

## 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.*

### Tentative Outline

Here is a tentative list of topics covered in 14 weeks of the classes.

- Week 1 and 2: Classical vs Quantum World:

As a warm up, we will begin with the planetary model of an atom where electrons encircle the nucleus somewhat analogous to the way planets encircle the sun. This picture where we try to apply classical laws or Newtonian physics to the atoms lead to lots of problems. We will watch Brian Greene's video:

<<https://www.youtube.com/watch?v=Y0QYnhHQ95Ug>>

And also Richard Feynman's video

<<https://www.youtube.com/watch?v=b0EChbwSuuQ>>

describing a “thought experiments” with electrons where we discover that the electrons behave neither like particles nor like waves... Welcome to the quantum world.

- Week 3 : Pre-Quantum era: Particles and Waves; and their characterization( mass and charge for particles ; frequency, wave length, amplitude for waves )

- Week 4-7: Quantum Revolution: Historical developments

(1) How the Radiation coming from a toaster led to the birth of quantum science ( Max Planck's Revolutionary Theory of Quanta)

(2) All Lights ( Infrared, ultraviolet etc.. ) consist of pockets of energy - photons: Einstein's theory of light quanta

(3) Light *acts* as billiard balls ( Compton Effect )

(4) Some is definitely wrong with classical theory : Atom is unstable.

Bohr proposes revolutionary model of atom that explains its stability and also the colors of light from sun.

(5) Wave-Particle Duality : de-Broglie theory unifies wave and particle picture

(6) Rewriting the laws of Nature: Heisenberg and Schödinger Theory replaces Newtons's Laws of Nature.

Probabilistic Nature of Laws of Nature ; Heisenberg uncertainty principle

- Week 8-9

(1) Quantum Spin: Discovery..

(2) Why Quantum spin is key to our existence: Bosons and Fermions

(3) Applications: NMR and Pet Scans

- Week 10: Discovery of Anti-Matter... Dirac's equation - Piece of Magic- Electron must have a partner- anti-electron ( positron);

What happens when particle-antiparticle collide ?? Richard Feynman's Simple diagrams provide the answer

- Week 11- 12 : Quantum Physics at Macroscopic scale:

Lasers, Superconductivity and Quantized Resistance

- Week 13-14 Quantum Entanglement, Dark Energy Dark Matter

Our Future in the Quantum World: Quantum Cryptography, Quantum Computers, Quantum Teleportation and much more...

Other Information:

Cell phones and other communicative devices are not to be used during class. Engaging in activities not related to the course (e.g., gaming, email, chat, etc.) will result in a significant

deduction in your participation grade.

All registered students for this class must have working audio/video on their computer. Students who signed on but do not respond when called during class discussion will be marked absent. If this occurs more than once, your class participation grade will be F. We seek to create a learning environment that fosters respect for people across identities. We welcome and value individuals and their differences, including gender expression and identity, race, economic status, sex, sexuality, ethnicity, national origin, first language, religion, age and ability. We encourage all members of the learning environment to engage with the material personally, but to also be open to exploring and learning from experiences different than their own. Disability Services at George Mason University is committed to upholding the letter and spirit of the laws that ensure equal treatment of people with disabilities. Under the administration of University Life, Disability Services implements and coordinates reasonable accommodations and disability-related services that afford equal access to university programs and activities. Students can begin the registration process with Disability Services at any time during their enrollment at George Mason University. If you are seeking accommodations, please visit <http://ds.gmu.edu/> for detailed information about the Disability Services registration process. Disability Services is located in Student Union Building I (SUB I), Suite 2500. Email: [ods@gmu.edu](mailto:ods@gmu.edu) — Phone: (703) 993-2474