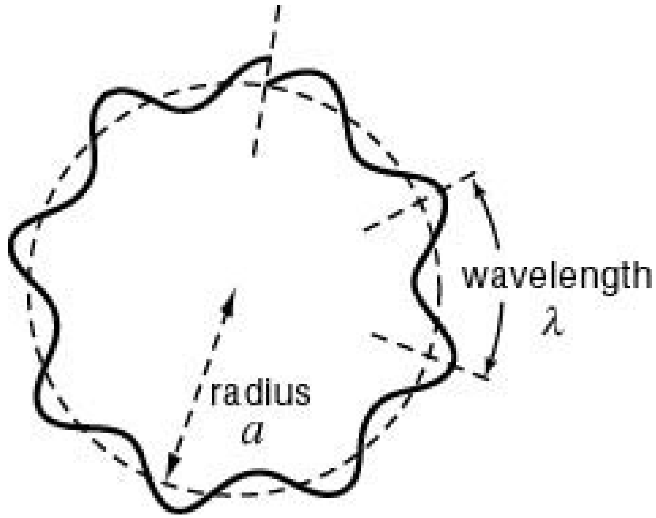
Bohr Model of Atom



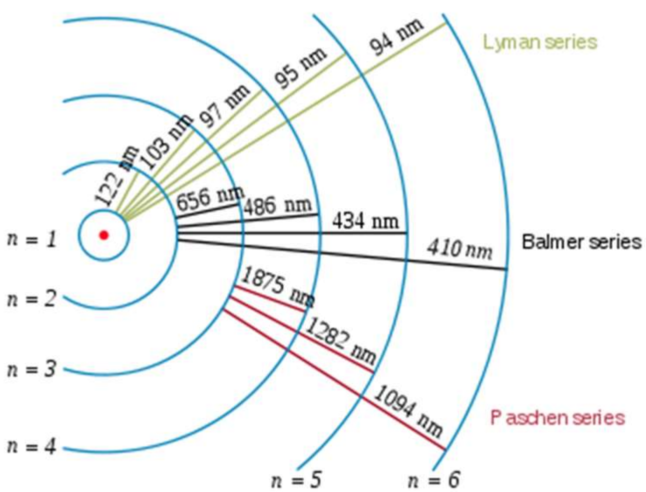
Angular momentum quantized

$$mvr = \frac{nh}{2\pi} \qquad \text{n=1,2,3,...}$$

$$(2\pi r = n\lambda\ )$$

Energy expression

$$E_n = -\frac{m_e e^4}{8\varepsilon_0^2 h^2}.\frac{1}{n^2}$$



Spectral lines

$$\Delta E = \frac{m_e e^4}{8\varepsilon^2 h^2}\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right) = h\nu \qquad n_i, n_f = 1, 2, 3, \ldots$$

Explains Rydberg formula

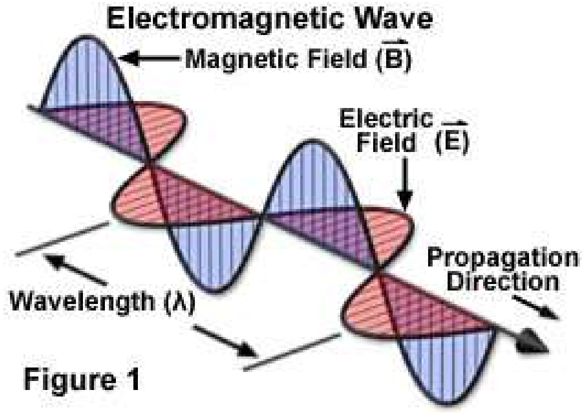
$$R_\infty = \frac{m_e e^4}{8\varepsilon^2 h^2} = 1.09678 \text{ x } 10^{-2}\,\text{nm}^{-1}$$

Ionization potential of H atom 13.6 eV

Bohr Model of Atom

The Bohr model is a primitive model of the hydrogen atom. As a theory, it can be derived as a first-order approximation of the hydrogen atom using the broader and much more accurate quantum mechanics

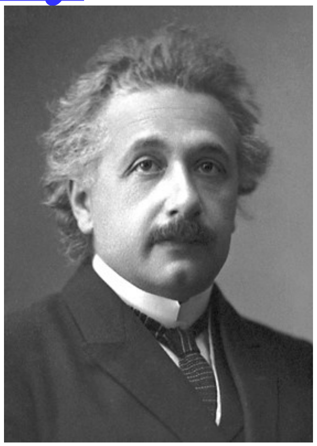
Photoelectric Effect: Wave –Particle Duality

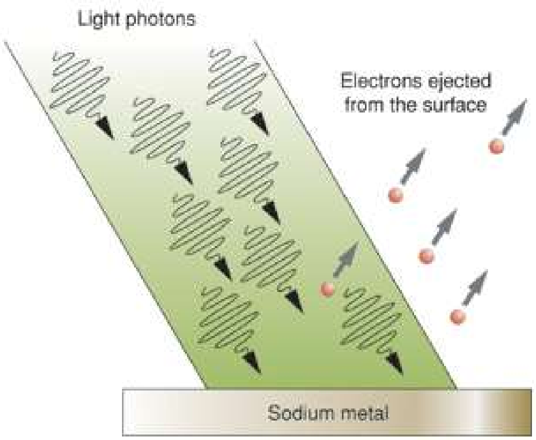


Electromagnetic Radiation

$$E = E_0 Sin(kx - \omega t)$$

Wave energy is related to Intensity
$I \propto E^2_o$ and is independent of ω



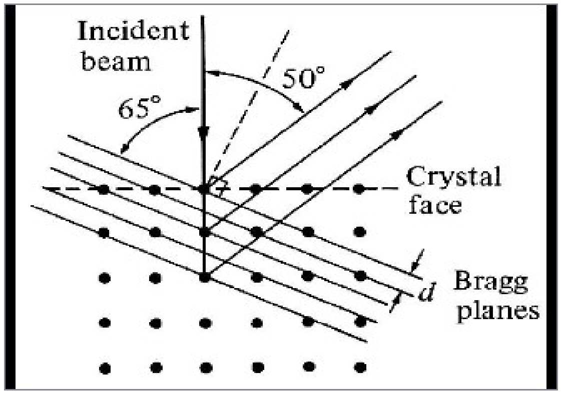


Einstein borrowed Planck's idea that ΔE=hν and proposed that radiation itself existed as small packets of energy (Quanta)now known as PHOTONS

$$E_P = h\nu = KE_M + \phi = \frac{1}{2}mv^2 + \phi$$

ϕ = Energy required to remove electron from surface

Diffraction of Electrons : Wave –Particle Duality



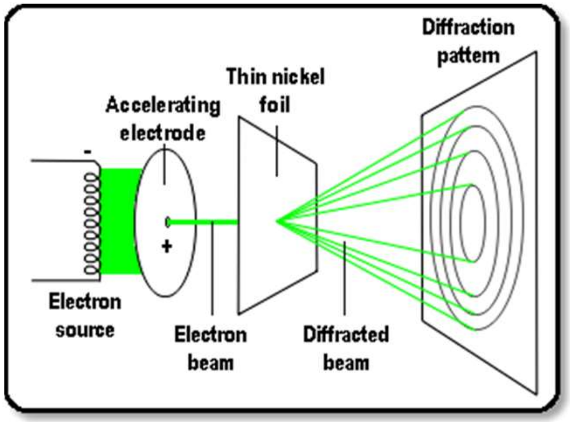
Davisson-Germer Experiment

A beam of electrons is directed onto the surface of a nickel crystal. Electrons are scattered, and are detected by means of a detector that can be rotated through an angle θ. When the Bragg condition $m\lambda = 2d\sin\theta$ was satisfied (d is the distance between the nickel atom, and m an integer) constructive interference produced peaks of high intensity

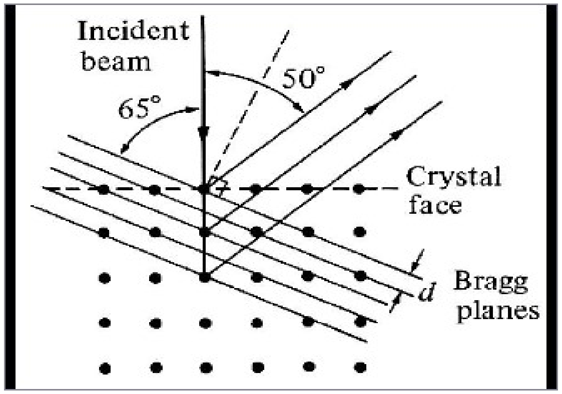
Diffraction of Electrons : Wave –Particle Duality

G. P. Thomson Experiment

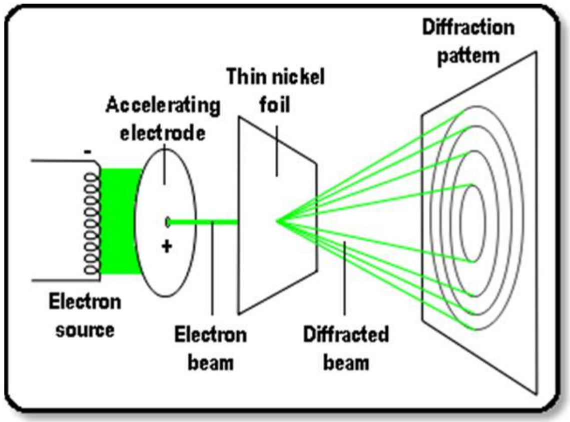
Electrons from an electron source were accelerated towards a positive electrode into which was drilled a small hole. The resulting narrow beam of electrons was directed towards a thin film of nickel. The lattice of nickel atoms acted as a diffraction grating, producing a typical diffraction pattern on a screen



Diffraction of Electrons : Wave –Particle Duality



The wavelength of the electrons was calculated, and found to be in close agreement with that expected from the De Broglie equation



de Broglie Hypothesis: Mater waves

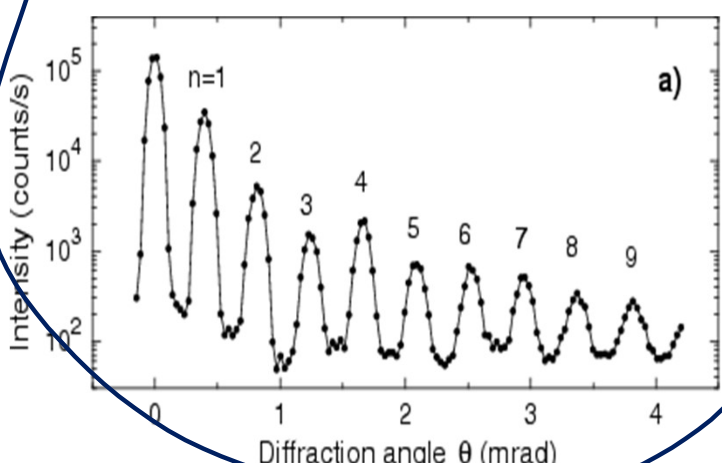
Since Nature likes symmetry,
Particles also should have wave-like nature

De Broglie wavelength

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

Electron moving @ 10^6 m/s

$$\lambda = \frac{h}{mv} = \frac{6.6\text{x}10^{-34}\ \text{J s}}{9.1\text{x}10^{-31}\ \text{Kg} \times 1\text{x}10^{6}\ \text{m/s}} = 7\times10^{-10}\,m$$



He-atom scattering

Diffraction pattern of He atoms at the speed 2347 m s^{-1} on a silicon nitride transmission grating with 1000 lines per millimeter. Calculated de Broglie wavelength $42.5\text{x}10^{-12}$ m

de Broglie wavelength too small for macroscopic objects

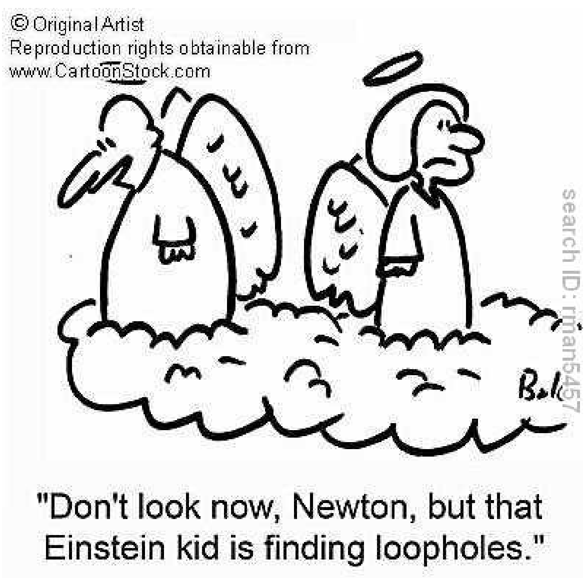
Wave –Particle Duality

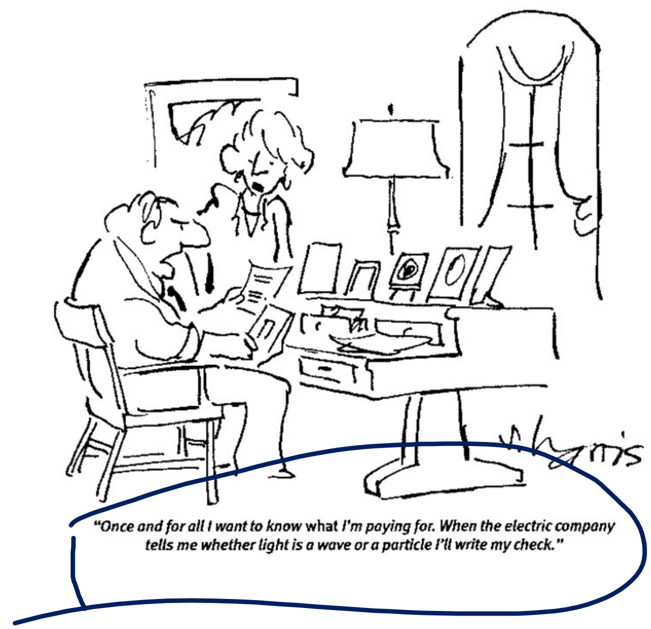
Light can be Waves or Particles. NEWTON was RIGHT!

Electron (matter) can be Particles or Waves

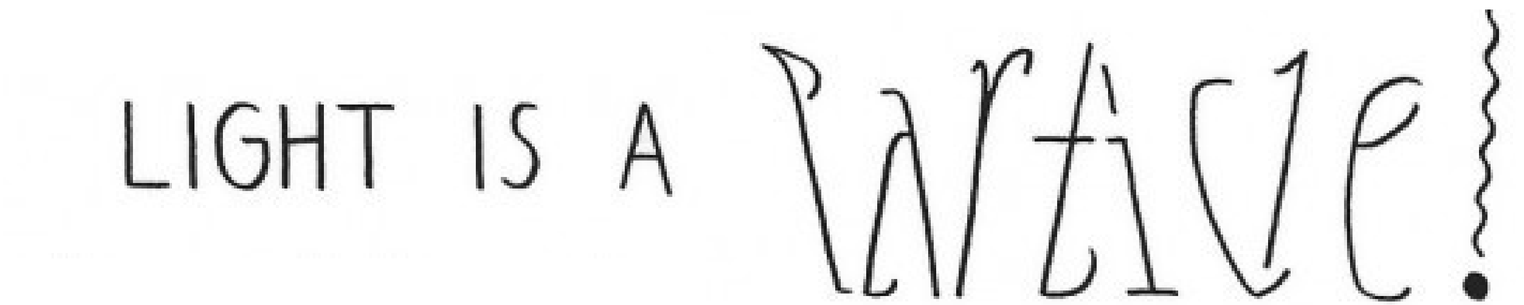
Electrons and Photons show both wave and particle nature "WAVICLE"

Best suited to be called a form of "Energy"

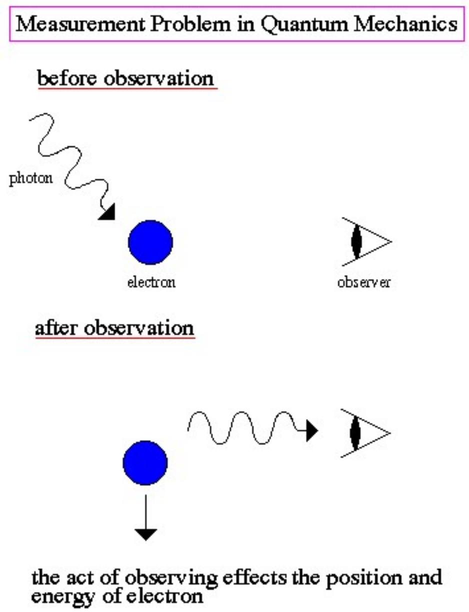


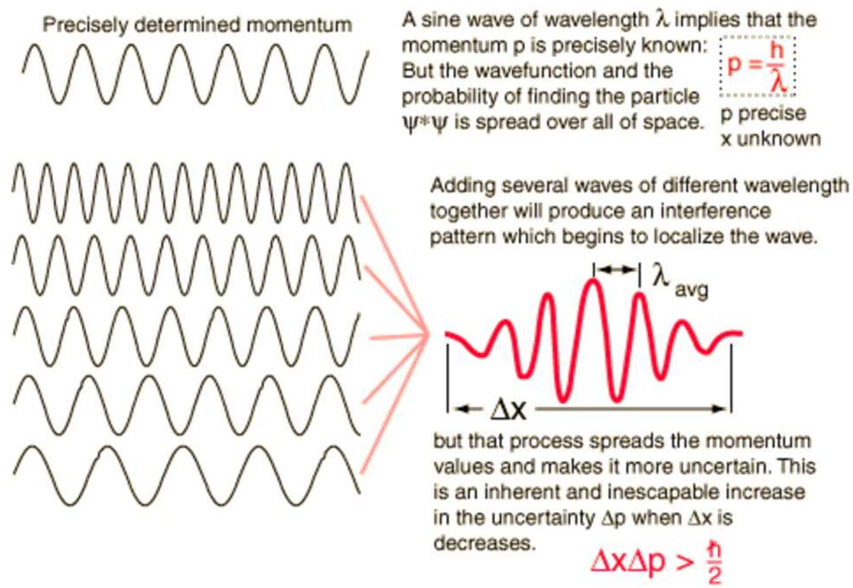


Wave –Particle Duality



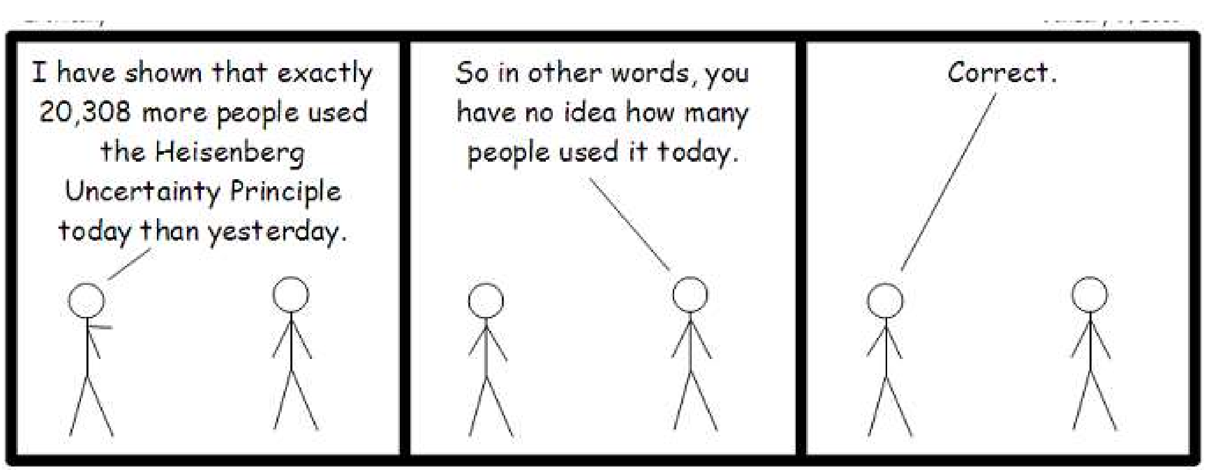
Uncertainty Principle

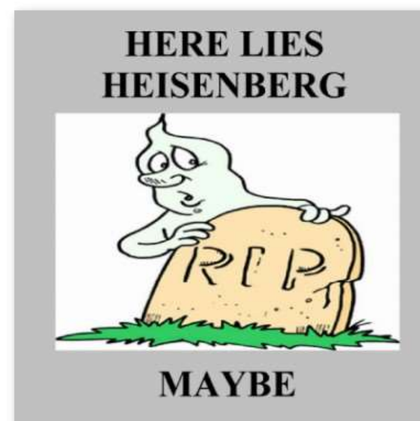




Uncertainty principle

$$\Delta x . \Delta p_x \geq \frac{h}{4\pi}$$





Schrodinger's philosophy

PARTICLES can be WAVES
and WAVES can be PARTICLES

New theory is required to explain the behavior of electrons, atoms and molecules

Should be Probabilistic, not deterministic (non-Newtonian) in nature

Wavelike equation for describing sub/atomic systems

Schrodinger's philosophy

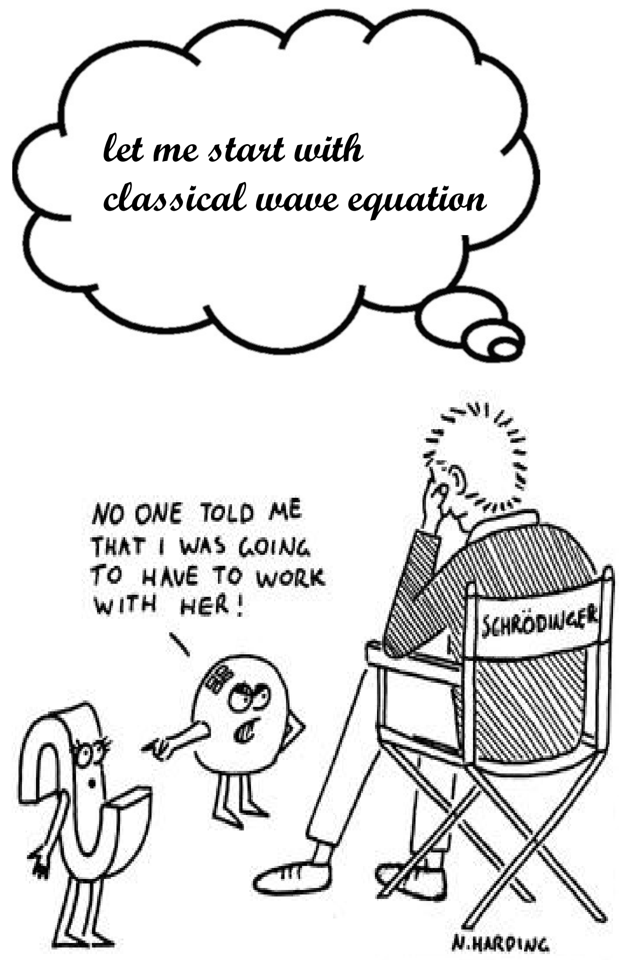
PARTICLES can be WAVES
and WAVES can be PARTICLES

A concoction of

$$E = T + V = \frac{1}{2}mv^2 + V = \frac{p^2}{2m} + V$$

$E = h\nu = \hbar\omega$ Wave is Particle

$\lambda = \dfrac{h}{p} = \hbar k$ Particle is Wave



Do I need to know any Math?

Algebra

$$A\left[c_1 f_1(x) + c_2 f_2(x)\right] = c_1 A f_1(x) + c_2 A f_2(x)$$

Trigonometry

$$Sin(kx) \qquad Cos(kx) \qquad e^{ikx}$$

Differentiation

$$\frac{d}{dx} \qquad \frac{d^2}{dx^2} \qquad \frac{\partial}{\partial x} \qquad \frac{\partial^2}{\partial x^2}$$

Integration

$$\int e^{ikx} dx \qquad \int_a^b f(x) dx$$

Differential equations

$$\frac{\partial^2 f(x)}{\partial x^2} + \frac{\partial^2 f(y)}{\partial y^2} + \frac{\partial f(x)}{\partial x} + \frac{\partial f(y)}{\partial y} + m f(x) + n f(y) = k$$

Schrodinger's philosophy

$$\frac{\partial^2 \Psi(x,t)}{\partial x^2} = \frac{1}{c^2}\frac{\partial^2 \Psi(x,t)}{\partial t^2}$$ Classical Wave Equation

$\Psi(x,t) = \text{Amplitude}$

$\Psi(x,t) = Ce^{i\alpha}$; Where $\alpha = 2\pi\left(\frac{x}{\lambda} - \nu t\right)$ is the phase

Remember!

$$E = h\nu = \hbar\omega$$

$$\lambda = \frac{h}{p} = \frac{2\pi}{k}$$

$$\alpha = 2\pi\left(\frac{x}{\lambda} - \nu t\right) = \frac{x \cdot p - E \cdot t}{\hbar}$$

Schrodinger's philosophy

$$\Psi(x,t) = Ce^{i\alpha} \quad \text{and} \quad \alpha = \frac{x \cdot p - E \cdot t}{\hbar}$$

$$\frac{\partial \Psi(x,t)}{\partial t} = iCe^{i\alpha} \cdot \frac{\partial \alpha}{\partial t} = i \cdot \Psi(x,t) \cdot \frac{\partial \alpha}{\partial t} = i \cdot \Psi(x,t) \cdot \left(\frac{-E}{\hbar} \right)$$

$$\boxed{\frac{-\hbar}{i} \frac{\partial \Psi(x,t)}{\partial t} = E \cdot \Psi(x,t)}$$