$-\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial x^2} = i\hbar\frac{\partial\Psi}{\partial t}$ $F_{net} = 0$

$\Psi(x,t) = A e^{i(kx-\omega t)}$ $\frac{\hbar^2 k^2}{2m} = \hbar\omega$

$= A[\cos(kx-\omega t) + i\sin(kx-\omega t)]$ $\frac{p^2}{2m} = E$

plane wave solution

prob. of finding particle at (x,t)

$|\Psi|^2 = \Psi^*\Psi = (A^* e^{-i(kx-\omega t)}) A e^{i(kx-\omega t)}$

$= A^* A = |A|^2 = \text{constant}$

equally likely to be found anywhere
perfect wave, no localization

Total probability = 1

$\int_{-\infty}^{\infty} |\Psi|^2 \, dx = 1$ solve this for A.

if $|\Psi|^2$ = constant & range $-\infty$ to ∞
then Ψ is unnormalizable & doesn't describe a real object

so $Ae^{i(kx-\omega t)}$ is not a real solution by itself

BUT Schrodinger eq. is linear

$-\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial x^2} = i\hbar\frac{\partial\Psi}{\partial t}$

if Ψ_1 & Ψ_2 are solutions
then $\Psi_1 + \Psi_2$ is also a solution

Solutions to Sch eq are
linear combinations of $A_k e^{i(kx-\omega t)}$
w/ different values of k

And some of these combos <u>are</u> normalizable.

Uncertainty

$x = 5\,m \pm 0.01\,m$

standard deviation $\sigma = \sqrt{\dfrac{\sum_i (x_i - \bar{x})^2}{N}}$

Δx

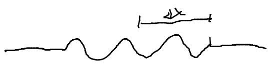
$5\,m \pm 0.01\,m$

$x \pm \Delta x$

plane wave

$\Delta x = +\infty$ location is completely unknown

$\Delta p = \Delta(\hbar k) = 0$ momentum is perfectly known



Δx smaller

$\Delta p \neq 0$ some uncertainty in λ

Δx is very small

Δp is very uncertain

More certain x is,
less certain $\lambda \to k \to p$ are

$$\Delta x \, \Delta p_x \geq \frac{\hbar}{2}$$

Heisenberg uncertainty principle

"$\geq$" depends on shape of $\Psi(x,t)$

Neither ~~co~~ Δx or $\Delta p = 0$
so you cannot know exact location
or exact momentum of an object.

Does an object even have an exact location? Some say yes, some no.

e.g. electron in an atom

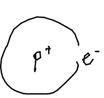
$\Delta x = 10^{-10}\,m$ (diameter of atom)

$\Delta p \geq \frac{\hbar}{2\Delta x} = 5 \times 10^{-25}\,kg\,m/s$

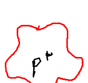
$\Delta v = \frac{\Delta p}{m} > 5.8 \times 10^{5}\,m/s$

at that speed, electron can travel $1\,Å$ (Δx) in $2 \times 10^{-14}\,s$.

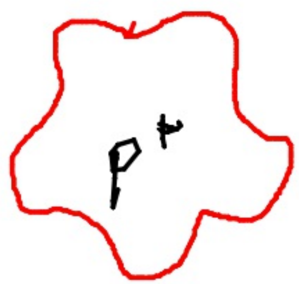
Electron could be anywhere in there
– electrons are waves inside atoms.



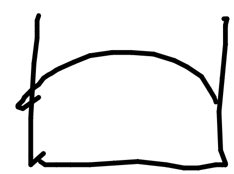
e^- should slow down (accelerating charge gives off energy) and crash into p^+ if it's a particle



Electron Forms a standing wave around the nucleus



And there is a minimum standing wave size



so electron can't ~~crash~~ get too close to p^+,

Electron is not accelerating - not orbiting nucleus - so no radiation is given off → stable atom.