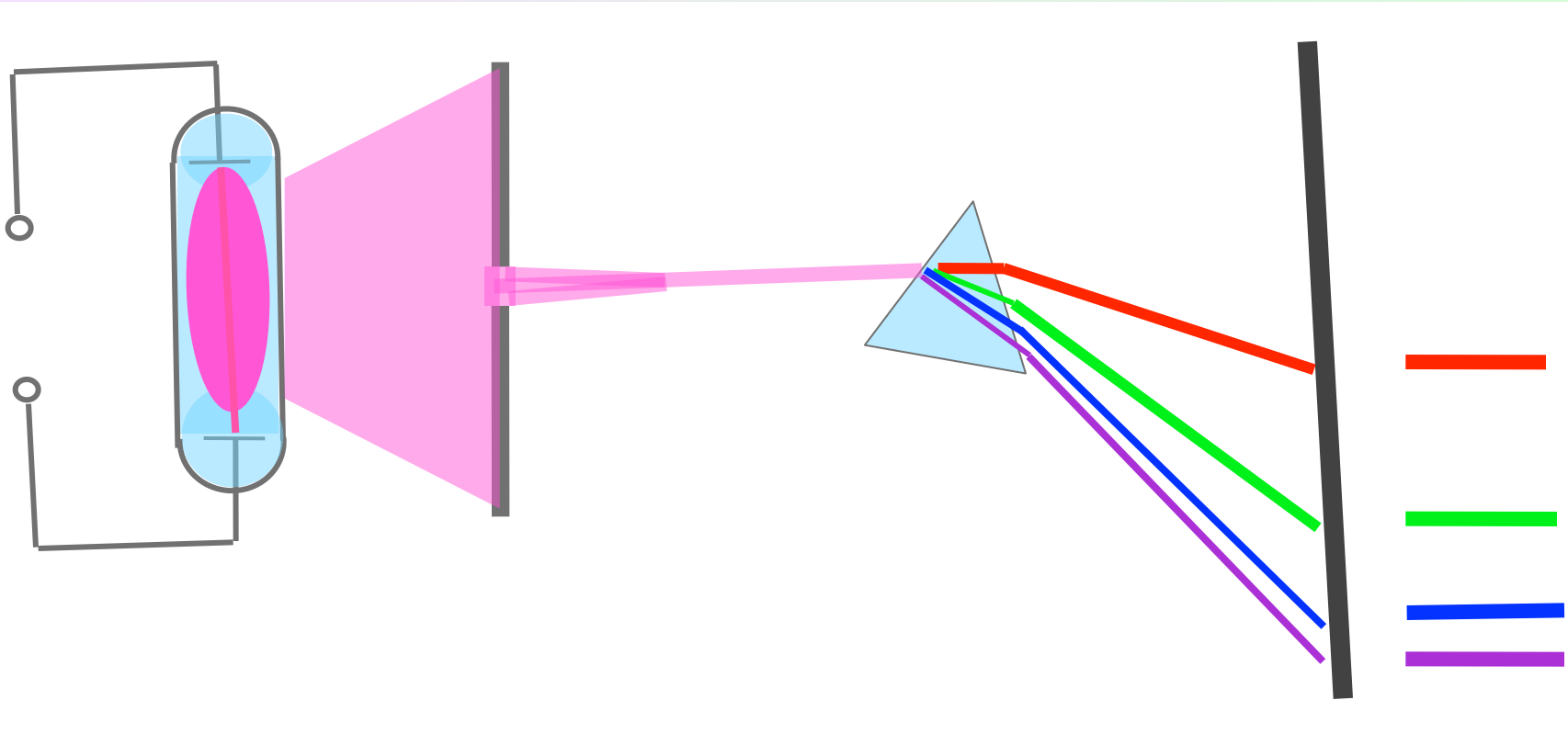
The Players

- Erwin Schrodinger
- Werner Heisenberg
- Louis Victor De Broglie
- Neils Bohr
- Albert Einstein
- Max Planck
- James Clerk Maxwell

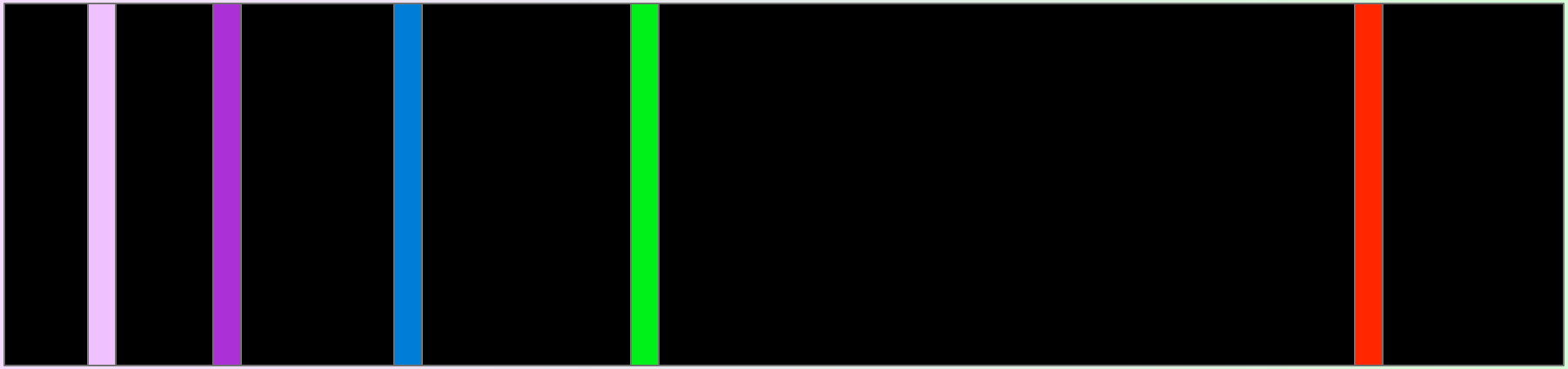
Neils Bohr

Explained the emission spectrum of hydrogen atom on basis of quantization of electron energy.



Emission spectrum

Emitted light is separated into component frequencies when passed through a prism.



397 410 434 486 656

wavelenth in nm

Hydrogen, the simplest atom, produces the simplest emission spectrum.

In the late 19th century a mathematical relationship was found between the visible spectral lines of hydrogen

the group of hydrogen lines in the visible range is called the Balmer series

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$$

Rydberg Constant

$$1.0968 \times 10^7 m^{-1}$$

Johannes Rydberg

Bohr Solution

the electron circles nucleus in a circular orbit

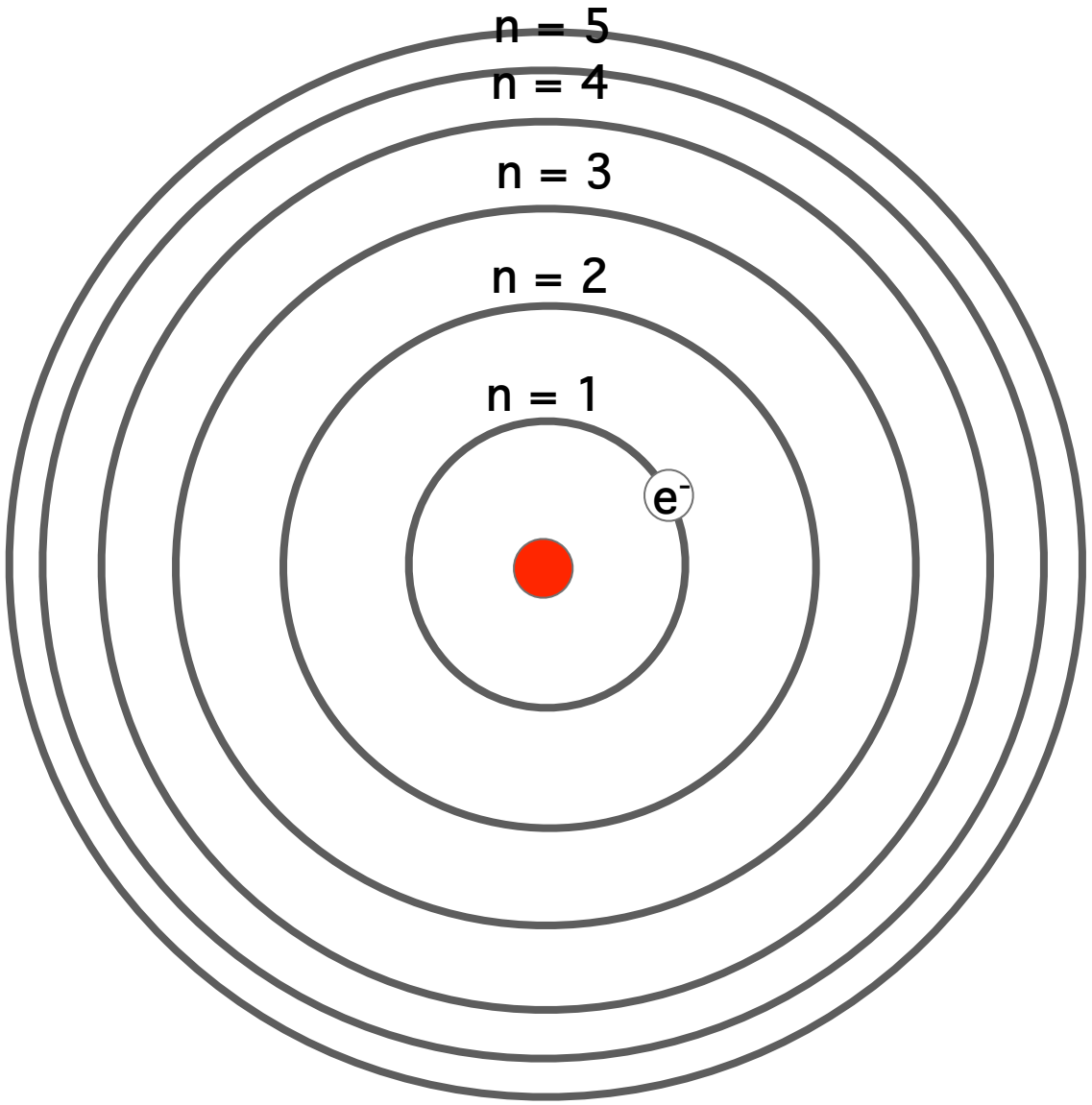
imposed quantum condition on electron energy

only certain "orbits" allowed

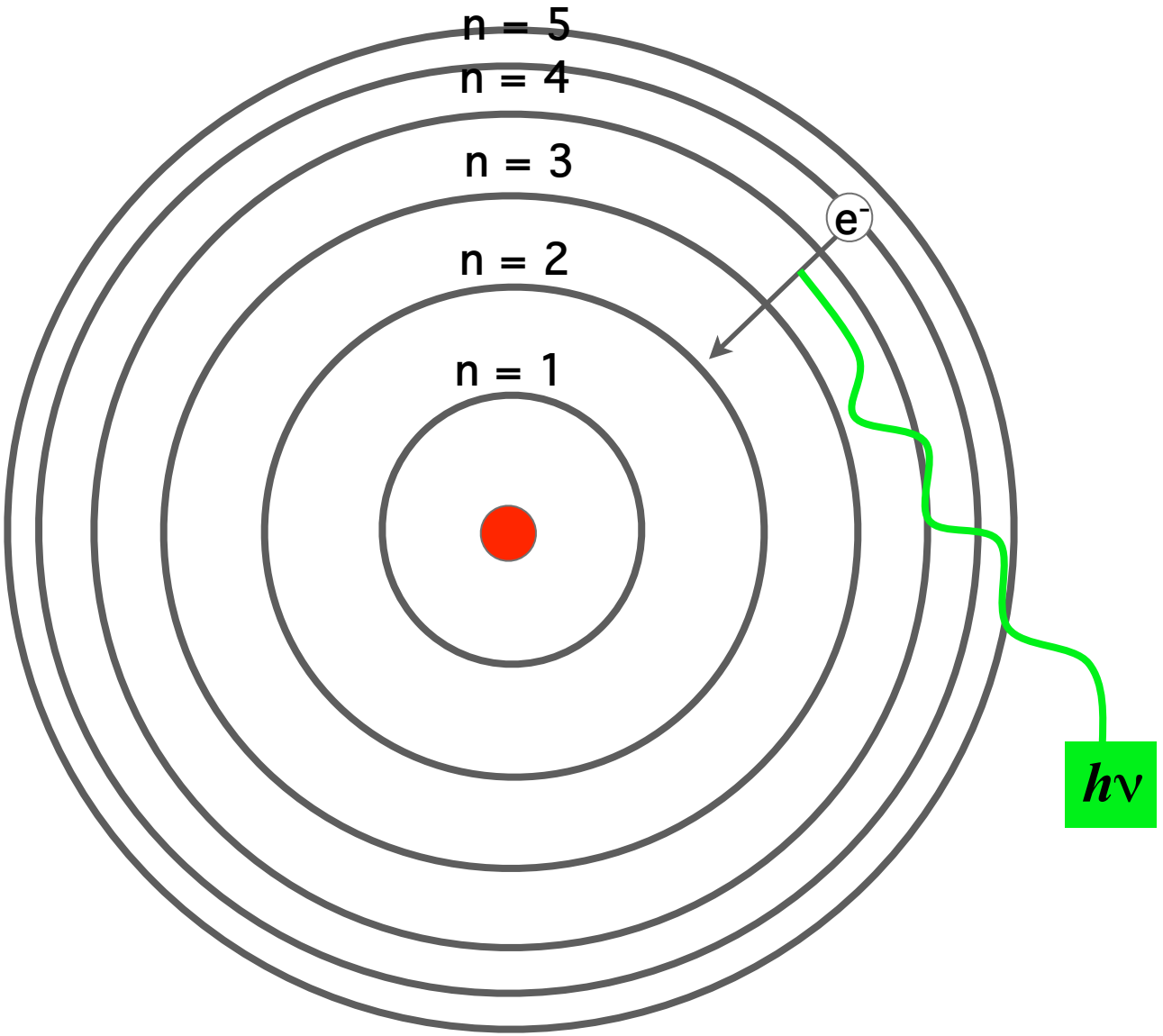
energy emitted is when electron moves from higher energy state (excited state) to lower energy state

the lowest electron energy state is ground state

ground state of hydrogen atom



excited state of hydrogen atom



$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$$

Rydberg Constant $1.0968 \times 10^7 m^{-1}$

Rewritten to solve for energy

$$h\nu = \Delta E = E_{\text{higher-energy orbit}} - E_{\text{lower-energy orbit}}$$

Where E is the energy is the released by an excited electron moving to a lower energy level

A Complex and only Partially Correct Solution

Neils Bohr

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Wave /Particle Duality

If a light wave has a “particular” nature might not a particle have wave properties.

Albert Einstein - 1905

Theory of special relativity

The laws of science should be the same for all freely moving observers, no matter what their speed (abandoning the idea of absolute time).

- equivalence of mass and energy
(derived from the theory of relativity)

$$E = m c^2$$

- E: energy
- m: mass
- c: speed of light, 3.00×10^8 m/s

Louis Victor De Broglie

showed that electrons have wave properties

wave-particle duality

$$\nu = c / \lambda$$

$$E_{(photon)} = h\nu$$

$$E_{(photon)} = mc^2$$

$$mc^2 = h\frac{c}{\lambda}$$

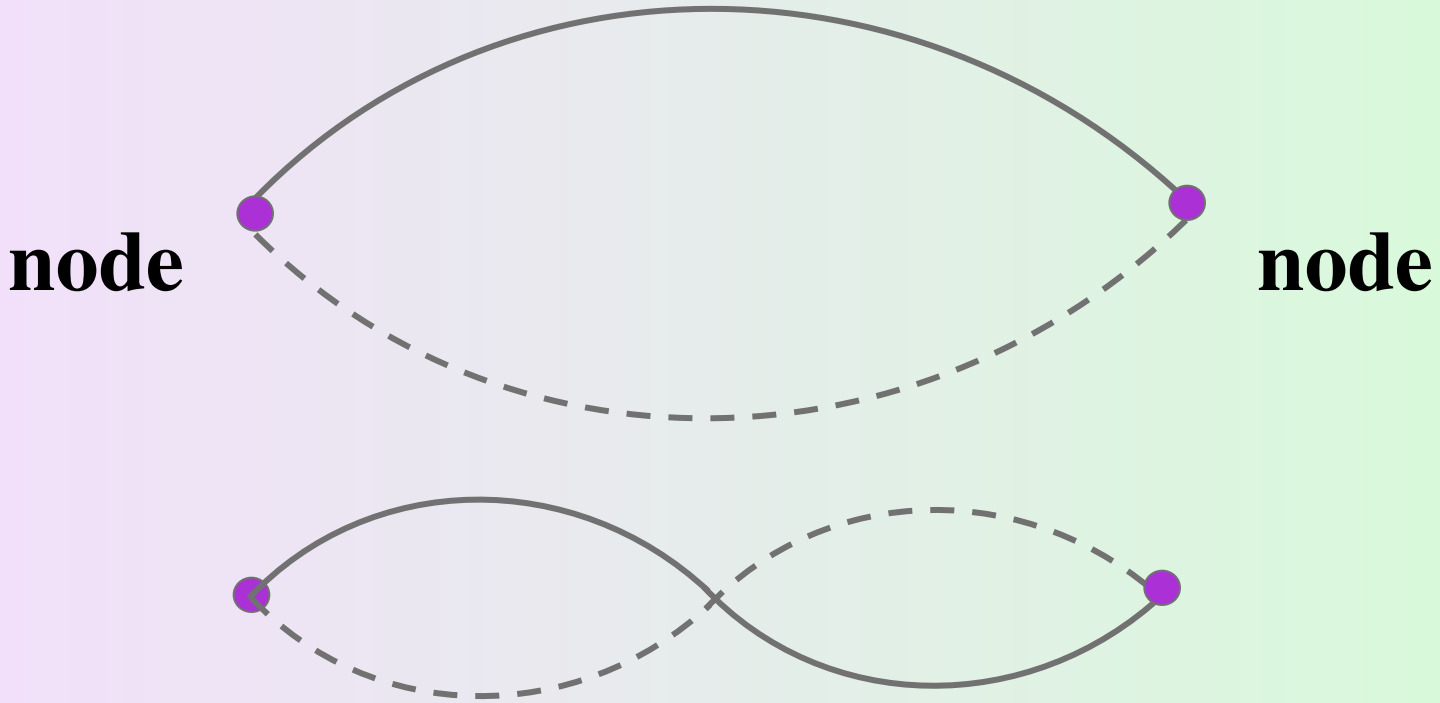
$$mc^2 = h\nu$$

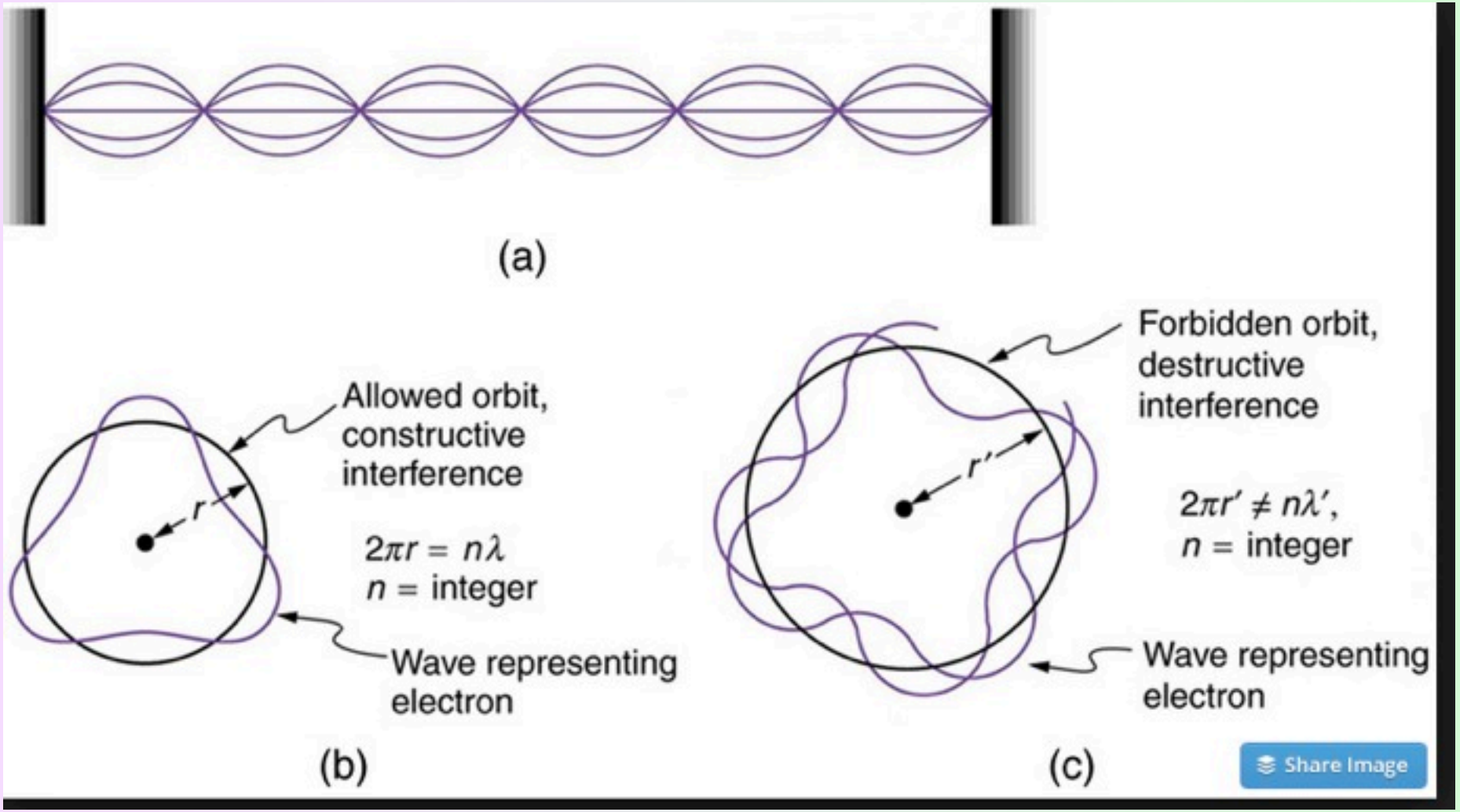
$$\lambda = \frac{h}{mc}$$

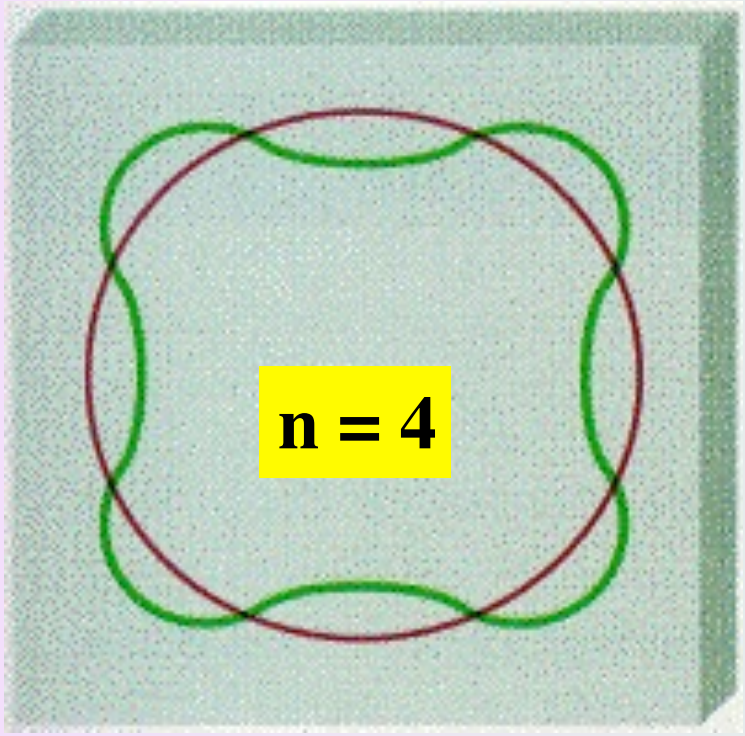
The less massive an object the longer its wavelength

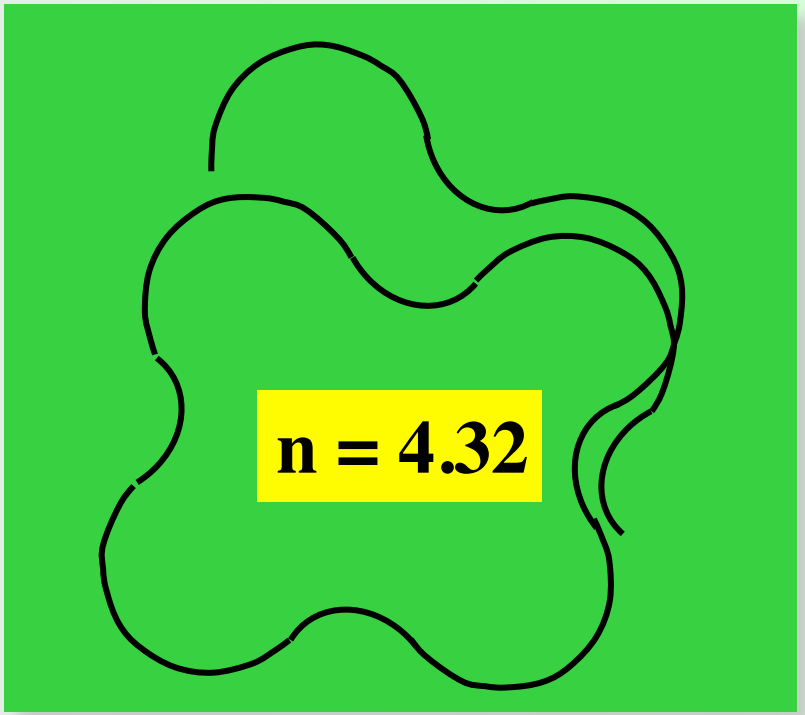
$$\lambda = \frac{h}{m\nu}$$

Standing Waves




(a)
Allowed orbit, constructive interference
r
$2\pi r = n\lambda$
n = integer
Wave representing electron
(b)
Forbidden orbit, destructive interference
r′
$2\pi r' \neq n\lambda'$,
n = integer
Wave representing electron
(c)
Share Image





hydrogen electron visualized as a standing wave around the nucleus

the circumference of a particular circular orbit has to correspond to a whole number of wavelengths

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Werner Heisenberg

Uncertainty principle

position and momentum of a electron cannot be simultaneously determined

if position is measured accurately, uncertainty in measuring momentum (speed) is large, vice versa

$$\Delta x \, \Delta P = h/4\pi$$

change in position

change in momentum

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Werner Heisenberg

Louis Victor De Broglie

Neils Bohr

Albert Einstein

Max Planck

James Clerk Maxwell

Erwin Schrodinger

wave (quantum) mechanics

<u>Schrodinger Equation</u>

attacks the problem of atomic structure by giving emphasis to the wave properties of the electron

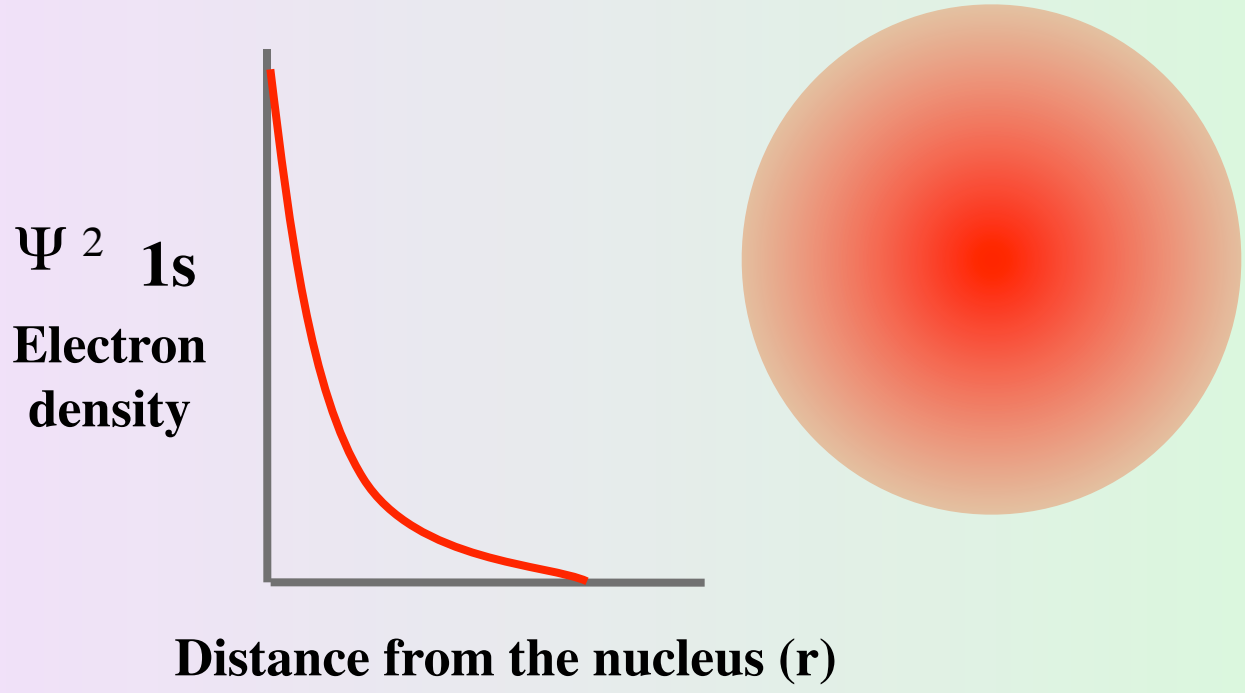
an orbital can be thought of as the wave function of an electron (ψ) which coordinates the x ,y, and z of an electrons position in a three-dimensional space

Solutions of the Schrodinger Wave Equation for a One-Electron Atom

n	l	m_l	orbital	solution
1	0	0	1s	$\Psi_{1s} = \frac{1}{\sqrt{\pi}} \left(\frac{Z}{a_0} \right)^{3/2} e^{-\sigma}$
2	0	0	2s	$\Psi_{2s} = \frac{1}{4\sqrt{2\pi}} \left(\frac{Z}{a_0} \right)^{3/2} (2 - \sigma) e^{-\sigma/2}$
2	1	0	$2p_z$	$\Psi_{2p_z} = \frac{1}{4\sqrt{2\pi}} \left(\frac{Z}{a_0} \right)^{3/2} \sigma e^{-\sigma/2} \cos\theta$
2	1	+1	$2p_x$	$\Psi_{2p_x} = \frac{1}{4\sqrt{2\pi}} \left(\frac{Z}{a_0} \right)^{3/2} \sigma e^{-\sigma/2} \sin\theta \cos\phi$
2	1	-1	$2p_y$	$\Psi_{2p_y} = \frac{1}{4\sqrt{2\pi}} \left(\frac{Z}{a_0} \right)^{3/2} \sigma e^{-\sigma/2} \sin\theta \sin\phi$

Erwin Schrodinger

the square of the Schrodinger Equation gives us the probability of finding an electron in a certain region of space



Charge-Cloud Model

No orbit path for electrons.

Energy levels or shells are the average points on a probability plot.

Atomic Orbital is the probability distribution of finding an electron with a specific energy level as defined by its quantum numbers.

Neils Bohr

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