CLASSICAL MECHANICS AND QUANTUM MECHANICS

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ABSTRACT:

Here we describe the distinction between the classical mechanics and quantum mechanics. Also described the formulation involved in clarification of dynamical variables and their analogy between classical mechanics and quantum mechanics. Additionally, introduced the "operators" used for indication of the dynamical variables in Quantum mechanics.

KEYWORDS: Newtonian Mechanics, Kinetic energy, Potential energy, Linear momentum

INTRODUCTION:

As we understand, classical mechanics explain the movement of objects moving at lower than light velocity. They call it "Newtonian mechanics," and this can be applied to a to all macroscopic bodies such as planets. Whereas quantum mechanics is called relativistic mechanics that apply to bodies of less than the size of nano. The motions of several in the viewpoint of classical mechanics.

METHODOLGY:

In the world of macroscopy, the static properties of the system do not change over time. An object's mass may be static property, but some dynamic variables explain the change in the system. The way the system state changes under specific actions is then explained by how time changes the dynamic variable. Some peculiar mathematical equations are derived under these forces actions to elaborate the bodies ' motion. "Movement equation" (most applicable equations) detailed the bodies ' time - dependent movement. The parameter "time" more than zero gives the macroscopic bodies some action.

Take a system (a point mass) for example, mass "m" that displays a static property. Let us consider the motion confines one dimensional linear space. According to classical mechanics, the state of the particle at any instant "t" is specified in terms of its position **x(t)** and velocity $\boldsymbol{v_x}$**(t).** Some other dynamic properties such as linear momentum $\boldsymbol{p_x}(\boldsymbol{t})$ =**m**$\boldsymbol{v_x}$, kinetic energy **T=**$\boldsymbol{\frac{mv^2x}{2}}$**,** potential energy **V(x),**total energy **E=(T+V)** etc., of this system depends only on "x" and v_x .The state of the system is known initially means that the numerical value of **x(0) and** $\boldsymbol{v_x}$**(0)** are mentioned .The below given equation describe the action on the particle in terms of a force, F_x,acting on the particle and this external force is proportional to the acceleration , $a_x = \frac{d^2x}{dt^2}$,where the mass (m) of the particle always remains constant.

$$F_x = ma_x = m\frac{d^2x}{dt^2} \quad \text{--- (1)}$$

The sound waves are mechanical waves and this hypothesis is confirmed by some beautiful examples. Classical mechanics that simultaneously predict a particle's position and momentum if its initial position and the cause of force on the particle in the atom. But quantity mechanically, predicting the starting point of particles exactly in the atom is impossible and meaningless content.

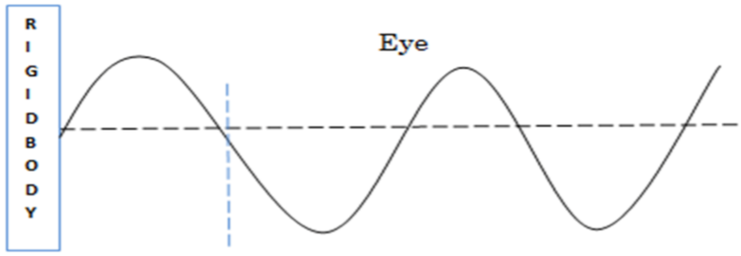

Fig 1: Graph of observer

If a rope is fixed at one end and the other is waved, then the observer at the other end will see a straight line and an ink mark on the rope clearly observed by the observer and I can accurately identify the position of the mark. Classically, the equation takes place for that mark's motion (we can imagine an electron at the place of the ink mark),

y(t)=A sin (wt + ∅) ----- (2)

Wave displacement with function time, t, is y (t) is ubiquitous, "A" represents particle amplitude in wave and "w" and "ϕ" is angular frequency and particle phase. In addition, the effective phase difference can be precisely calculated at the point where the other end of the rope is fixed.

But if an electromagnetic wave falls on the rigid end surface, it superimposes the reflected ray with incident ray. There is a standing wave, but it is not observed by the observer and it is very difficult at that moment to predict exactly the effective difference in the path.

The equation for this action is illustrate as $2\mu t \cos r \pm \Pi = n\lambda$ -----(3)

'μ' *represents the refractive index of rigid body, and wavelength of light.* ***

3. According to quantum mechanics, the atomic and subatomic scale "state" of a system is fully specified by a "state function" The system dynamics is described by the time dependence of this state function. The state function is a set of selected variables, called the system's "canonic variables." For example, the case of a particle of mass "m" forced to move along x-axis in a linear space. The state function specified by the symbol, which is a function of "x." The state of particle changes with time is specified by the φ(x, t) and the particles "wave function" is also specified by the same. Sometimes the function of the state can also be expressed as a canonical conjugate variable to represent the coordinate position and linear momentum of the system particle….$\varphi(p_{x,}\ t)$. The particle's dynamic variables can be formulated either in equivalent form or in either form of representation. If the dynamical variable use the form φ(x, t), it is said to be " Schrodinger representation and Ψ (p_x ,t) it is used in " momentum representation."

The probabilistic nature of the microscopic particle measurement process is embedded in the state function's physical interpretation of the state function. For example wave function$\psi(x,t)$ is in the general complex function of x and t , meaning it is the phasor of the form $\psi = |\psi| e^{i\theta}$ with an amplitude$|\psi|$ and a phase ϕ. The magnitude of the wave function, $|\psi(x,t)|$ gives statistical information the result of measurement of the position of the particle $|\psi(x,t)|^{2}\, dx$ is then interpreted as probability of finding particle in the collection of particles . in quantum mechanics , the action on the dynamic system is generally specified "observable" property corresponding to the "potential energy operator" ,say $\hat{V}$(r).

In general, all dynamic properties are represented by operator that are function of x and $\widehat{p_{x.}}$

A "hat ∧" over a symbol in the language of quantum theory indicates that the symbol is mathematically an "operator", which in the Schrodinger representation can be a function of x and / or a differential operator involving x.

For example, the operator representing the linear momentum, $\widehat{p_x}$ in the Schrodinger representation is represented by an operator that is proportional to the first derivative with respect to x,

$\widehat{p_x}$= $(-i\hbar\frac{\partial}{\partial x})$ ------(4)

Where ħ is the plank's constant h divided by 2π. h is one of the fundamental constants and numerical value h = 6.626 $\times 10^{-27}$ erg -s

Some of the operators listed below from the both classical & quantum mechanics,

CLASSICAL QUANTITY	QUANTUM MECHANICAL OPERATOR
Cartesian components of position x,y,z	$\hat{x}\hat{y}\hat{z}$
Position vector "r"	$\hat{r}$
Momentum "p"	$(i\hbar \underset{\nabla}{\rightarrow})$
Cartesian components of linear momentum px py pz	$(-i\hbar\frac{\partial}{\partial x}, -i\hbar\frac{\partial}{\partial y}, -i\hbar\frac{\partial}{\partial z})$
Total energy	$i\hbar\frac{\partial}{\partial t}$

In general, the total energy of the system is represented as the "Hamiltonian" and is usually represented by the symbol $\widehat{H}$. As in Newtonian mechanics, it is the sum of the system's kinetic energy and potential energy

$\widehat{H}=\frac{\widehat{Px^2}}{2m}+\hat{V}(x) = -\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2}+\hat{V}(x)$ -------(5)

The Hamiltonian, plays a crucial role in the movement equation that deals with quantum system dynamics.

The main equation of motion is postulated by Schrodinger is that the time – rate of change of the state function is proportional to the Hamiltonian "operating" on the state function.

$i\hbar\frac{\partial\varphi}{\partial t}. = \widehat{H}\varphi$ $---$ (6)

A partial differential equation is given for the 1-dimensional single particle system from Schrödinger representation:

$i\hbar\frac{\partial\Psi}{\partial t} = [-\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2} + \hat{v}(x)]\ \varphi$ -----(7)

Equation (7) in quantum mechanics is the basic equation of motion. In quantum mechanics, the equation of Schrödinger (6) is analogous to the equation of motion of Newton, eq(1), in classical mechanics.

4) A fundamental distinction between classical mechanics and quantum mechanics is that the state of the dynamic system is fully specified in classical mechanics by the position and velocity of each component of the system. It is completely definite the accuracy of finding a particle in a system. But quantum mechanically, this accuracy cannot be given because the particle's velocity is so velocity (equal to the velocity of light) that its size is so small. Only likely particle position prediction can be decided. Boundary condition on the position of particle will applied to range **x=0** to **x=L**, then probably distribution function ….. is integrated over this range must be equal to 1 and the wave function said to be normalize.

$1=\int_0^1 \varphi(x) * \varphi(x)\, dx = \int_0^1 |\varphi(x)|^2 dx..$

If the wave function is normalized, the absolute value of the probability of finding the particle in the range from **x to x + dx is** $[\boldsymbol{\varphi(x)}]^2$.

According, there is an average value, the position of the particle in the state φ, which is called the "expectation value" of the position of the particle.

$$\langle x_\varphi \rangle = \int_0^L \varphi * (x) x \varphi(x) dx = \int_0^L x\ |\varphi(x)|^2 dx..$$

CONCLUSION:

By applying some fundamental physical phenomenon, the motion of a point object and its remaining dynamic properties can be easily determined. But the exact position and momentum of a sub - atomic particle in atomic particles is leading us in the direction of challenge. Classically explained the prediction of a sub - atomic particle's position and momentum and the forces that support these particles to move around at specific speed etc. The mechanical way of seeing the world in Quantum reveals the secrets behind matter.

REFERENCE:

[1] Helvetica, Physica Acta 60, 384–393.
[2] [RSII] M. Reed, B. Simon, Methods of Morden Mathematical Physics, Vol. 2

Fourier Analysis and Self-Adjointness. Academics Press, 1972

[3] [LL] L.D Landau ,E.M. Lifshitz, Quantum Mechanics: Non – Relativistic Theory Pergamon (1997).
[4] [K] H. Kleinert , Path Integrals in Quantum Mechanics, Statistics, and Polymer Physics. World Scientific (1995).
[5] [Fo] G . Folland , Real Analysis. Academic Press, Wiley, 1984
[6] [HS] P. Hislop , I.M. Signal, Introduction to Spectral Theory. Springer,1996.
[7] [A] V.I Arnold, Mathematics Methods of Classical Mechanics .Springer ,1989.
[8] [Sh] L.I .Shiff, Quantum Mechanics .McGraw (1995).
[9] [A] V.I Arnold , MATHEMATICAL METHODS OF CLASSICAL MECHANICS. Springer ,1986
[10] Zitterbewgung and the Electron (JOURNAL OF MODERN PHYSICS) (September 25,2012)
[11] Introducing the Paraquantum Equations and Applications (june 13,2013)

[12] Why it is Necessary to Construct the Mechanics of Structured Particles and How to do it. (feb,14,2014)