

## The Quantum World

*This course presents revolutionary developments in science. These developments have given us transistors, lasers, computers, nuclear power and many more devices have the potential for transforming our lives that is beyond our present imagination. Along with its highly inspiring history to resolve intellectual crisis of the 20<sup>th</sup> century, and a close look at the lives of many geniuses, it addresses the inherent aesthetics, the simplicity and the weirdness of the laws of nature.*

### Scope of the Course

- Classical vs Quantum picture –Physics before and after 20<sup>th</sup> century.
- **Quantum weirdness** –
  - Particle can sometimes act as a particle and sometimes as a wave. Similarly, waves can behave sometimes as particles—
  - Classical vs Quantum Particles..... Unlike classical particles, where a spinning particle can stop spinning, quantum particles either spin all the time or never spin.
  - Spinning particles may not return to its starting state after 360 degree rotation !!! This property divides particles into two types: **Fermions** which do not return to their starting state after 360-degree rotation and **Bosons** which do return to their starting state after 360-degree rotation. Fermions require two 360-degree rotations to recover their original state. All particles in nature are either Bosons or Fermions.
  - Some particles have other exotic properties described as color, charm and strangeness.
  - Quantum particles in getting from A to B explore all possible paths – all at once –
  - Particles exist at two locations simultaneously –
  - We are not suppose to ask how a particle gets from A to B –
  - Solid walls may not be able to stop particles –
  - You cannot determine the position and the velocity of a particle simultaneously...
  - *spooky action - at -a distance* –
- **Why do we care about Quantum weirdness ?? ... What difference does it make ???**

- Our Future in the Quantum World....
- Laws of Nature and Paul Dirac's principal of "mathematical beauty"
- Quantum physics and consciousness
  - Quantum Cryptography
  - Quantum Computers
  - Quantum Teleportation

### **Do we believe in Quantum Theory ???**

There are many who are skeptical about quantum physics... Most of the skepticism is due to its weird nature....

Why do most believe in the theory ???

In last 100 years that we have had quantum theory, No violation has been found – there are NO experiments that contradicts the predictions of theory

The precision in its predictive power is mind boggling:

EXAMPLE: Take the calculation of magnetic moment of the electron...

Magnetic property of the spin provides, with remarkable precision, the validity of quantum theory.

- 2.00244 (experimental) ( 1932)
- 2.08 (theoretical)
- 2.00231930482 ( experimental) (1983)
- 2.00231930476 ( theoretical)

- 2.00231930436182 ( experimental) ( 2017)
- 0.00000000000005 ( uncertainty)

**Do we understand everything.....And what does it all mean....**

The classical and the quantum laws ( equations) are monuments of scientific progress, just as cathedrals are monuments to the spirit of middle ages. We continue to reinterpret them but they are part of scientific knowledge which may out- last even the beautiful cathedrals of earlier ages. We know this...Yes, NOBODY doubts that the Pythagorean theorem will ever fade away. . .

Men of science who discovered these laws are saints of mathematics and physics whose teachings will continue to guide us as we explore new horizons. . . Quantum revolution that began in 20th century is perhaps ready for next revolution. We puzzle over unsolved mysteries quantum gravity, dark energy, dark matter. We try to comprehend the physical reality such as, the quantum teleportation and what it means to be at two places at the same time.

As we savor the scientific discoveries, we continue to dream and wonder what lies ahead. Yes, life is never dull in the quantum world. . ...

It is human curiosity and inquisitiveness that drives men and women to explore...applications follow... sometimes it takes decades....