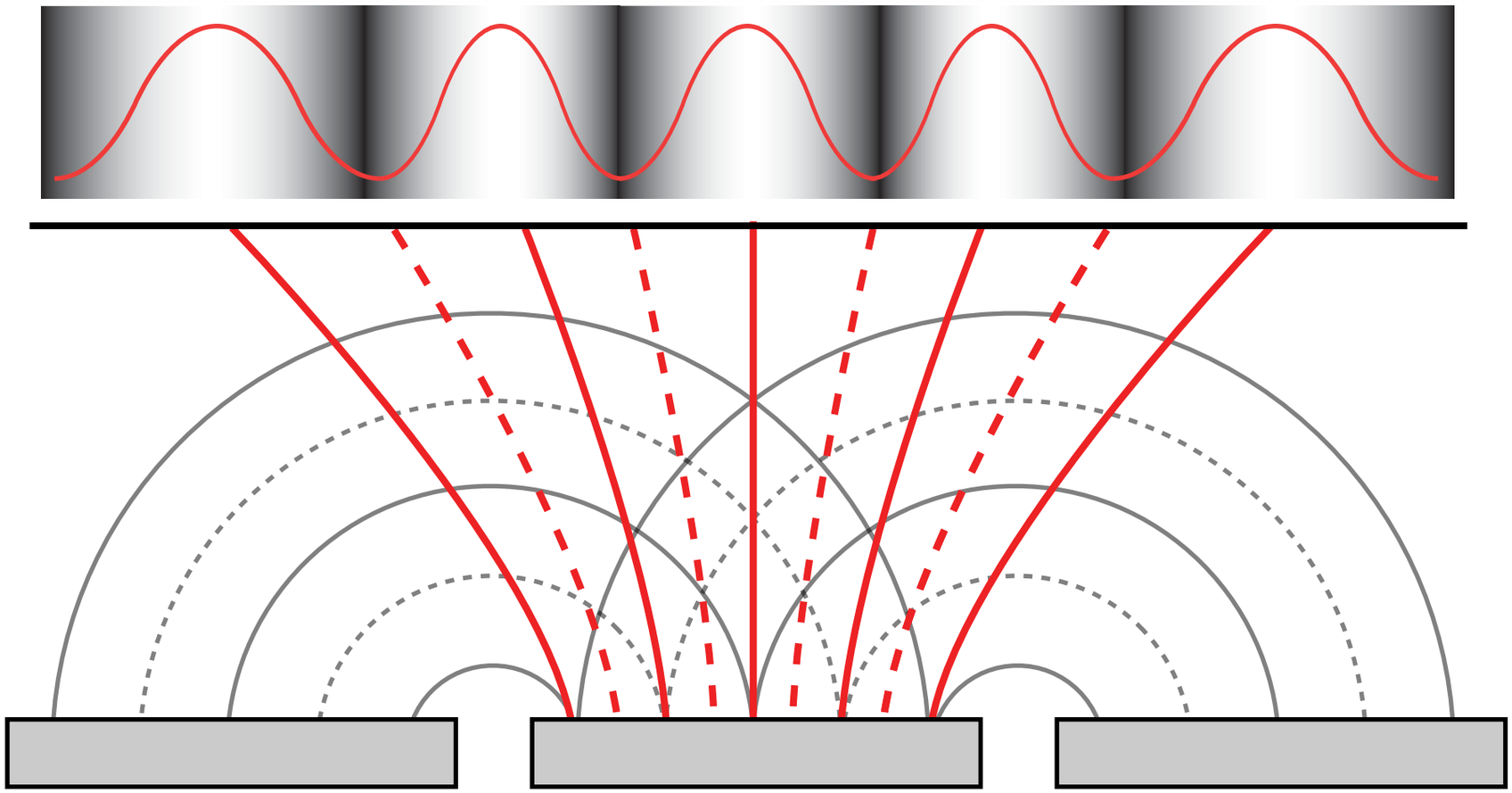


Monochromatic laser source



White light source: colour bands due to the increased / decreased intensity of particular wavelengths.

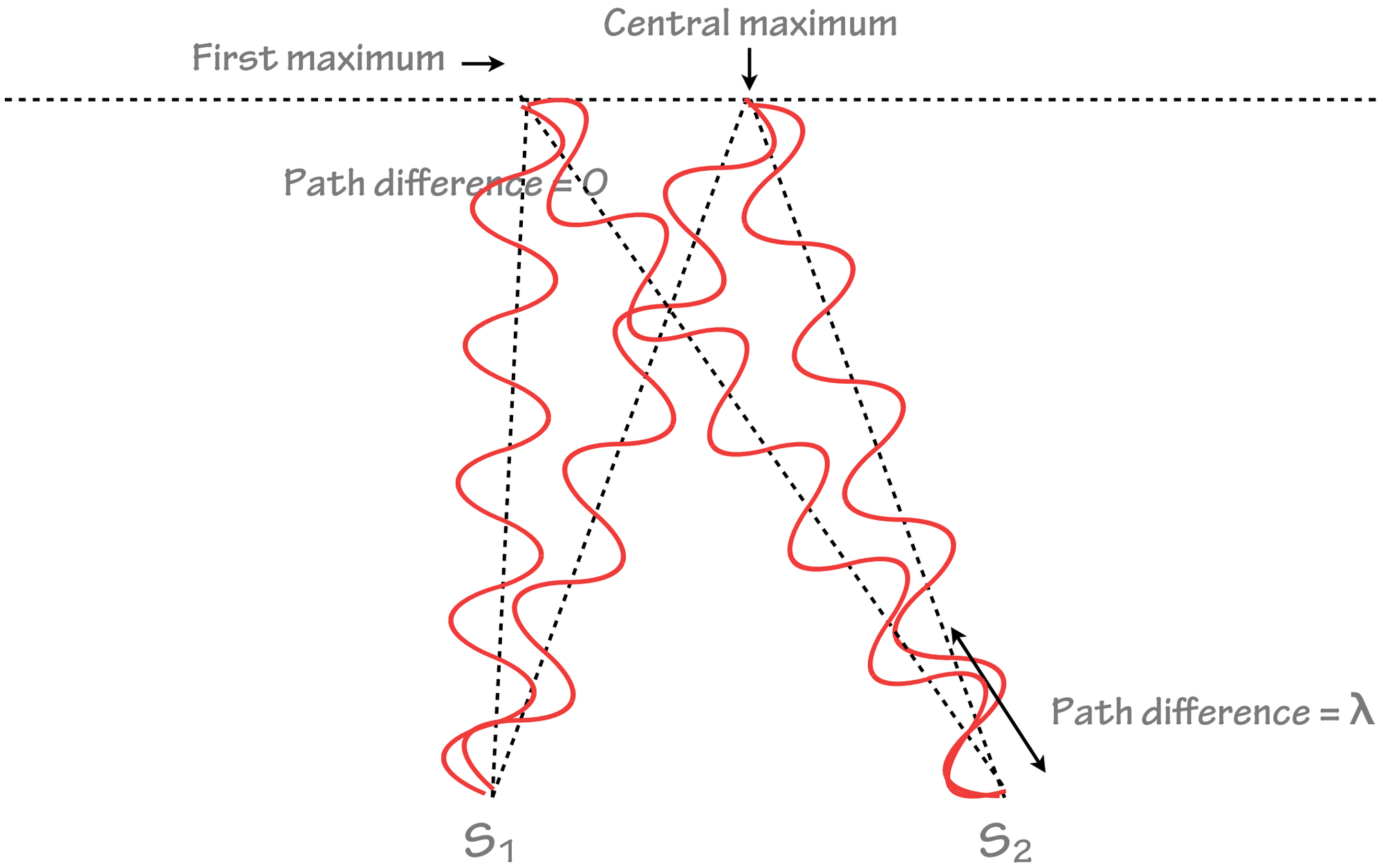
Double slit interference



- Maximum intensity (constructive interference) where the path difference from the point to both slits is a multiple of a whole wavelength: $n\lambda$.
- Spacing of maxima is proportional to λ/d

Double slit interference

- Bright lines (maxima) are the result of constructive interference.



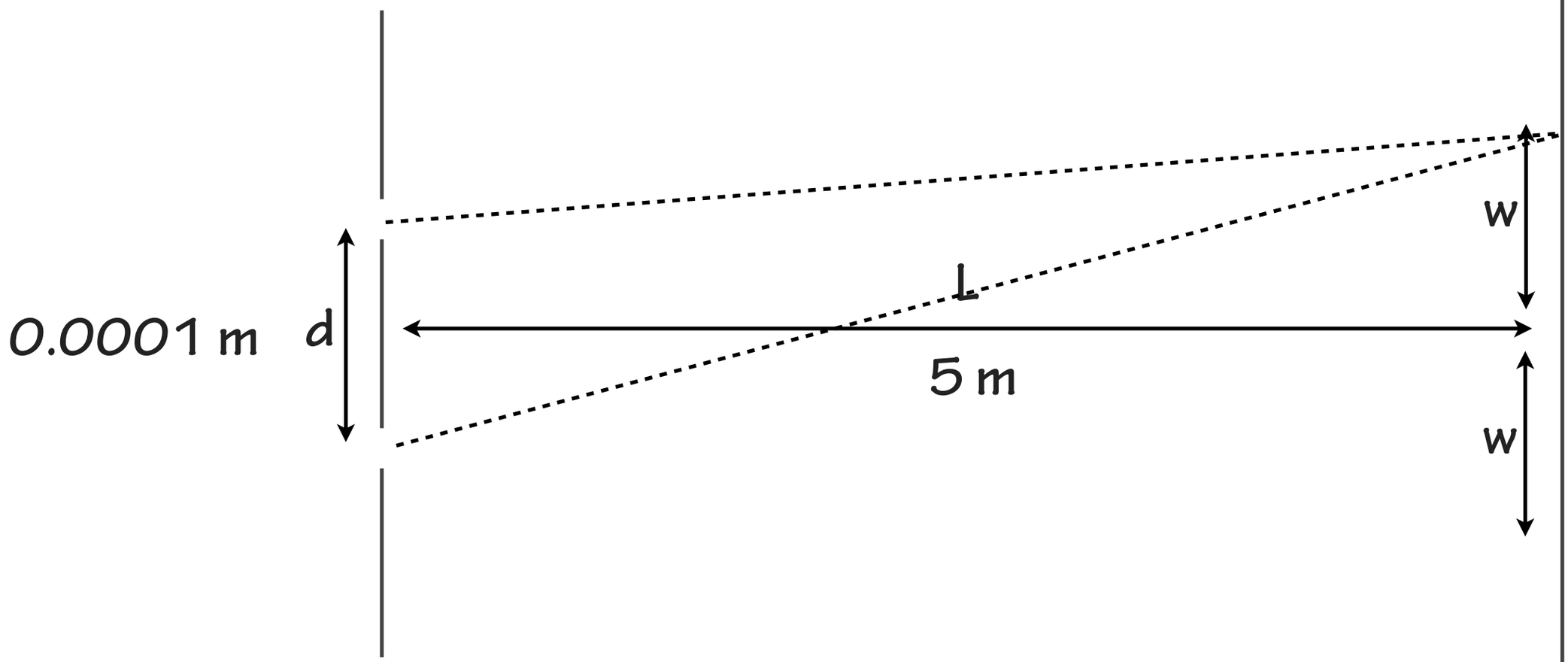
Double slit interference

- Maximum intensity (*constructive interference*) where the path difference from the point to both slits is a multiple of a whole wavelength: $n\lambda$.
- Minima (*destructive interference*) where path difference = $(n-1)\ \lambda/2$.
- Spacing of maxima is proportional to λ/d.

Double slit interference

Double slit interference

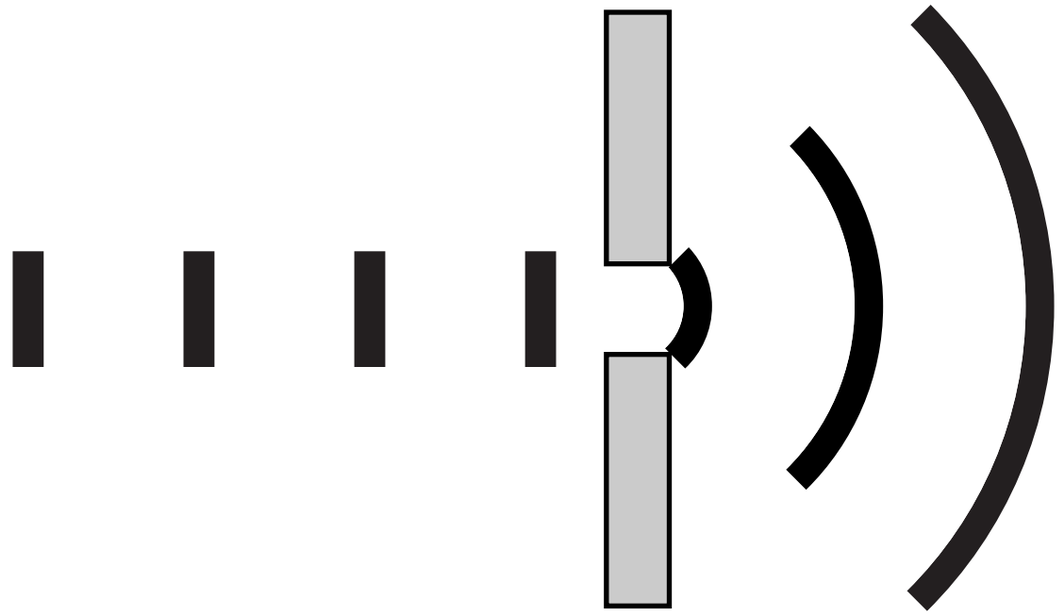
- eg slits 0.1 mm apart, violet light λ=400nm. Spacing of central & first maxima when projected 5m is:



$$w = L\frac{\lambda}{d} \qquad w = 5m \times \frac{4\times10^{-7}\ \text{m}}{1\times10^{-4}\ \text{m}} \qquad w = 2\times10^{-2}\ \text{m} = 2\ \text{cm}$$

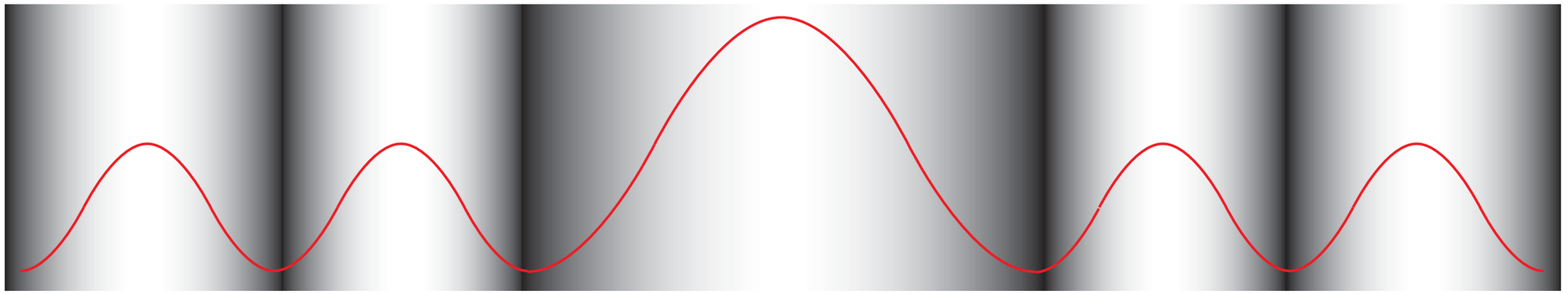
Diffraction

- Diffraction is the spreading of waves around objects or through gaps.
- Diffraction of light is significant for gaps of that are up to100 times larger than the wavelength.



Single slit interference

- Diffraction results in series of light & dark lines from constructive & destructive interference.
- Each edge of the slit acts as a point source for wave propagation.
- As light can pass straight through the middle, the central bright band is wider & more intense than the ones either side.



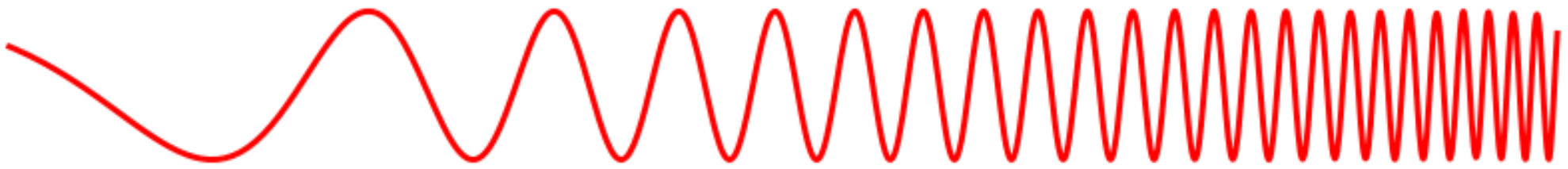
Single slit diffraction

The electromagnetic nature of light

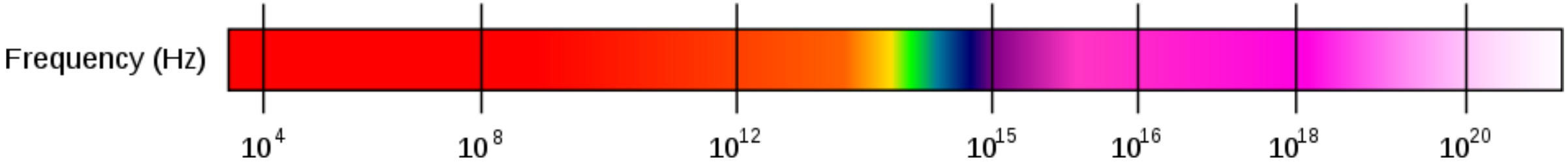
- In the 19th century, James Clerk Maxwell made predictions about magnetic fields ⇔ electric fields. An EM wave would continue to propagate at 3×10^8 m/s.

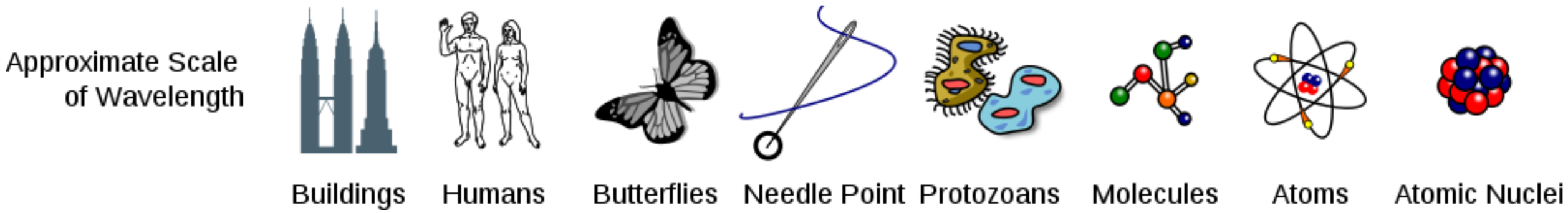
- Heinrich Hertz set up an induction coil with a spark jumping across a gap; with a similar coil a distance away. The second coil also sparked.
- This showed that the **electromagnetic waves** were being transmitted.

The electromagnetic spectrum



Radiation Type	Radio	Microwave	Infrared	Visible	Ultraviolet	X-ray	Gamma ray
Wavelength (m)	10^{3}	10^{-2}	10^{-5}	0.5×10^{-6}	10^{-8}	10^{-10}	10^{-12}





Light as electromagnetic radiation

- Light is a part of the **electromagnetic spectrum** (radio waves → gamma radiation).
- Visible light is violet (~400nm) → red (~700nm).
- Electromagnetic radiation is a **transverse wave** with perpendicular alternating electrical and magnetic fields.
- Electromagnetic radiation is **polarised**. The oscillations occur in defined planes (eg polaroid lens in sunglasses & LCD screens, TV antennas).