Physics 570A Lecture 1

Chronology of QM

Max Planck (1901)

Black-body radiation

$E = nh\nu$, $n = 0, 1, 2, \cdots$

$h = 6.62618 \times 10^{-34}$ J s

Planck's constant

Einstein (1905)

photoelectric effect

$h\nu = W + K.E.$

Bohr (1913)

Hydrogen atom

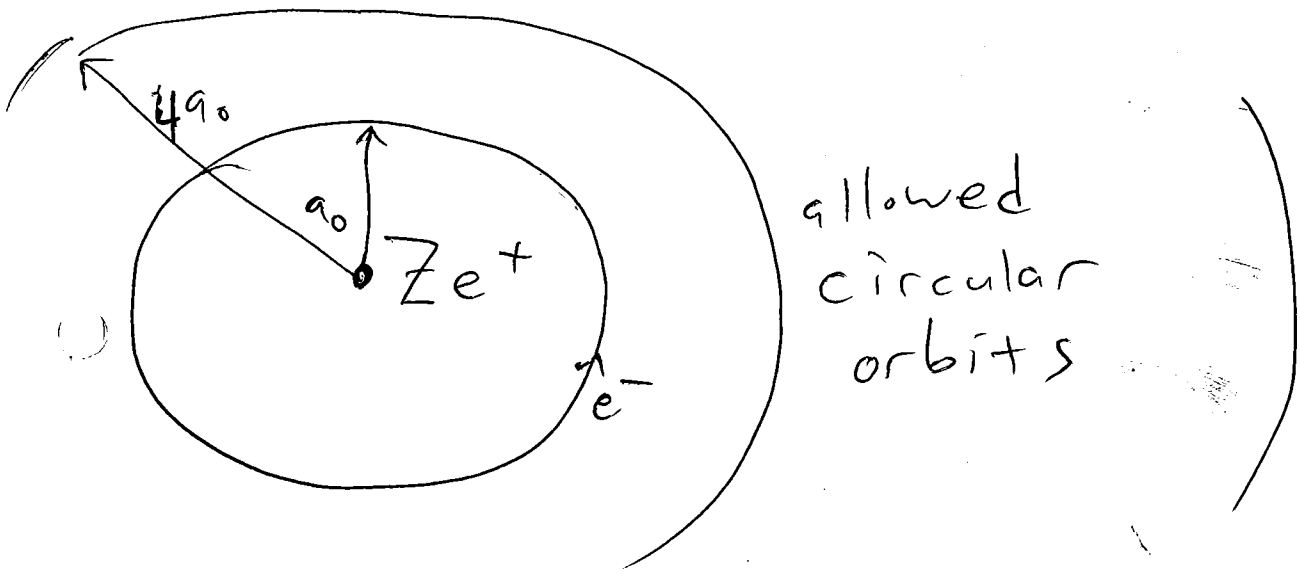
$$\mu = \frac{m_e m_N}{m_e + m_N}$$

Assumption: $\mu v r = n \hbar$ $\quad n = 1, 2, 3, \ldots$

$$\hbar \equiv \frac{h}{2\pi}$$

$$\Rightarrow E_n = -\frac{\mu e^4}{2\hbar^2}\frac{Z^2}{n^2} \qquad \frac{\mu e^4}{2\hbar^2} = 13.6\,\text{eV}$$

$$r_n = n^2 a_0 \qquad a_0 = \frac{\hbar^2}{\mu e^2} \simeq 0.5\ \text{Å}$$



Sommerfeld (1915)

extended Bohr's model to include elliptical orbits, more general (integrable) systems.

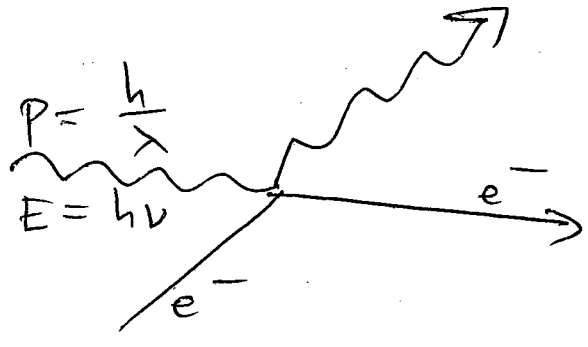
Einstein (1918)

Critique of Bohr-Sommerfeld quantization rules — they only work for integrable systems, e.g., not for three-body problem.

[Gutzwiller (1970) solved Einstein's problem for classically chaotic systems.]

Compton (1923)

Compton scattering



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

$E = h\nu$

} photon

waves behave like particles

de Broglie (1923)

particles behave like waves!

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

Explains Bohr's quantization of angular momentum:

$mvr = n\hbar$

$pr = n\hbar$

$\frac{hr}{\lambda} = n\hbar \Rightarrow n\lambda = 2\pi r$

standing waves

Heisenberg (1925)

matrix mechanics

uncertainty principle

$$\Delta x \, \Delta p_x \geq \hbar/2$$

Schrödinger (1925)

wave mechanics

Dirac (1927)

shows approaches of H. & Sch. are equivalent.

Born, Bohr & Heisenberg (late 1920s)

Copenhagen interpretation

QM = probabilistic theory

Objections of Einstein et al.

Einstein-Podolsk-Rosen (1935)

EPR paradox, argues QM is inconsistent with relativistic causality because "collapse" of wavefunction must occur faster than the speed of light. Entanglement at a distance.

Everett (1957)

"many-worlds" interpretation of QM. No collapse postulate. Same predictions as Copenhagen int.

Bell (1964) proves

inequalities satisfied by any local, realistic theory.

Aspect (1982) Experiment

confirms EPR experiment violates Bell inequalities. QM not derivable from a local realistic theory.