h dimensionality and de Broglie wavelength

Units of h?

$$h = \frac{[E]}{[\nu]} = \frac{M\frac{r^2}{t^2}}{\frac{1}{t}} =$$

r - length
M - mass
t - time

$$= \frac{Mr^2}{t} = \underbrace{[r]}_{r}\underbrace{\left[M\frac{r}{t}\right]}_{p}$$ – angular momentum

$\pm\frac{1}{2}\hbar$ - spin

Since $[h]=[r][p]$ we can be inventive.

What units of h lead us to?

We can associate length to the particles.

m $\quad \lambda = \frac{h}{p}$ ~ de Broglie wavelength

If the particle does not move

$$\lambda = \frac{h}{mc}$$ – Compton wavelength

(Compton $\lambda \neq$ de Broglie λ)

$$mc^2 = E_{ph} = h\nu = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{h}{mc}$$

wavelength of photon with same energy.

For electron of mass m:

$$\lambda \sim 2.1\ \text{pm}\ !$$

Louis de Broglie (1924)

de Broglie suggested duality is applicable to other particles:

photon: particle E, p $\longleftrightarrow$ wave ν

If photons are dual (particle and wave) why particles in general can be seen as waves.

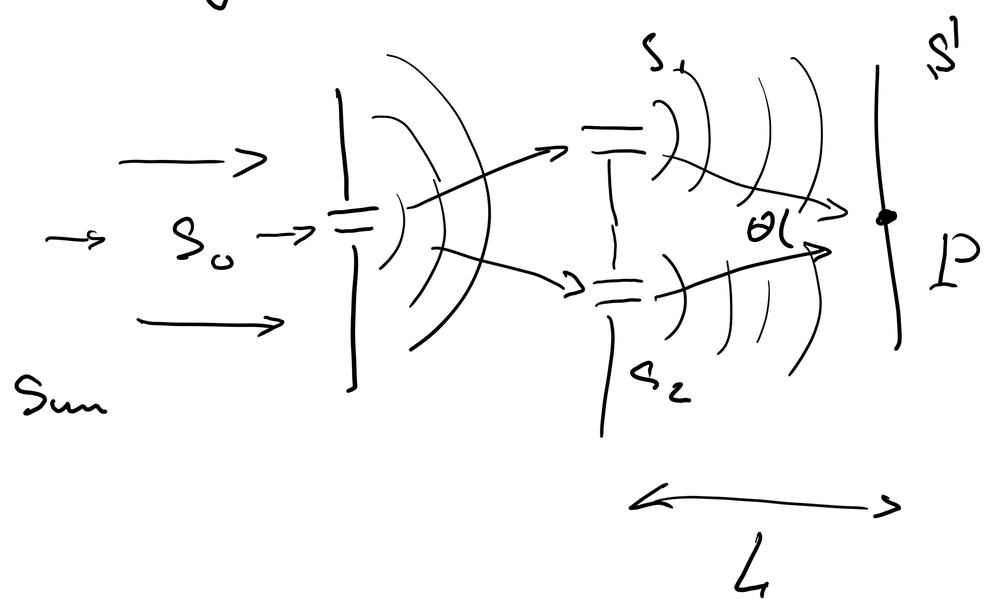
But wave of what?

Probability amplitudes

de Broglie said we will associate λ to particle

$$\lambda = \frac{h}{p}$$ plane wave

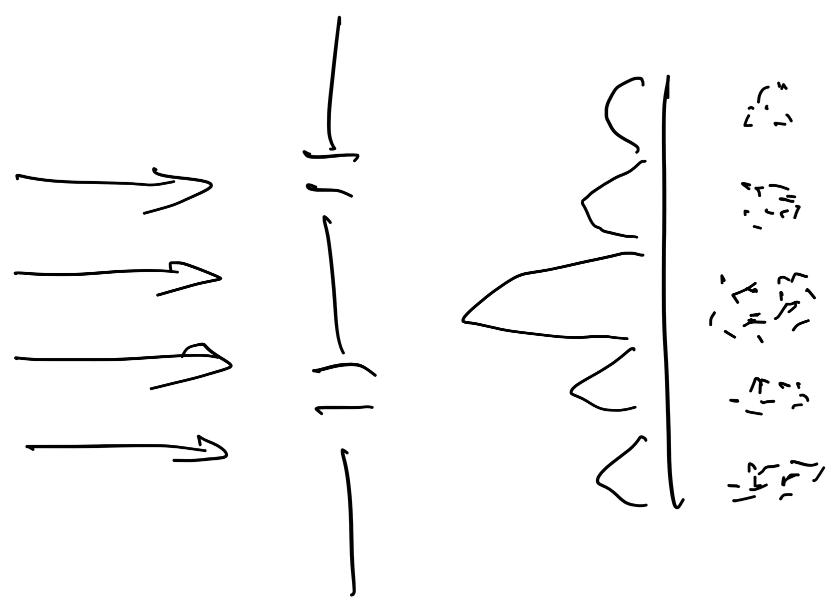
Young interferometer beginning of $\overline{\text{XIX}}$ century



$\Delta x = \frac{\lambda}{\theta}$ – width of interference pattern

$S_1S_2 = 1$ mm
$L = 1$ m
$\lambda = 600$ nm

$\Delta x \approx 0.6$ mm



Two-slit experiment from photon to molecules 10 kDa (1 pm)

de Broglie allowed to introduce wave function.