Quantum Mechanics – Historical Background

Physics in the Late 19th Century (prior to quantum mechanics (QM))

- Atoms are basic constituents of matter
- Newton's Laws apply universally
- The world is deterministic

According to classical mechanics (CM):
Given initial positions $\vec{\mathbf{r}}_0$ and velocities $\vec{\mathbf{v}}_0$, and given all forces $\vec{\mathbf{F}}(t)$ $\Rightarrow$ all the future can be predicted!

$$\vec{\mathbf{v}}(t) = \int_{\vec{\mathbf{v}}_0}^{\vec{\mathbf{v}}} d\vec{\mathbf{v}}' = \int_{t_0}^{t} \frac{\vec{\mathbf{F}}}{m} dt' \qquad \left(\vec{\mathbf{F}} = m\vec{\mathbf{a}} = m\frac{d\vec{\mathbf{v}}}{dt} \right)$$

$$\vec{\mathbf{r}}(t) = \int_{\vec{\mathbf{r}}_0}^{\vec{\mathbf{r}}} d\vec{\mathbf{r}}' = \int_{t_0}^{t} \vec{\mathbf{v}} dt' \qquad \left(\frac{d\vec{\mathbf{r}}}{dt} = \vec{\mathbf{v}} \right)$$

Physics was complete except for a few decimal places !

- Newtonian mechanics explained macroscopic behavior of matter -- planetary motion, fluid flow, elasticity, etc.
- Thermodynamics had its first two laws and most of their consequences
- Basic statistical mechanics had been applied to chemical systems
- Light was explained as an electromagnetic wave

— However there were several experiments that could not be explained by classical physics and the accepted dogma !

- Blackbody radiation
- Photoelectric effect
- Discrete atomic spectra
- The electron as a subatomic particle

— Inescapable conclusions would result from these problems

- Atoms are <u>not</u> the most microscopic objects
- Newton's laws <u>do not</u> apply to the microscopic world of the electron

OUTCOME ⇒ New Rules!!!

Quantum Mechanics!

- Describes rules that apply to electrons in atoms and molecules
- <u>Non-deterministic</u>, <u>probabilistic</u> ! A new philosophy of nature

— Explains unsolved problems of late 19^{th} century physics

— Explains bonding, structure, and reactivity in chemistry