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Creation of Dark Energy

Semiclosed Friedman Universe

Highlights

Singular Nature of Inflation

Metaphysics of Classical Space

Discovering Thoughts, Inventing Future

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Subluminal Evolution and Superluminal Creation of Dark Energy

By Noboru Hokkyo
Senjikan Institute

Abstract- In an attempt to find an origin of dark energy it is found that the hypothetical pair of gravitationally bound Planckeon of mass $m_{pl} \sim 0.5$g and the Higgs boson of masss $m_H \sim !0^{-4} m_{pl}$ creates a negative attractive potential $-Gm_{pl}m_H/l_{pl}$. The corresponding temperature of thermal creation $T \sim 10^{28}$K is higher than $T \sim 10^{27}$K accepted by the standard inflationay cosmology, but within the asymptotic limit $T \sim \infty$ interpolated from Hubble's expansion history to the point origin of the Hubble universe.

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SUBLUMINALEVOLUTIONANDSUPERLUMINALCREATIONOFDARKENERGY

Subluminal Evolution and Superluminal Creation of Dark Energy

Noboru Hokkyo

Abstract- In an attempt to find an origin of dark energy it is found that the hypothetical pair of gravitationally bound Planckeon of mass $m_{pl} \sim 0.5$g and the Higgs boson of masss $m_H \sim$!0^{-4} m_{pl} creates a negative attractive potential $-Gm_{pl}m_H/l_{pl}$. The corresponding temperature of thermal creation $T \sim 10^{28}$K is higher than $T \sim 10^{27}$K accepted by the standard inflationay cosmology, but within the asymptotic limit $T \sim \infty$ interpolated from Hubble's expansion history to the point origin of the Hubble universe.

I. Introduction

As an addendum to previous discussions on the signal trasmission in bi-directional EPR correlation, "zizagging against causal wind,"[1] a cosmological implication of magnetic monopole and Higgs boson is discussed by extending the Plankeon model of dark energy to a combined Plackeon-Higgs boson model.

II. Ticking Particle Orbit

Consider a test particle ticking (quantized) with Planck period $l_{pl} = \hbar/m_{pt}c$ and moving on the surface of the Friedman universe. The line element ds of the particle orbit is given in the Friedman-Reisner-Nordstrħom form:

$$ds^2 = c^2g_{tt}dt^2 - g_{rr}dr^2 \;\; r^2d\theta^2, \; (g_{tt} = g_{rr}^{-1})$$

$$= [1 - r^2/r_g^2 + L^2/(m_{pl}cr)^2].$$

$$= (1 - r^2/r_g^2 + L^2l_{pl}^2/r^2), \qquad (1)$$

where

$$L = m_{pl}r^2d\theta/dt,$$

$$= l_\theta\hbar/2\pi, \;\; l_\theta = \text{integer}. \qquad (2)$$

is the quantized angular momentum preventing the universe from gravitational collapse by ticking world lines crossing the time axis of the Minkowki space at $ct = l_{pl}$ at $r = 0$.

III. Superluminal Evolution

The observed velocity of the signal transmission or the light velocity dr/dt is determined by putting $ds^2 = 0$ as

$$dr/dt = c(g_{tt}/g_{rr})$$

$$= (1 - r^2/r_g^2 + L^2l_{pl}^2/r^2).) \qquad (3)$$

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Starting from quantum fluctuations of preexisting spacetime metric for $0 < r < l_{pl}$, the light velocity is superluminal at $r \sim l_{pl}$. After Big Bang at temperature $T \sim 10^{27}$K, dr/dt decreases with the increase of r towards dr/dt = c at $r_c = (r_gl_{pl})^{1/2} \sim 10^{-2}$cm for $r_g = R \sim 10^{28}$cm. During the superluminal and inflationary epock of electroweak and grand unification of gauge fields by Higgs mechanics, a causally related small region extends from $\sim 10^{-25}$cm to $r \sim 10$ cm followed by a brief interlude of reheating, returning to the pre-inflationary temperature of the universe. Further evolution of the universe is described by the standard Friedman universe starting the radiation dominated phase of Hubble's evolutional history expanding with s subluminal velocity. Hubble constant

$$H = v/d \qquad (3)$$

relates the velocty v of a massive extragalactic object to its distance d from the Earth.

IV. Subluminal Evolution

Subluminal expansion and contraction of the Friedman universe is described by the density parameter $\Omega_\Lambda = \rho_\Lambda/\rho_{c\Lambda}$ where ρ_Λ is the constant energy density uniformly filling the universe and $\rho_{c\Lambda}$ is the critical energy density. For $\Omega_\Lambda = 1$ the universe is closed; For $\Omega_\Lambda = 0$ it is empty and flat; For $0 < \Omega_\Lambda < 0.5$ the lower hemisphere filled with dark matter, filled with free Planckeon having positive rest mass energy $m_{pl}c^2$, is open to asymptoically flat outer space through single-valued Schwarzschild throat; For $0.5 < \Omega_\Lambda < 1$ the evolutionarilly earlier upper hemisphere, filled with dark energy, filled with negatiive energy attractive potential $-Gm_{pl}^2/l_{pl} = -m_{pl}c^2$, is almost closed and joined onto asymptotically flat space through double-valued Schwarzschild bottleneck (Einstein-Rosen bridge); For $\Omega_\Lambda \sim 1$ bottleneck is ticking (pulsating) with Planck period creating Planck scale black hole ouside the event horizon.

V. Mass Defect

During subluminal evolution from $r = r_c$ to r_g, the mass defect develops between Newtonian mass M and the relativistic proper mass M_p calculated from the proper radius $R_p = \int^R g_{rr}rdr$:

$$M_p = \rho_\Lambda V_p$$

$$= (3/2)(R/r_g)^3\sin^{-1}(R/r_g). \qquad (4)$$

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We find that M_p increases with the increase of the world radius from $r \sim l_{pl}$, where $\sin^{-1}(l_{pl}/r_g) \sim 1$, until V_p fills the lower hemisphere of the spherical universe, where $\sin^{-1}(l_{pl}/r_g) = \pi/4$. With further increase of r, R_p decreases towards $R_p \sim l_{pl}$, where $\sin^{-1}(l_{pl}/r_g) \sim \pi/2$, forming a gravitational semiclosure with $V_p \sim 0$ and $M_p \sim 0$, developing Planck scale black holes outside the gravitatioal radius $r = r_g = R$.

VI. Superluminal Particle Creation

The detection in 2014 of Higgs boson of about 100 proton mass using CERN high energy proton-proton collision seems to simulate the particle creation by Big Bang ocuuring near but beneath the equator of the semiclosed Friedman universe dividing evolutionarilly earlier upper hemishere filled with dark energy and lower filled with dark matter with density parameter $\Omega_m \sim 0.5$, joined onto outer space through Schwarzschld throat.

VII. Magnetic Monopole and Nambu's Mass Formula

Recently in June 2016 in Tokyo a successful artificial creation of magnetic monopole, using spin ice of rare earth metalsals, was anounced.[2] The magnetic monopole was predicted by Dirac in 1931 and its neccessary existence was emphasized by t'Hooft and others in the grand unified gauge theory after Big Bang. We here point out that the monopole mass spectrum

$$m_{mono} = n(\hbar c/e), \quad n = \text{integer} \tag{5}$$

is hidden in Nambu's mass spectrum[1] for elementary particles discovered before 1952:

$$\begin{aligned} m_n &= n(\hbar c/e^2)m_e, \quad n = \text{integer}, \\ &= (137n/2)\, m_e, \quad m_e = \text{electron mass}, \\ n &= 3, 4, 14, 15, 16, 17, 18, 19, 24, 33 \end{aligned} \tag{6}$$

for μ, π, K, τ mesons), P/N (proton/neutron), Λ, Ξ, Ω, Λ_c. The Higgs boson mass is found to be about 100 proton mass. We not that the quantized angular term in the expression of ds^2 represents a monopole. Nambu's mass formula does not apply to Higgs boson requring $n \sim 10^4$.

VIII. Planckeon-Higgs Boson and Dark Energy

Nambu's mass formula (6) is rewrtten as

$$m_n = nGm_{pl}^2/L = n, \quad n \text{ integer}, \tag{7}$$

where $L = \hbar/m_e c$ is the electron Compton wavelength. In the Plackeon model of dark energy, the universe is filled with gravitational Bohr atoms, gravitationally bound pairs of Planckeons, each atom creating negative energy attractive potential $-Gm_{pl}^2/l_{pl}$. We here extend this model and redefine the gravitational Bohr atom as the gravitationally bound pair of a Planckeon and Higgs boson creating a negative attractive potential

$$-Gm_{pl}m_H/l_{pl} \tag{8}$$

where m_H is the mass of the Higgs boson. Being $m_{pl} \sim 0.5$g and $m_H \sim !0^{-4}\, m_{pl}$, the temperature required for thermal creation is $T \sim 10^{28}$K compared to $T \sim 10^{27}$K accepted by the standard inflationay cosmology, but within the asymptotic limit interpolated from Hubble's expansion history.

IX. Fissionary Big Bang Universe

We have so far discussed a cosmological bi-directional EPR correlation $P \leftrightarrow S \leftrightarrow Q$ between events P and Q sharing a common source at S. In the Big Bang cosmology the inflationary epock lasts from the radius of the universe $r = r_c \sim 10^{-25}$cm ($\sim 10^{-35}$sec) to $r = 10$ cm). It is thus conceivable that a counter-propagating pair of positive energy uiniverse P and anti-universe Q is created during the inflationary epock. Then the oppositely charged two universes can be causaly related by superluminal signal exchange in PC and T-symmetric way. This model applies to the V-shaped bi-directional EPR correlation of the semiclosed Friedman universe, joined onto asymptotically flat outer space through Schwarzschild bottleneck, the Higgs field sweeping the unified gauge field lines of force extending to infinity through the bottlenec, if the univese is electrically and baryonically charged, in search of oppositly charged universe.

References Références Referencias

1. N. Hokkyo, Physics and Space Science 15(6) 2015.
2. K. Kimura et al. Nature Communications, 17 June, 2016.

Addendum

In Ref.[1] the last term in Eq.(23) should be

$$\int_A^R d\tau = \ldots\ldots \rightarrow \int_A^R d\tau \exp i[(\omega_A + |\omega_B| + \omega_C]\tau \tag{23}$$

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The Cosmological Constant and Dark Energy: Theory, Experiments and Computer Simulations

By Stanislav I. Konstantinov
Russian State Pedagogical University of Herzen

Abstract- This paper presents a model of the cosmic medium, which allows to describe the physical nature and microscopic structure of dark energy and has the macroscopic properties of both positive and negative pressure density. It is indicated that the cosmological constant Λ characterizes the elastic properties of the dark energy, and "antigravity universal law" is the law of elasticity Hooke. The evidence base is based on the results of experiments conducted in superfluid ^{3}He-B in the p-state analogue projecting dark energy. In addition, for the construction of the resonance curves of the photoelectric effect in the near-Earth space environment, we used the results of observations obtained by space detector PAMELA, Fermi and detector AMS, installed on board the ISS.

Keywords: dark energy, dark matter, cosmological constant λ, gravitation, antigravitation, electron, positron, spin, mass, dipole, domain, pressure, density, polarization, superfluid ^{3}He-B.

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THECOSMOLOGICALCONSTANTANDDARKENERGYTHEORYEXPERIMENTSANDCOMPUTERSIMULATIONS

Strictly as per the compliance and regulations of :

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Stanislav I. Konstantinov

Abstract- This paper presents a model of the cosmic medium, which allows to describe the physical nature and microscopic structure of dark energy and has the macroscopic properties of both positive and negative pressure density. It is indicated that the cosmological constant Λ characterizes the elastic properties of the dark energy, and "antigravity universal law" is the law of elasticity Hooke. The evidence base is based on the results of experiments conducted in superfluid ^{3}He-B in the p-state analogue projecting dark energy. In addition, for the construction of the resonance curves of the photoelectric effect in the near-Earth space environment, we used the results of observations obtained by space detector PAMELA, Fermi and detector AMS, installed on board the ISS.

Keywords: dark energy, dark matter, cosmological constant λ, gravitation, antigravitation, electron, positron, spin, mass, dipole, domain, pressure, density, polarization, superfluid ^{3}He-B.

I. Introduction

Professor A.D.Chernin introduced into physics a new term "World antigravitation law" as the opposite of "law of gravitation" Isaac Newton [1]. Let's look at whether enough grounds for such a large-scale correction of physical laws.

Antigravitation cosmological theory of general relativity Einstein described by a linear force versus distance:

$$FE = (c^2 / 3)\ \Lambda R, \qquad (1)$$

where Λ - the cosmological constant.

The interpretation of the cosmological constant in a spirit of understanding of the antigravitating environment with a constant density was the basis for the standard cosmological model ΛCDM (Λ- Cold Dark Matter).

The model ΛCDM dark energy is taken as an invisible space environment, physical nature and microscopic structure of which is unknown. However, it is assumed that the dark energy as a macroscopic medium has a number of special, peculiar only to her properties:

1) its density is positive and negative pressure and the energy density is equal in absolute value;
2) it does not create the attraction and antigravitation [1].

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Presumably, as a result of these special properties of dark energy in the observable universe repulsive force exceeds the force of gravity. This conclusion was made on the basis of astronomical observations carried out by a team of researchers from the Habble Space Telescope (HST). They established an accelerated cosmological recession of galaxies.

However, Nobel Prize 2011. Brian Schmidt, in his article "The path to measuring an accelerating Universe", was forced to admit: "The discovery of the accelerated expansion of the universe caused a huge amount of theoretical research. Unfortunately, the apparent break in our understanding of this problem has not yet happened - the cosmological acceleration remains as mysterious as in 1998. Future experiments will test more accurately consent flat ΛCDM - models with observational data. It is possible that there is disagreement, rejecting the cosmological constant, as the cause of accelerated expansion, and theoretically it will be necessary to explain this fundamental result. It will be necessary to wait for the theoretical insights that interpret anew the standard cosmological model, possibly with the help of information obtained from a completely unexpected source. "[2].

In this paper, based on the development of the theory of superfluid media are invited to expand the scope of the standard model and give a physical explanation of the cosmological acceleration, based on the structural features and the elastic properties of the space environment.

II. Experiments

a) Phase transitions in superfluid ^{3}He-B as an analogue of dark energy and dark matter

In the early 21 th century began to appear, which offers a model of the physical vacuum, with the properties of a superfluid liquid, consisting of a pair of oppositely electrically charged particles - fermions with zero total spin of the pair. This model describes the dielectric properties of the vacuum and the birth therein pairs of oppositely electrically charged particles (electron-positron) [4]. Further development of the theory of superfluid environment will consider the phase transitions in the model of the physical vacuum, similar to phase transitions in superfluid ^{3}He-B [3]. L.B.Boldyreva in its superfluid model of the physical vacuum (SPV), has significantly expanded the analogy between the properties of superfluid ^{3}He-B and the

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space environment (dark energy and matter), mainly due to the account properties of vortices and the spin polarization of the medium in the vortex, the inertial properties of the vortex, and superfluid spin currents between them. [5] In this model SPV included the elements of the model of the physical vacuum G.I. Shipov [6] polarization model of heterogeneous physical vacuum V.L. Dyatlova [7] and the theory of ether A.V. Rykova [4].

First of all, it should be noted that the experimentally installed electric polarization of the medium in the core of the vortex in superfluid ^{3}He-in is due to deformation of the atoms ^{3}He consisting of electrically oppositely charged electrons and protons. A similar mechanism of electric dipole moment of the vortex core must exist in the cosmic medium, the microscopic structure of which are electrically oppositely charged electrons, positrons and protons, forming a dipole. Growth of the relative share of positrons in the total flux of positrons and electrons in the cosmic medium, since more than 30 GeV photon energy was discovered detector PAMELA, Fermi and others. Moreover, according to new data, the detector AMS, installed on board the ISS, positron spectrum with increasing energy to become more stringent, while the electron spectrum changes little. [8] It can serve as indirect evidence of the presence in near-Earth space environment of the two phase states, characterizing dark energy and dark matter as a unique two phases in ^{3}He-B: A superconducting phase and spontaneously ferromagnetic β phase [15]. Further, in NASA experiments, conducted in 1989-1992, via spacecraft Cosmic Background Explorer (COBE), was established anisotropy of background radiation, which may also serve to confirm the heterogeneity of the structure in the space environment [10]. The relative motion of the particles that make up a Cooper pair in superfluid ^{3}He-B corresponds to the p-state. In this state between the electrically charged particles of like with spins oriented in the same direction, there are forces of attraction, and between the electrically oppositely charged particles with spins oriented in the same direction of the force of repulsion.

Similarly, the interaction of particles in superfluid ^{3}He-B must interact and microparticles in virtual space environment. In ^{3}He-B holds the magnetization of the cores of the vortices along the axis of the vortex, that is, there is a spin polarization of superfluid in the core of the vortex. This phenomenon indicates that the superfluid ^{3}He-acting effect in Barnett (there is a transfer of angular momentum coupled atoms ^{3}He-B components whirlwind spins of atoms). This process is particularly significant in the core of the vortex. The existence of the effect in superfluid Barnett ^{3}He-B is confirmed experimentally: vortices with opposite spins, the constituent atoms are characterized by the opposite direction of flow velocity of the liquid. By analogy, in the core of the vortex microparticles space environment holds spin polarization, ie, the orientation of the spins of the microparticles in the same direction. At the core of the vortex formed two spatially separated electrically oppositely charged "clusters" of microparticles. Therefore, one can speak of the electric dipole moment of the quantum object created by this vortex. We have said that in the district of state between the electrically oppositely charged microparticles with spin oriented along the same line, there are forces of repulsion.

The result of these forces is the appearance of an electric dipole moment of the vortex core. Since vortex cores in the space environment are electric dipoles, there is the electric polarization of the medium. This means that the pair of the microparticles constituting the space environment is "stretched" along the electric field. Thus, the space environment in a twist area can be characterized by a state of "full stretch". As part of the simulation model on the effect of superfluid vortex core can be mathematically described by introducing the pressure P at the boundary of the vortex core. Sign pressure depends on the nature of the internal stresses in the environment. If these internal stresses have the character of "comprehensive sprain", the pressure will be negative.

In addition, experimentally proved that when the photon energy $W \geq 1$ MeV in the space environment (physical vacuum) takes place of a pair of elementary particles electrons and positrons with nonzero rest mass. This suggests that the density of the cosmic medium positive.

Thus, the proposed model of the space environment above (analog ^{3}He-B) meets the characteristics of dark energy, and its microscopic structure does not contradict with modern physical notions.

As a result of astronomical telescope Planck universe is composed of:

- Dark energy (68.3%);
- Dark matter (26.8%);
- "Ordinary" (baryonic) matter (4.9%) [9].

Dark energy and dark matter form galactic and intergalactic medium, accounting for 95% of the average density of matter in the universe. This environment does not emit, absorb or reflect light, which is understandable, if we assume that it is a light-carrying medium. The key distinction of the dark energy of the dark matter is that dark matter attracts, possesses gravity, while dark energy, in a sense inherent anti-gravity. It causes the universe to expand rapidly. However, in the field of galaxies, where large masses of gravitating matter perturbs the vortex-wave processes, accompanied by spin precession microparticles in the vortex domain of the space environment, generate significant weight, a lot of large masses of particles in the medium.

Additional mass is created by the cosmic object in the medium (dark energy) due to inertial properties of the core of the vortex. The value added to the mass Δm, is associated with the precession frequency of the spins of the microparticles in the core of the vortex, or, equivalently, with the frequency of the wave function ωsh Schrödinger equation:

$$\Delta m = \hbar\, \omega sh / c^2 , \qquad (2)$$

where c - velocity of light [5]

A macroscopic approach, the hydrodynamic behavior of the added weight of spherical bodies of any nature (including those of charged clusters) in superfluid ^{3}He-B (analogue of dark energy) is the primary source of job Stokes. It is a complex force F (ω), exerted by the fluid on the sphere of radius R, performs periodic oscillations with a frequency ω. Within the low Reynolds numbers we have:

$$F(\omega) = 6\pi\eta R\, [1+R/\delta(\omega)]V(\omega) + 3\pi R^2\sqrt{2\eta\rho/\omega}\, [1+2R/9\delta(\omega)]\, i\omega V(\omega), \qquad (2a)$$

$$\delta(\omega) = (2\eta/\rho\omega)^{1/2}$$

where ρ - fluid density, η - the viscosity, V - velocity amplitude sphere, δ (ω) - the so-called viscous penetration depth, which increases with an increase in viscosity and a decrease of the oscillation frequency.

The real part of the expression (2a) is a known Stokes force derived from the movement of fluid in the sphere. Imaginary component (coefficient of $i\omega V$) is naturally identified with the effective mass of the cluster added:

$$M_{eff}(\omega R) = 2\pi\rho R^3/3\, [1+9/2\, \delta(\omega)/R]$$

Origin added (attached) mass Meff (ωR), depending on the frequency ω and the radius R of the sphere of the cluster associated with the excitation of the field around a moving cluster of hydrodynamic velocity υ_i (r) and the appearance in connection with this additional kinetic energy. In superfluid additional mass has two components: superfluid and normal [16].

Magnetic resonance experiment conducted with a rotating vortex cores. Also it found that in the case of superfluid ^{3}He-B has an effect of Einstein - de Haas: this rotation liquid volume during magnetization. Since atom magnetization ^{3}He means and their spin polarization, the effect of Einstein - de Haas - a volume of liquid during the rotation dS / dt, where S is the total spin fluid volume selected. A similar effect should be observed, and in contact with the dipole vortex of dark energy in the magnetic field of the galaxy. Emerging with large domains have sufficient weight to gravitation and are the building blocks that make up dark matter.

In intergalactic space, where the disturbing factor of the masses of large space structures is absent, and there is no dark matter. RZG is the radius of zero gravity (outer space, where the force of gravity and repulsion are equal). When R <RZG predominant attraction, with R> RZG - repulsion. The paper A.Chernin [1] calculated the value of the radius around the local group RZG - gravitationally bound quasi-stationary system with a total mass M = (2 - 3) x 10^{12} M_Θ. This mass constitute the "normal" (baryonic) matter of stars and interstellar medium, and dark matter, which is about five times more. The value RZG = 1,3-1,4Mpk. [1].

In the space defined by the radius RZG, the physical cause of formation of structures of dark matter (gravitating medium) may be similar to the one that causes the formation of stars from interstellar substances - Jeans gravitational instability. J. Jeans (1902) first showed that the initially homogeneous gravitating medium with the density $\rho 0$, is unstable with respect to small perturbations of density. If the environment has arisen condensation, the gravitational force will seek to increase it, and the elastic force will seek to expand the impact and return it to its original state. Under the influence of these opposing forces, the medium will either vibrated or will undergo repetitive motion. The nature of the motion depends on the relationship between the wavelength of the disturbance and some critical scale, called the Jeans scale:

$$LJ = cs\, [\pi/(G\rho 0)]^{1/2} \qquad (3)$$

This value depends on environmental parameters: velocity of acoustic vibrations in a medium (the speed of the longitudinal wave) cs and density ρ_0.

It defines the minimum scale perturbations, from which the elastic force of the medium are not able to withstand the forces of gravity, and that it leads to the gravitational instability of the medium [13]. In this small-size random packing medium grow in time if they cover an area of linear size L> LJ. Perturbations with scales smaller than the Jeans length L <LJ, are acoustic vibrations.

Since the space environment (dark energy) internal stresses are characterized by "extensive stretching", causing a negative pressure, the cosmological constant Λ in equation (1) describes the elastic properties of the medium, and the formula itself (1) in accordance with Hooke's law describes the repulsive forces between the structural elements forming a dark. Because of this, not some "universal law of anti-gravity" ie antigravity center corresponding to the center of gravity, cannot speak.

b) *Numerical values of the physical parameters that characterize how the microscopic structure of quantum objects medium (dark energy) and its macroscopic*

The following are numerical parameters of structural objects of the space environment from the work A. Rykova "Fundamentals of the theory of ether" [4]. Structural objects of dark energy are electrically charged vortex dipole "kvazikollapsov" derived from virtual electrons and positrons.

When a size of a structure element of the ether is r = $1.3988 \cdot 10^{-15}$ m, the ultimate deformation of the dipole (a destruction limit) would be dr effects = $1.0207 \cdot 10^{-17}$ m. At that, the distance between virtual charges r of the electron and positron, forming the dipole, is 2.0145 times less than a classical electron radius. Dipole destruction occurs only when deformation is 1/137 of its the integer value that says of extraordinary stability of the ether. Deformation in the ether, which is below this value, should have an electro elastic nature. A force of the elastic deformation of the ether has an enormous value Fdef = $1.1550 \cdot 10^{19}$ n. [4].

With regard to the macroscopic parameters of the space environment can be stated as follows:

The cosmological dark energy density is now measured with an accuracy of a few percent $\rho v=(0.721\pm0.025)\bullet10^{29}$g/cm^3 or $\rho v=(0.721\pm0.025)\bullet 10^{32}$ kg/m[12]

The gravitational constant $G=6.6720\bullet10^{-11}$ N$\bullet$m^2/kg^2

The value of the cosmological constant Λ, and the negative pressure P we find on the basis of representations about antigravitating environment with a constant density, laid down in the standard cosmological

Model ΛCDM, from the following relations: [1]

$$\rho v = c^2\Lambda /(8\pi G) \qquad \Lambda = (8\pi G\rho v)/c^2 \tag{4}$$

$$Pv=-\rho vc^2 \tag{5}$$

Substituting in the formula (4) a known density $\rho v = (0.721 \pm 0.025) \bullet 10^{32}$ kg / m^3 and G = $6.6720 \bullet 10^{-11}$ N $\bullet$ m^2 / kg^2 find cosmological constant Λ:

The absolute value of Λ (s^2) = $1.17 \bullet 10^{23}$ N / (kg $\bullet$ m)

Substituting into the formula (5) known density ρv find the pressure.

The pressure is negative and the energy density equal to the absolute value [1] :

$$Pv = -(0.721\pm0.025)\cdot10^{32} \text{ kg/m}^2$$

A similar expression for the negative pressure can be obtained by considering an analogue of dark energy - a superfluid ^{3}He-B. As part of the simulation model a superfluid steady motion described by the equation [11]:

$$\rho v\, u^2 / 2 + \rho v\, \mu = \text{const} \tag{6}$$

where μ - chemical potential,

ρv - density of the medium,

u - the propagation velocity of the liquid.

At the core of superfluid vortex ^{3}He-B due to the orientation of the spins of the atoms in one direction ^{3}He phase transition occurs with the formation of the superconducting phase A and spontaneously ferromagnetic β-phase. As a result of the phase transition within the core of the vortex potential μ inside the vortex is not [5]. In connection with this action superfluid at the vortex core can be analytically described pressure input P on the border of the vortex core environment. Sign pressure depends on the nature of the internal stresses in the environment. If the internal voltage have the character of "comprehensive sprains" [11], the pressure will be negative. Thus it can be assumed that the pressure P at the boundary of the vortex core of the dipole in the medium satisfies the equation:

$$\rho v\, u^2 /2 - P = \text{const.} \tag{7}$$

which is identical to the expression (5), adopted in the standard model for dark energy. Considering that in hydrodynamics, pressure force Fp. are the integral:

$$Fp = - \int s'\, Pnds, \tag{8}$$

where n - waterproof external normal to the surface S '

ds - an infinitesimal element of the surface

Using (6) we get:

$$Fp = - ½ \int s'\, \rho v\, u^2\, nds \tag{9}$$

That is all the dynamic characteristics will have a sign opposite to that which they would have had for the usual ideal incompressible fluid with the same kinematic properties [5].

Strength Fp - a repulsive force acting in the space environment (dark energy) between the structural elements of the environment (dipole vortices) for u = c. That it has the effect of anti-gravitation, and may cause the accelerated expansion of the universe.

c) *Resonance curves of the photoelectric effect in the cosmic medium*

Consider the features of the phenomenon that is the photoelectric effect destruction process photons structural elements of the space environment and the birth of a pair of oppositely charged microparticles (electrons and positrons). The experimental curves of the relative growth of the flow of electrons and positrons in the space environment, since the photon energy (photoelectric threshold) Wk = 1 MeV energy and ending with cosmic radiation 200GeV, suggest a resonant nature of the process of creation of electrons and positrons. For photons with energies below the Wk = 1 MeV photoelectric effect is observed. However, the photoelectric effect is not observed for gamma radiation. Moreover, it has been experimentally established the presence of two photoelectric threshold and two resonant peaks, which may indicate the presence of near-Earth space in the two phase of the space environment: dark energy and dark matter. Resonance curves birth of electrons and positrons from the virtual micro-particles forming the dipole vortices are shown in Figure 1. The curves are plotted on the materials presented in [4,8].

The striking similarity between the two-humped dispersion curve of energy excitations in superfluid 4 He (Landau curve) [17] and the double-humped resonance curve of the photoelectric effect at the birth of electrons and positrons in the near-Earth space environment the hypotheses that dark energy and dark matter are present therein as two phases of a cosmic medium.

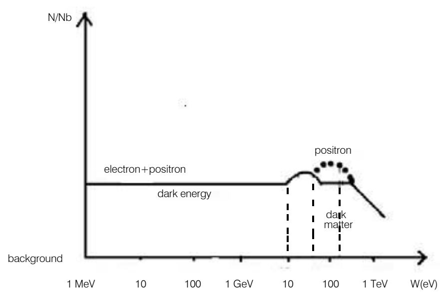

Figure 1: Resonance curves of photoelectric effect in near-Earth medium

The frequency corresponding to the critical energy of the photon (ν) and wavelength (λ), and the precession frequency of the rod vortex dipole dark energy (ω) (electron - positron) and the speed of the vortex dipole domain of dark matter (electron - positron + proton) define as the frequency of the wave function of Schrödinger and de Broglie (they describe the same probability density of finding a particle at any point in space):

$$\nu = W/h \text{ or } \quad \omega = W/\hbar \quad \text{and} \quad \lambda = 2\pi s/\omega \qquad (10)$$

where W - the photon energy

h - Planck constant $h = 6.6260 \cdot 10^{-34}$ J / Hz

$\hbar = h / (2\pi)$ $\hbar = 1{,}0546 \cdot 10^{-34}$ J / Hz

c - the speed of light $c = 299792458$ m / s

An analysis of the resonance curves shown in Figure 1 can determine the frequency of the photon, the corresponding photoelectric threshold for dark energy and the natural frequency of rotation of the vortex dipole (photon resonance frequency) and its wavelength. Similarly, in Figure 1 we find the frequency photon corresponding photoelectric threshold for the dark matter and the natural frequency of rotation of the dipole domain, as well as the approximate boundaries of the frequency of electromagnetic radiation, in which the photoelectric effect in outer space is not available.

For dark energy: $Wk(de) \geq 1$ MeV$=1.6493 \cdot 10^{-13}$ J. $\nu k(de) = 2.4891 \bullet 10^{20}$ Hz $\omega k(de) = 1.4945 \bullet 10^{21}$ Hz
$\lambda k(de) = 1.23 \bullet 10^{-12}$ m

$Wr(de) \approx 20$ GeV$=33 \bullet 0^{-10}$J $\nu r(de) = 4.7 \bullet 10^{24}$Hz $\omega r(de) = 2.82 \bullet 10^{25}$ Hz $\lambda r(de) = 6.39 \bullet 10^{-17}$ m

For dark matter: $Wk(dm) \geq 30$ GeV$=46.5 \bullet 10^{-10}$ J. $\nu k(dm) = 7.1 \bullet 10^{24}$ Hz
$\omega k(dm) = 4.26 \bullet 10^{25}$ Hz $\lambda\, k(dm) = 4.4 \bullet 10^{-17}$ m
$Wr(dm) \approx 200$GeV$=330 \bullet 10^{-10}$ J $\nu r(dm) = 4.78 \bullet 10^{25}$ Hz $\omega r(dm) = 28.2 \bullet 10^{25}$ Hz
$\lambda r(dm) = 0.6 \bullet 10^{-17}$ m

The natural frequency of the dipole dark energy solves the problem of the stability of its structural elements with the same classical position that the stability of atomic structures on the basis of nuclei and electrons. The length of the stable orbit dipole must fit an integer de Broglie waves.

The length of a circular orbit dipole dark energy:

$$Ld = 2\pi r, \qquad Ld(de) = 8.7890 \bullet 10^{-15} \text{ m}. \qquad (11)$$

where r-size structural element dipole equal to the distance between the virtual particles: an electron and a positron in the dipole $r = 1.3988 \bullet 10^{-15}$ m of dark energy. A ratio of the dipole orbit length Ld to the dipole own wavelength $\lambda r(de) = 6.39 \bullet 10^{-17}$ m is equal to 137,5335.

This approximate integer value of wavelengths' halves fits into the orbit length and is a quantum condition for stability in the dipole structure of the cosmic ether. Number 137.5335 agrees well the experimentally obtained value for a magnitude of the fine structure $\alpha = 1/1370355$ of elementary particles. This fact underlines a deep connection between a structure of the structural unit within the cosmic ether (dipole) and a structure of elementary particles [4].

The resonant nature of the pair of elementary particles under the influence of external radiation is a fundamental process of the universe is formed in the space environment divergent flow or drain and source. Direct experimental determination of the resonance dependence of birth N elementary particle pairs of frequency ν is almost completely silenced by modern physics. Following the deceptive logic of the modern theory, this dependence is drawn as a monotonically increasing curve [14].

The Earth has an electric charge, which, because of the Coulomb repulsion, tends to a spherical

surface of the planet. The electrification process of the near-Earth environment that behaves like the incompressible fluid looks like according to an expression by N. Tesla a yield state. At that, the energy is primarily transmitted along the curve - the shortest way between a source and a receiver on the Earth's surface. Distribution of currents of the "electric fluid" on the Earth's surface one describe analytically with the theory of the stationary, two-dimensional, ideal incompressible fluid on the Riemann surface.
See Appendix A.

III. Conclusion

Rapid development of the theory of superfluid medium and high-precision astronomical data in recent years, obtained by Planck space telescopes and the HST, the detector PAMELA, Fermi, AMS, allows to fill the vacuum of space of the Universe physical content. In the framework presented in the new cosmological model, the space environment (dark energy and dark matter) has a quantum structure, and is seen as a superfluid environment (not-in analog), allowing nondissipative moving celestial bodies. This interpretation of the cosmological model allows us to give an answer on the nature of dark matter, the puzzle of the accelerated expansion of the universe and the role of the cosmological constant in the process.

Appendix A

Riemann Spaces and Modelling the Globe Electrisation Process

As interpreted by Helmholtz-Monastyrsky [18], the theory of analytic functions on the Riemann surface we can present as an issue of physics. We will show that the theory of the stationary two-dimensional ideal incompressible fluid on the surface entirely down to reduces to the theory of analytic functions. Let us consider a stationary fluid flow u on the plane (x, y).The flow speed at each point has x-component P (x, y) and y-component Q (x, y).Through the cell with sides Δ x, Δy per a time unit the mass of liquid outflows (liquid density is constant and equals to

$$\int_0^{\Delta y} \{P\,(x+\Delta x,\ y+h) - P\,(x, y+h\}\,d\,h + \int_0^{\Delta x} \{Q\,(x+l,\ y+\Delta y) - Q\,(x+l, y\}\,d\,l \quad \text{(A.1)}$$

Approximating an arbitrary domain Ω with rectangles and applying the Green's formula, we obtain that the integral (A.1) is equal to:

$$\iint \left(\frac{dP}{dx} + \frac{dQ}{dy}\right) dxdy. \quad \text{(A.2)}$$

Since the fluid is incompressible and nowhere appears and disappears in the Ω domain, it follows that the expression (A.2) is zero. The stronger statement is also reasonable, i.e. flow divergence u is zero:

$$\text{Div U} = \frac{d\,P}{dx} + \frac{dQ}{dy} = 0 \quad \text{(A.3)}$$

The flow circulation along the curve C is defined as the integral

$$\int \text{Pdx} + \text{Qdy}.$$

If this integral along any closed curve is zero, then the flow is called irrotational. For any single-bound domain, it follows that statement Pdx + Qdy is a complete differential of the function u (x, y).This function is harmonic.

The function U (x, y) is called the flow speed potential. Helmholtz introduced this concept. Curves U (x, y) = const are called equipotential lines. A tangent line to the equipotential line forms such an angle α with the axis x, that

$$\text{tg}\,\alpha = -\frac{d\,U}{dx} / \frac{d\,U}{dy}, \text{ if only } \Delta U \neq 0.$$

The flow speed vector makes an angle β with the x axis,

$$\text{tg}\,\beta = \frac{d\,U}{dy} / \frac{d\,U}{dx},$$

i.e. the flow goes orthogonally to equipotential lines in the direction of increasing U function.

As we remember, the harmonic function u (x, y) defines the function of

$$\text{f}\,(\text{z}) = \text{u} + i\upsilon$$

where υ is a conjugate to the harmonic function u, defined from Cauchy-Riemann equations (A.4). Essentially, Cauchy solves the following problem, under which conditions for the complex function f (z) the integral ∫ f (z) dz in a closed loop ℓ is zero. However, he does not speak explicitly of the complex function, but applying pairs of real functions P(x, y) and Q (x, y), gets his main result: the integral∫ f (z) dz does not depend on the integration path if such conditions are met:

$$\frac{dP}{dx} = \frac{dQ}{dy};\ \frac{dP}{dy} = -dQ/dx \quad \text{(A.4)}$$

This condition is a (A.4)- characteristic property of analyticity (holomorphicity) of function of a complex variable. In modern literature, the common name is the Cauchy-Riemann condition. The function f (z) people call the complex potential of the flow.

The tangent line to the curve υ = const makes an angle γ with the x axis and

$$\text{tg}\ \gamma = -\frac{dv}{dx} / \frac{dv}{dy} = \frac{du}{dy} / \frac{du}{dx} = \text{tg}\ \beta$$

i.e. the u flow goes along the curve υ = const. These curves people call streamlines.

The condition $\frac{d^2u}{dx^2} + \frac{d^2u}{dy^2} \neq 0$, equivalent to f '(z) ≠ 0, indicates that streamlines are orthogonal to equipotential lines except at points where f' (z) = 0

This physical analogy allows us to interpret any properties of analytic functions exceptionally clearly. For example, if the analytic function f (z) has at the point zo f' (zo) = 0, then curves u = const and υ = const do not cross at zo = xo + iyo at right angles. Such points are called stationary points, e.g. for the function

$$f(z) = ao + a2\, z^2$$

curves u = const and υ = const intersect at an angle π / 4.

With the same success, we can explore arbitrary features of analytic functions.

Consider the flow with the potential f (z), a derivative f '(z) of which is the rational function, i.e. has only pole specifics $(z\text{-}zo)^{-n}$. Then the function f (z) itself we can represent in the neighbourhood of a specific point in the form of

$$f(z) = A \log(z - zo) + A1\,(z - zo)^{-1} + \ldots + \varphi(z) \qquad (A.5)$$

where φ(z) - function without specifics

Features of flows defined with the function f (z) are made from specifics of streams made by individual components (A.5).

Let us consider an influence of the logarithmic term. Let us at first assume that A is a real number. Let us choose a circle of the radius r around the point zo:

$z = zo + re^{i\varphi}$ and assume that A log (z-zo) = u + iυ;

separating the real and imaginary parts, we obtain A log r = u, Aφ = υ.

Streamlines υ = const will be radii going from the point zo, while equipotential lines u = const - will be circles with a centre in zo.

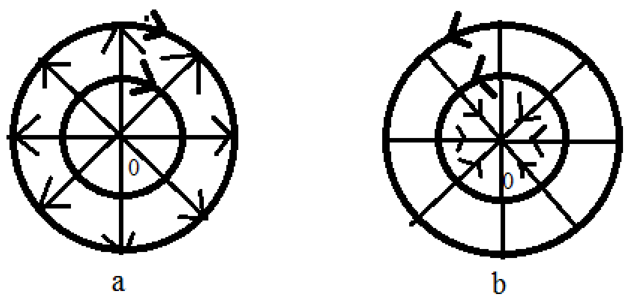

Figure A.1: Divergent flow or drain, source and curls in the near-Earth environment

Thus, the point zo will be either the source (Fig. A.1) or the fluid outlet (Fig. A.1b), depending on the operator A (the liquid will either outflow, or flow into the point z0). If A is a purely imaginary value, then we obtain the conjugate stream A = iB, u = -B φ, υ = log r. Circles will be streamlines. Such streams are called curls. Direction of motion (clockwise or counter clockwise) depends on the B operator.

We have obtained a great result. All features of the analytic function f (z) on the sphere we can describe in terms of the fluid flow with a defined number of sources, outlets, curls, etc.

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GJSFR-A Classification: *FOR Code: 020102*

PLANCKEONORIGINOFDARKENERGYANDSINGULARNATUREOFINFLATIONINSEMICLOSEDFRIEDMANUNIVERSE

Strictly as per the compliance and regulations of :

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I. Introduction

Previous discussions[1,2] on the Plankeon origin of dark energy are extended to include the imaginary pair of gravitationally bound Planckeon-Higgs boson composite. The inflationary superluminal expansion of the universe is likely to be related to a singular nature of the transition amplitude of Higgs boson between two neighboring points separated by a spacelike interval in the ultraviolet region outside the light cone, future and past, favoring the creation of the boson composites.

II. Standard Inflation

In the standard inflation theory, the universe starts either from a large quantum fluctuation of a pre-existing spacetime metric at Planck radius $l_{pl} \sim 10^{-33}$cm and time $l_{pl}/c \sim 10^{-43}$cm, or from the singular hot Big Bang at temperature $T_B = 10^{27}$K occurring at $r = r_B \sim 10^{-25}$cm and time $\sim 10^{-35}$sec, expanding the radius of the universe from r_B to

$$(T_0/T_B)R = (3/10^{27})(10^{28}\text{cm}) \sim 10\text{cm}, \qquad (1)$$

where T_0 is the present temperature and R the present radius of the universe, explaining the large scale homogeneity of the universe.

III. Friedman Inflation

Consider a Friedman universe, filled with a uniform distribution of constant energy density ρ_Λ, having Euclidean radius R, mass $M = \rho_\Lambda V$ and volume $V = 4\pi R^3/3$. The motion of a test particle ticking (quantized) with Planck period $l_{pl} = \hbar/m_{pl}c$ and moving on the surface r of the universe is described by the PC- and T-symmetric line element ds^2 with Lorentz-Friedman-Reissner-Nordström metric:

$$\begin{aligned} ds^2 &= c^2 g_{tt} dt^2 - g_{rr} dr^2 \ (g_{tt} = g_{rr}^{-1}), \\ &= c^2[1 - r^2/r_g^2 + L^2/(m_{pl}cr)^2] \\ &= c^2(1 - r^2/r_g^2 + L^2 l_{pl}^2/r^2), \\ &= c^2[(1 - r/r_g)(1 + r/r_g) + L^2 l_{pl}^2/r^2)], \qquad (2) \end{aligned}$$

where $r_g = 2GM/c \leq R$ is the gravitational radius of the closed ($= R$) and semiclosed ($< R$) universe, and

$$\begin{aligned} L &= m_{pl} r^2 d\theta/dt, \\ &= l_\theta \hbar/2\pi, \ l_\theta = \text{integer}. \qquad (3) \end{aligned}$$

is the quantized angular momentum of the test particle crossing the time axis of the future light cone at $ct = l_{pl}$ in Minkowski space.

There the test particle moves on the 4-dimensional hyperboloid, $(ct)^2 - r^2 = l_{pl}^2$ (Lorentz sphere), with velocity dr/dt obtained by solving $ds^2 = 0$. We find that the light velocity changes from superlumial to luminal and then to subluminal as

$$\begin{aligned} dr/dt &= c\,(g_{tt}/g_{rr})^{1/2} \\ &= c(1 - r^2/r_g^2 + L^2 l_{pl}^2/r^2). \\ &= c\,(1 - l_{pl}^2/r_g^2 + L^2) > c \text{ at } r = l_{pl} \\ &= c \ \text{ at } \ r = r_c = (r_g l_{pl})^{1/2} \\ &= 0 \ \text{ at } \ r_c < r < r_g - r_{pl} \\ &> c \ \text{ at } \ r = r_g. \qquad (4) \end{aligned}$$

The inflationary history of the universe can thus be described as a superluminal expansion of the universe starting at $r = l_{pl}$ and ending at $r_c = r = (r_g l_{pl})^{1/2}$. The astronomical observations[4] of the large-scale homogeneity of the distribution of matter and galaxy formation on the scale of 10^{10} light years can be explained by the superluminal and bi-directional EPR causal connection[1,2] between radius $r = l_{pl}$ and r_c, while stars, clusters of galaxies, voids and other structures larger than 10^8 light years, violating a perfect homogeneity by less than a part in a thousand 10^3, seem to indicate the

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quantized angular momnetum less than $l_\theta \sim 10^3$ so that $r_c = (r_g l_{pl})^{1/2} = l_\theta 10^{-2}$cm = 10cm.

IV. De-Sitter Inflation

The de-Sitter universe filled with Planckeon energy $m_{pl}c^2 = \hbar c/l_{pl}$ is described by the line element:

$$ds^2 = c^2(1 - \Lambda r^2)$$
$$= c^2(1 - r^2/l_{pl}^2), \qquad (5)$$

where Λ is the cosmological constnt. The light velocity is determined from $ds^2 = 0$ as

$$dr/dt = c(1 - r^2/l_{pl}^2). \qquad (6)$$

Thus Einstein's equation with cosmological term Λ predicts a subluminal inflation:

$$\exp(\sqrt{\Lambda}ct) = \exp(ct/l_{pl}) = \exp 10^{43} t, \qquad (7)$$

starting at t = 0 with dr/dt < c and ending at Planck time $t_{pl} = l_{pl}/c$ with dr/dt = 0 and $\exp(\sqrt{\Lambda}ct) = 0$, showing an uncertainty relation between position l_{pl} and momentum $m_{pl}c$: $l_{pl}m_{pl}c = \hbar$ defining the Compton wavelength $l_p = \hbar/m_{pl}c$ of a Planckeon.

V. Mass Defect of Friedman Universe

Consider the Panckeon model Friedman universe filled with uniform distribution of constant dark energy density ρ_Λ. During the subluminal expansion of the universe from radius t = r_c to R – l_{pl}, the mass defect develops between Newtonian mass M = $\rho_\Lambda V$ and the general relativistic proper mass M_p calculated from the proper radius $R_p = \int^R g_{rr}dr$ and the proper volume $V_p = 4\pi R_p^3/3$:

$$M_p = \rho_\Lambda V_p$$
$$= (3/2)(R/r_g)^3 \sin^{-1}(R/r_g)M. \qquad (8)$$

We find that M_p increases with the increase of the world radius from r ~ l_{pl}, where $l_{pl}/r_g \sim 1$. With further increase of r towards $r = r_g - l_{pl}$, R_p decreases towards l_{pl}, where $r/r_g \sim 1$, forming a gravitational semiclosure with surface area $4\pi l_{pl}^2$ having holographic information content $4\pi(R/l_{pl})^2 = 10^{120}$.

VI. Magnetic Monopole and Nambu's Mass Formula

Recently in June 2016 in Tokyo a successful artificial creation of magnetic monopole, using spin ice of rare earth metals at low temperature below critical, was anounced.[5] The magnetic monopole was predicted by Dirac in 1931 and its neccessary existence was emphasized by Zel'dovich, t'Hooft and others in the grand unified theory as a primordial problem. We here point out that the monopole mass spectrum

$$m_{mono} = n(\hbar c/e), \quad n = \text{integer} \qquad (9)$$

is hidden in Nambu's mass spectrum[1] for elementary particles discovered in 1952 before grand unification of gauge fields:

$$m_n = n(\hbar c/e^2)m_e, \quad n = \text{integer},$$
$$= nGm_{pl}^2/L = (137n/2)\, m_e,\ m_e = \text{electron mass},$$
$$n = 3, 4, 14, 15, 16, 17, 18, 19, 24, 33 \qquad (10)$$

for μ, π, K, τ (mesons), P/N (proton/neutron), Λ, Ξ, Ω, Λ_c (baryons).

The angular term in the line element ds^2 of Friedman universe (Eq.(2)) can give magnetic monopoles of mass $m_{mono} = 10^{-3}m_{pl}$ with mass spectrum

$$m_{mono} = l_\theta 10^{-3} m_{pl},\ l_\theta \text{ integer}, \qquad (11)$$

indicating energy emission during quantum transitionon from higher, say, $l_\theta \sim 10^2$ to lower orbit (circular) on the perturbed background radiation at temperture T = 10^{32}K. We note that the higher orbit is highly multi-directional, locally violating the spherical symmetry of the Friedman universe.

It is conceivable that the gravitationally bound pair of Planckeon and magnetic monople creates the binding energy, solving the primordial problem:

$$Gm_{mono}m_{pl}/l_{pl} = 10^{-3}m_{pl}c^2 = 10^{19}\kappa T. \qquad (12)$$

VII. Cosmologial Implication of Mass Spectrum

In his Nishina Memorial Lecture in 1983 t'Hooft[6] asked: Is quantum field theory a theory? and showed an artistic view of mass spectrum of relatively stable point-like paricles. There Nambu's mass spectrum ranging from 1Mev towards 100Gev (leptons, mesons and hadrons) is extended to include gauge paricles, real and imaginary, required to make a quantum field theory a theory. G. t' Hooft calls the mass range between 10^{16} to 10^{19}Gev a trangent range, and the range beyond 10^{19}Gev the blackhole range characterized by the spectrum density $\rho(E) = \exp(4\pi M/m_{pl})^2$ of the blackhole of 10^{19}Gev scale mass M.

We here propose to call the 10^{20}Gev scale mass M the Newtonian mass of semiclosed Friedman universe (r_g < R) having Planck scale proper mass $M_P \sim m_{pl}$ with holographic information content $4\pi(M/m_{pl})^2 = 120$.

VIII. Plankeon-Higgs Boson Origin of Dark Energy

In 2014 the CERN high energy proton-proton collision experiment detected the Higgs boson with mass m_H of about 133 proton mass m_P:

$$m_H \sim 10^2 m_P \sim 10^{-17} m_{pl} \sim 10^{-22}\text{g}. \qquad (13)$$

Being a scalar field, the Higgs boson has no spin, has no electric and color charge. It has its own anti-particle and CP-symmetry.

The cosmological implication of the graviton-Higgs boson composite has been discussed[7] in curved space time as it may generate huge cosmological constant Λ in negative sense, while its anti-boson composite may flatten the curve in positive sense. We here consider a gravitationary bound Plankeon-Higgs boson composite having potential energy:

$$Gm_H m_{pl}^2/l_{pl} = 10^{-17} m_{pl} c^2 \sim 10^{15} \kappa T, \quad (14)$$

in positive sense as a source of dark energy filling the evolutionarily earlier upper hemisphere of the semiclosed Friedman universe. Towards a solution of the primordial problem of observed abense of magnetic monopoles, we may also consider the monopole-Higgs boson composite having potential energy in positive sense:

$$Gm_H m_{mono}^2/l_{pl} = 10^{-14} m_{pl} c^2 \sim 10^{12} \kappa T. \quad (15)$$

IX. Singular Nature of Higgs Boson

Consider a scalar field $\varphi(r, t)$ created by a Higgs boson at $(r, t) = (0, 0)$ obeying CP and T symmetric Klein-Gordon equation: [12,14]

$$[\partial^2/\partial^2(ct) - \partial^2/\partial^2 r - (m_H c/\hbar)^2]\varphi$$

$$[(\partial/\partial(ct) - \partial/\partial r)(\partial/\partial(ct) + \partial/\partial r) - (m_H c/\hbar)^2]\varphi$$

$$= \delta(r, t), \quad (16)$$

giving the amplitude of transition (propagator) $D(s^2)$ between two points separated by 4-dimensional distance $s^2 = (ct)^2 - r^2$: [12,14]

$$D(s^2) = -\delta(s^2)/4\pi + (\lambda/4\pi s)H_1^{(2)}(s/\lambda)$$

$$\sim \delta(s^2) \text{ on the light cone } ds^2 = 0 \quad (17)$$

$$\sim (1/|s|)^{3/2}\exp(-is/\lambda) \text{ within the light cone } ds^2 > 0, \quad (18)$$

$$\sim (1/|s|)^{3/2}\exp(-|s|/\lambda) \text{ outside the light cone } ds^2 < 0. \quad (19)$$

Here $H_1^{(2)}$ is the Hankel function of the sccond kind and $\lambda = \hbar/m_H c$ is the Higgs wavelength. We find that $D(s^2)$ gives a singular attractive potential:

$$D(s^2) \sim (1/|s|)^{3/2}\exp(-|s|/\lambda)$$

$$\sim (1/|s|)^{3/2} \sim (1/l_{pl})^{3/2}, \quad (20)$$

favoring the superluminal (spacelike) creation of Planckeon-Higgs boson composites outside the light cone in the transional region between quantum field theory and the blackhole cosmology.

X. Historical Comments

In the early attempts to find origins of quasistellar radio sourses, Zel'dovich,[9] Novikov,[10] Stanyukovich,[11] and others examined models of radiating Planck scale black hole (Planckeon) filled with a scalar field obeying Klein-Gordon equation with spherically symmetric metric.[11] For the radiation to be observed, the inner universe is requred to be open to an asympotically flat Euclidean space though a Schwarzschild bottleneck pulsating with Planck period. As the presently radiating black hole can be a final state of the contracting past universe as well as the initial state of an exanding future universe, we are led to an infinite series of (CP and T symmetric) world within world model under the Middle Way doctorine[2] restated as the unitary and holographic princinple, to be compared to currently dicussed nonlocal and acausal parallel world models.[3,13]

XI. Acknowledgements

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14. N. N. Bogoliubov and D. V. Shirkov, Introduction to the Theory of Quantized Fields: Translated into English by G. Volk off, University of British Columbia, Vancouver, from freshly printed copies of the Russian edition airmailed from Moskow. The Jordan-Pauli proagator $D(s^2)$ used there does not allow Feynman's 'zigzagging causality'[1,2] including virtual pair creation and annihilation of bosons between points separated by a spaceike distance $s^2 < 0$ in the ultraviolet region outside the light cone.

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The Difficulties of Quantum Mechanics and its Investigations of Development

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Abstract- When the states and properties of microscopic particles were described by linear SchrÖdinger equation the quantum mechanics had a lot of difficulties, which cause a centenary controversy in physics and have not a determinate conclusions till now. Thus we used a nonlinear SchrÖdinger equation to replace the linear SchrÖdinger equation and to depict and study in detail the states, properties and rules of motion of microscopic particles. Concretely speaking, we here investigated the properties and rules of wave-particle duality of microscopic particles and its stability, the invariances and conservation laws of motion of particles, the classical rule of motion, Hamiltonian principle of particle motion, corresponding Lagrangian and Hamilton equations for the microscopic particle, the mechanism and rules of particle collision in different nonlinear systems, the uncertainty relation of position and momentum of particles, the features of reflection and transmission of the particles at interfaces as well as the eigenvalue and eigenequations of the particles, and so on. The results obtained from these investigations show clearly that the microscopic particles described by the nonlinear SchrÖdinger equation have exactly a wave- particle duality, motions of its centre of mass meet not only classical equation of motion but also the Lagrangian and Hamilton equations, its mass, energy and momentum and angular momentum satisfy corresponding invariances and conservation laws, their collision has the feature of collision of classical particles, the uncertainty of position and momentum of the particles has a minimum, it is a bell-type solitary wave contained envelope and carrier wave, which but differs from not only KdV solitary wave but linear wave, its eigenvalues and eigenequations obey Lax principle and possess plenty of unusual peculiarities. The above natures and properties of the particles are different completely and in essence from those described the linear SchrÖdinger equation in the quantum mechanics. This shows that to use nonlinear SchrÖdinger equation changes the intrinsic natures of microscopic particles in quantum mechanics and makes the microscopic particles have the wave-particle duality. Thus the centenary controversy in physics could be solved by this idea and theory. At the same time, these results impel the quantum mechanics to develop toward the nonlinear theory, or speaking, nonlinear quantum theory is a necessary direction of development of quantum mechanics.

Keywords: microscopic particle, nonlinear systems, nonlinear interactions, quantum mechanics, localization, wave-corpuscle duality, motion rule, dynamic property, nonlinear schrödinger equation.

I. The Nature and Properties of the Microscopic Particles Described by the Schrödinger Equation in the Quantum Mechanics

a) *Fundamental hypothesizes of quantum mechanics*

As known, quantum mechanics established by several great scientists, such as, Bohr, Born, SchrÖdinger and Heisenberg, etc., in the early 1900s [1-7] has served as the foundation of modern science in the history of physics and science and was extensively used to describe the states and properties of motion of microscopic particles. When the developmental history of quantum mechanics are remembered we find that its some fundamental hypothesizes and principles were disputed also about one century. What is this? This is due to plenty of difficulties and contradictions existed in quantum mechanics. An astonishing problem is that these disputations have not an unitized conclusion up to now[8-15]. This means that these difficulties are stern and crucial. After undergoing one centenary disputation we now ask what are the successes and shortcomings of quantum mechanics on earth? what are in turn the roots and reasons resulting in these difficulties and questions? Can or cannot these difficulties be solved ? How do we solve these difficulties? A series of problems need us to solve and are also worth to solve seriously, at present. In order to investigate and solve these problems we have to look back to these fundamental hypothesizes of quantum mechanics. These hypothesizes can be outlined as follows[1-12].

(1) The states of microscopic particles is represented by a vector of states $|\psi\rangle$ in Hilbert space, or a wave function $\psi(\vec{r},t)$ in coordinate representation. It reflects the properties of wave of motion of the microscopic particles and can be normalized (i.e. $\langle\psi|\psi\rangle=1$). If β is a constant number, then both $|\psi\rangle$ and $\beta|\psi\rangle$ describe a same state.

(2) A mechanical quantity of microscopic particle, such as, coordinate x, momentum p and energy E, etc., is represented by an operator in Hibert space. An observable mechanical quantity corresponds to a Hermitean operator, the eigenvectors of its state constructs a basic vector in the Hibert space. This shows that the values

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of the physical quantity are just eigenvalues of these operators. The eigenvalues of Hermitean operator are some real numbers. The eigenvectors corresponding to different eigenvalues are orthogonal with each other. A common eigenstates of commutable Hermitean operators are constituted as an orthogonal and complete set, $\{\psi_L\}$. Any vector of state, $\psi(\vec{r},t)$ may be expanded by it into a series as follows:

$$\psi(\vec{r},t)(=\sum_L C_L\psi_L(\vec{r},t), \quad \text{or} \quad |\psi(\vec{r},t)\rangle = \sum_L \langle\psi_L|\psi\rangle|\psi_L\rangle \tag{1}$$

where $C_L = \langle\psi_L|\psi\rangle$ is the wave function in representation L. If the spectrum of L is continuous, then the summation in Eq.(1) should be replaced by an integral: $\int dL\cdots$. Equation(1) can be regarded as a projection of wave function $\psi(\vec{r},t)$ of the microscopic particle system in the representation, The Eq.(1) is the foundation of transformation between different representations and of measurement of physical quantities in quantum mechanics. In the quantum state described by $\psi(\vec{r},t)$, the probability getting the L' in the measurement of L is $|C_L|^2$ = $|\psi_{L'}|^2 = |\langle\psi_{L'}|\psi\rangle|^2$ in the case of discrete spectrum, the probability is $|\langle\psi_{L'}|\psi\rangle|^2 dL$ in the case of continuous spectrum. In a single measurement of any a mechanical quantity, only one of the eigenvalues of corresponding operator can be obtained, the system is then said to be in the eigenstate belonging to this eigenvalue.

The two hypothesizes are the most important assumptions and stipulate how the states of the microscopic particles are represented in quantum mechanics

(3) A mechanical quantity in an arbitrary state $|\psi\rangle$ can only take an average value by

$$\langle\hat{A}\rangle = \langle\psi|\hat{A}|\psi\rangle/\langle\psi\|\psi\rangle, \text{ or } \langle\hat{A}\rangle = \langle\psi|\hat{A}|\psi\rangle \tag{2}$$

when Ψ is normalized, i.e., possible values of the physical quantity, A, may be obtained by calculating this average. In order to find out these possible values, a wave function of states must be firstly known. Condition for determinate value the quantity, A, has in this state is $\overline{\langle\Delta A\rangle^2}$ =0. Thus we can obtain the eigenequation of the operator Â to be as follows

$$\hat{A}\psi_L = \hat{A}\psi_L \tag{3}$$

From this equation we can determine the spectrum of eigenvalues of the operator Â and its corresponding eigenfunction Ψ_L. The eigenvalues of Â are possible values observed from experiment for this physical quantity. All possible values of Â in any other states are nothing but its eigenvalues in its own eigenstates. This hypothesis reflects the statistical nature in the description of microscopic particle in quantum mechanics.

(4) Hilbert space is a linear one and the mechanical quantity corresponds to a linear operator. Then corresponding eigenvector of state, or wave function, satisfies the linear superposition principle, i.e., if two states, $|\psi_1\rangle$ and $|\Psi_2\rangle$ are ones of a particle, then their linear superposition:

$$|\psi\rangle = C_1|\psi_1\rangle + C_2|\psi_2\rangle, \tag{4}$$

describes also the state of the particle, where C_1 and C_2 are two arbitrary constants,. The linear superposition principle of quantum state is determined by the linear characteristics of the operators and this is why the quantum theory is referred to as linear quantum mechanics. However, it is noteworthy to point out that such a superposition is different from that of classical wave, it does not result in changes in probability and intensity of particle.

(5) Correspondence principle. If the classical mechanical quantities, A and B, satisfy the Poisson brackets:

$$\{A,B\} = \sum_n\left(\frac{\partial A}{\partial q_n}\frac{\partial B}{\partial p_n} - \frac{\partial A}{\partial p_n}\frac{\partial B}{\partial q_n}\right)$$

where q_n and p_n are generalized coordinate and momentum in classical system, respectively, then the corresponding operators Â and $\hat{B}$ in quantum mechanics satisfy the following commutation relations:

$$[A,B]=(AB-BA)=-ih\{A,B\} \tag{5}$$

where i= $\sqrt{-1}$ and h is the Planck constant. If A and B are substituted by q_n and p_n respectively, we have:

$$[\hat{p}_n,\hat{q}_m]=-ih\delta_{nm}, \quad [\hat{p}_n,\hat{p}_m]=0$$

This reflects the fact that the values taken for physical quantity are quantized. Based on this fundamental hypothesis, the Heisenberg uncertainty relation can be obtained as follows:

$$\overline{(\Delta A)^2}\,\overline{(\Delta B)^2}\geq\frac{|C|^2}{4} \tag{6}$$

where $[\hat{A},\hat{B}]=i\hat{C}$ and ΔA = $<\hat{A}$ - $<\hat{A}>>$. For the coordinate and momentum operators, the Heisenberg uncertainty relation takes the usual form:

$$\Delta x\Delta p\geq\hbar/2$$

(6) The time dependence of a quantum state $|\psi\rangle$ of a microscopic particle is determined by the following SchrÖdinger Equation:

$$-\frac{\hbar}{i}\frac{\partial}{\partial t}|\psi\rangle=\hat{H}|\psi\rangle \tag{7a}$$

or

$$i\hbar\frac{\partial\psi}{\partial t}=-\frac{\hbar^2}{2m}\nabla^2\psi+\hat{V}(\vec{r},t)\psi \tag{7b}$$

where $\hat{T}=\hbar^2\nabla^2/2m$ is the kinetic energy operator, $\hat{V}(\vec{r},t)$ is the externally applied potential operator, m is the mass of particles, $\psi(\vec{r},t)$ is a wave function describing the states of particles, $\vec{r}$ is the coordinate or position of the particle, and t is the time. This is a fundamental dynamic equation of the microscopic particle in time-space. Corresponding Hamiltonian operator of the systems, H, is assumed to give by

$$\hat{\mathrm{H}}=\hat{T}+\hat{V}=-\frac{\hbar^2}{2m}\nabla^2+\hat{V} \tag{8}$$

This fundamental hypothesis amounts to assume that the independence of Hamiltonian operator of the systems with wave function of states of particles, and the SchrÖdinger equation (7) is a linear one for the wave function $\psi(\vec{r},t)$ in quantum mechanics. This is an another of reasons to be referred to it as linear quantum mechanics. This hypothesis shows that the states and properties of the systems or microscopic particles at any time are determined by the Hamiltonian of the systems, or nonlinear SchrÖdinger equation (7).

If the state vector of the system at time t_0 is $|\psi(t_0)\rangle$ then the mechanical quantity and wave vector at time t are associated with those at time t_0 by a unitary motive operator $\hat{U}(t,t_0)$, namely

$$|\psi(t_0)\rangle=\hat{U}(t,t_0)\,|\psi(t_0)\rangle$$

here $\hat{U}(t,t_0)=1, \hat{U}^+\hat{U}=\hat{U}\hat{U}^+=I$. If let $\hat{U}(t,0)=\hat{U}(t)$ then the equation of motion becomes

$$-\frac{\hbar}{i}\frac{\partial}{\partial t}\hat{U}(t)=\hat{H}\hat{U}(t) \tag{9}$$

When H does not depend explicitly on an time t and $\hat{U}(t)=\exp[i\hat{H}t/\hbar]$, If H is an explicit function of time t, we then have

$$\hat{U}(t)=1+\frac{1}{i\hbar}\int_0^t dt_1\,\hat{H}(t_1)+\frac{1}{(i\hbar)^2}\int_0^t dt_1\,\hat{H}(t_1)\int_0^{t_1} dt_2\,\hat{H}(t_2)+\cdots \tag{10}$$

This equation shows a causality relation of the microscopic law of motion. Obviously, there is an important assumption in quantum mechanics, i.e., the Hamiltonian operator of the system is independent on the wave function of state of the particle. This is a fundamental assumption in quantum mechanics.

(7) Principle of full-identity. No new physical state occurs when same two particles exchange mutually their positions in the systems, in other words, it satisfies $p_{kj}|\psi\rangle=\lambda|\psi\rangle$, where $\hat{p}_{kj}$ is a exchange operator. The wave function for an system consisting of identical particles must be either symmetric, ψ_s, $(\lambda=+1)$ or antisymmetric, ψ_a, $(\lambda=-1)$, and this property remains invariant with time and is determined only by the nature of the particle. The wave function of a boson particle is symmetric and that of fermion is antisymmetric.

(8) Assumption of measurement of physical quantities in quantum systems. There was no assumption made about measurement of physical quantities at the beginning of quantum mechanics. It was introduced later to make the quantum mechanics complete. The foundation of this hypothesis is the equations (1) and (3). However, this is a nontrivial and controversial topic which has been a focus of scientific debate. This problem will not be discussed here. Interested reader can refer to some literatures.

In one word, these hypothesizes stipulate the representation forms of states and mechanical quantities and Hamiltonian of microscopic particles and the relationships satisfied by them. Concretely speaking, the states of microscopic particle is represented by a wave function, which satisfies the linear SchrÖdinger equation (7) and linear superposition principle in Eq.(4) and normalization condition, the square of its absolute value represents the probability of the particle at certain point in space, and is used to indicate the corpuscle feature of microscopic particle. The mechanical quantities of microscopic particle are represented by the operators, which satisfy the commutation relation in Eq.(5) and uncertainty relation in Eq.(6), their values are denoted by some possible average values or eigenvalues of corresponding operators in any states or eigenstates, respectively. The Hamiltonian operator of the systems is independent on the wave function of state of the particles and denoted only by the sum of kinetic and potential energy operators in Eq.(8), which determine the states of the particles by virtue of Eq.(7). These are just the quintessence and creams of quantum mechanics.

b) The Successes and Difficulties as Well as Disputations in Quantum Mechanics

On the basis of several fundamental hypothesises mentioned above, Heisenberg, SchrÖdinger, Bohn, Dirac, etc[1-7]., have founded up the theory of quantum mechanics which describes the law and properties of motion of the microscopic particles. This theory states that once the externally applied potential fields and the conditions at the initial states for the particle are given, the states and features of the particles at any time later and any position can be easily determined by linear SchrÖdinger equations (7)-(8) in the case of nonrelativistic motion. The quantum states and their occupations of electronic systems, atom, molecule, and the band structure of solid state matter, and any given atomic configuration are completely determined by the above equations. Macroscopic behaviors of the systems, such as, mechanical, electrical and optical properties may be also determined by these equations. This theory can also describes the properties of microscopic particle systems in the presence of external electromagnetic-field, optical and acoustic waves, and thermal radiation. Therefore, to a certain degree, the linear SchrÖdinger equation describes the law of motion of microscopic particles of which all physical systems are composed. It is the foundation and pillar of modern science.

One of the great creative point of quantum mechanics is just to forsake completely traditional representations of particles in classical physics, in which the wave functions or vectors are used to describe the state of microscopic particles and the operators are introduced to represent the mechanical quantity of the particles. their applied results show that this is available. Thus quantum mechanics had great achievements in descriptions of motion of microscopic particles[1-12], such as, electron, phonon, photon, exciton, atom, molecule, atomic nucleus and elementary particles, and in predictions of properties of matter based on the motion of these quasi-particles. For example, energy spectra of atoms (such as hydrogen atom, helium atom) and molecules (such as hydrogen molecule) and compounds, the electric, magnetic and optical properties of atoms and condensed matters can be calculated based on the quantum mechanics, and these calculated results are in basic agreement with experimental measurements. Thus the establishment of the theory of quantum mechanics has revolutionized not only physics but also many other science branches, such as, chemistry, astronomy, biology, etc., and at the same time, created many new branches of science, for example, quantum statistics, quantum field theory, quantum electronics, quantum chemistry, quantum biology, quantum optics, etc.. One of the great successes of quantum mechanics is the explanation of the fine energy-spectra of hydrogen atom, helium atom and hydrogen molecule. The energy spectra predicted by quantum mechanics for these simple atoms and molecules are completely in agreement with experimental data. Furthermore, modern experiments have demonstrated that the results of Lamb shift and superfine structure of hydrogen atom and anomalous magnetic moment of electron predicted by the theory of quantum electrodynamics are coincident with experimental data within an order of magnitude of 10^{-5}. It is therefore believed that the quantum electrodynamics is one of successful theories in modern physics.

Despite the great successes of quantum mechanics, it nevertheless encountered some problems and difficulties[7-15]. In order to overcome these difficulties, Einstein had disputed with Bohr and others for the whole of their life, but very sorry that these difficulties remained still up to now. The difficulties of quantum mechanics are well known and have been reviewed by many scientists. When one of founders of the quantum mechanics, Dirac, visited to Australia in 1975, he give a speech on development of quantum mechanics in New South Wales University. During his talk, Dirac mentioned that at the time, great difficulties existed in the quantum mechanical theory. One of the difficulties referred to by Dirac was about an accurate theory for interaction between charged particles and an electromagnetic field. If the charge of a particle is considered as concentrated at one point, we shall find that the energy of a point charge is infinite. This problem had puzzled physicists for more than 40 years. Even after the establishment of renormalization theory, no actual progress had been made……..Therefore, Dirac concluded his talk by marking the following statements: It is because of these difficulties, I believe that the foundation for the quantum mechanics has not been correctly laid down. I cannot accept that the present foundation of the quantum mechanics is completely correct."

However, have what difficulties in the quantum mechanics on earth evoked these contentions and raised doubts about the theory among physicists in the world? It was generally accepted that the fundamentals of the quantum mechanics consist of Heisenberg matrix mechanics, SchrÖdinger wave mechanics, Born's explanation of probability for the wave function and Heisenberg uncertainty principle, etc.. These were also the focal points of debate and controversy[12-15]. The debate was about how to interpret the quantum mechanics. Some of the questions being debated concern the interpretation of the wave-corpuscle duality, probability explanation of wave function, Heisenberg uncertainty principle, Bohr complementary (corresponding) principle, the quantum mechanics which describes whether the law of motion for a single particle or for an assembly consisting of a great number of particles. The following is a brief summary of issues being debated and disputed in quantum mechanics. (1) First, the correctness and completeness of the quantum mechanics were challenged. Is quantum mechanics correct? Is it complete and self-consistent? Can the properties of microscopic particle systems be completely described by the quantum mechanics? or speaking, Whether the SchrÖdinger equation (7) can describe completely the states and properties of microscopic particles in a realistically physical systems. Meanwhile, the quantum mechanics in principle can describe the physical systems with many-body and many particles, but it is not easy to solve such a system and plenty of approximations must be used to obtain some approximate solutions. In doing this, a lot of true and important phenomena and effects of the systems are artificially neglected or thrown away. This is very sorry for physics. Do the fundamental hypothesizes contradict each other? , whether the hypothesis for the independence of Hamiltonian operator of the systems on wave function of states of particles in Eq.(8) is correct.

(1) Is the quantum mechanics a dynamic or a statistical theory? Does it describe the motion of a single particle or a system of particles? The dynamical equation (7) seems as equation of a single particle, but its mechanical quantities are determined based on the concepts of probability and statistical average. This caused confusion about the nature of the theory itself.

(2) How to describe the wave-corpuscle duality of microscopic particles? What is the nature of a particle defined on the hypotheses of the quantum mechanics? The wave-corpuscle duality is established by the de Broglie relations. Can the statistical interpretation of wave function correctly describe such a property? There are also difficulties in using wave package to represent the corpuscle nature of microscopic particles. Thus wave-corpuscle duality was a major challenge to the quantum mechanics.

(3) Was the uncertainty principle due to the intrinsic properties of microscopic particle or a result of uncontrollable interaction between the measuring instruments and the system being measured?

(4) A particle appears in space in the form of a wave, and it has certain probability to be at a certain location. However, it is always a whole particle, rather than a fraction of it, being detected in a measurement. How can this be interpreted? Is the explanation of this problem based on wave package contraction in the measurement correct?

Since these are important issues concerning the fundamental hypotheses of the quantum mechanics, many scientists were involved in the debate. Unfortunately, after being debated for almost a century, there are still no definite answers to most of these questions. While many enjoyed the successes of the quantum mechanics, other were wondering whether the quantum mechanics is the right theory of real microscopic physical world, the microscopic particle has or has not wave-corpuscle duality on earth, because of the problems and difficulties it encountered. Modern quantum mechanics was born in 1920s, but these problems were always the topics of heated disputes among different views and different schools till now. It was quite exceptional in the history of physics that so many prominent physicists from different institutions were involved and the scope of the debate was so wide. The group in Copenhagen School headed by Bohr represented the view of the main stream in these discussions. In as early as 1920s, heated disputes on statistical explanation and incompleteness of wave function arose ever between Bohr and other physicists, including Einstein, de Broglie, SchrÖdinger, Lorentz, etc, who has doubted and continuously criticized Bohr's interpretations. This results in a life-long disputations between Bohr and Einstein, which is unprecedented and went through three stages.

The first stage was during the period from 1924 to 1927, when the theory of quantum mechanics had just been founded. Einstein proceeded from his own philosophical belief and his scientific goal for an exact description of causality in the physical world, and expressed his extreme unhappiness with the probability interpretation of the quantum mechanics. In a letter to Born on December 4, 1926, He said that " Quantum mechanics is certainly imposing. But an internal sound tells me that it is not the real thing (der Wahre Jakob). The theory says a lot, but it does not bring us any closer to the secret of the "Old one." I, at any rate, am convinced that He is not playing at dice."

The second stage was from 1927 to 1930. After Bohr had put forward his complementary principle and had established his interpretation as main stream interpretation, Einstein was extremely unhappy. His main criticism was directed at the Heisenberg uncertainty relation on which Bohr's complementary principle was based.

The third stage was from 1930 until the death of Einstein. The disputation during this period is reflected in the debate between Einstein and Bohr over the "EPR" paradox proposed by Einstein together with Podolsky and Rosen[13-15]. This paradox concerned the fundamental problem of the quantum mechanics, i.e. whether it satisfied the deterministic localized theory and the microscopic causality. The disputation to this problem maintains a longer period.

To summarize, the long-dated disputation between Bohr and Einstein schools was focused on three problems: (1)Einstein upheld to belief that the microscopic world is no different from the macroscopic one, particles in microscopic world are matters and they exist regardless of the methods of measurements, any theoretical description to it should in principle be determinant. (2) Einstein always considered that the theory of the quantum mechanics was not an ultimate and complete one. He believed that quantum mechanics is similar to the classical optics. Both of them are correct theories based on statistical laws, i.e., when the probability $|\psi(\vec{r},t)|^2$ of a particle at moment t and location r is known,, an average value of observable quantity can be obtained using statistical method and then compared with the experimental results. However, understanding to processes involving single particle was not satisfactory. Hence, $\psi(\vec{r},t)$ has not give everything about a microscopic particle system, and the statistical interpretation cannot be ultimate and complete. (3)The third issue concerns the physical interpretation of the quantum mechanics. Einstein was not impressed with the attempt to completely describing some single processes using quantum mechanics, which he made very clear in a speech at the fifth Selway International Meeting of physics. In an article, "Physics and Reality", published in 1936 in the Journal of the Franklin Institute, Einstein again mentioned that what the wave function $\psi(\vec{r},t)$ describes can only be a many-particle system, or an assemble in terms of statistical mechanics, and under no circumstances, the wave function can describe the state of a single particle. Einstein also believed that the uncertainty relation is a result of incompleteness of the description of a particle by $\psi(\vec{r},t)$, because a complete theory should give precise values for all observable quantities. Einstein also did not accept the statistical interpretation because he did not believe that an electron possess free will. Thus, Einstein's criticism against the quantum mechanics was not directed towards the mathematic formalism of the quantum mechanics, but to its fundamental hypotheses and its physical interpretation. He considered that this is due to the incomplete understanding of the microscopic objects. Moreover, the contradiction between the theory of relativity and the fundamental of the quantum mechanics was also a central point of disputation. Einstein made effort to unite the theory of relativity and quantum mechanics, and attempted to interpret the atomic structure using field theory. The disagreements on several fundamental issues of the quantum mechanics by Einstein and Bohr and their followers were deep rooted and worth further study. This brief review on the disputes between the two great physicists given above should be useful to our understanding on the nature and problems of the quantum mechanics.

c) The Roots Produced these Difficulties in Quantum Mechanics

From the above description we see that the difficulties and questions of quantum mechanics exist hugely and extensively, the disputations on it between Einstein and Bohr are drastic, their branches are also considerable. However, what are the reasons and roots generating these difficulties on earth? This is just a key problem on quantum mechanism and its development. Only if the roots are sought we can solve these difficulties and improve and develop quantum mechanics. For this purpose we have to look carefully at the essences and significances of the above hypothesizes of quantum mechanics.

As known, the linear SchrÖdinger equation (7) is a wave equation describing the properties and rules of motion of microscopic particles. In the light of this theory we can find the solutions of the equation[8-12] and know thus the states and properties of the particles, if only the externally applied potential is known, whether or no complicated systems and interactions among the particles. This is very simple process finding solutions. However, for all externally applied potentials, the solutions of the equation are always a linear or dispersive wave, for example, at $V\left(\vec{r},t\right)=0$, its solution is a plane wave as follows:

$$\psi\left(\vec{r},t\right)=A'\exp[i(\vec{k}\cdot\vec{r}-\omega t)] \tag{11}$$

where k is the wavevector of the wave, ω is its frequency, and A' is its amplitude. This solution denotes the state of a freely moving microscopic particle with an eigenenergy of

$$E=\frac{p^2}{2m}=\frac{1}{2m}(p_x^2+p_y^2+p_z^2),(-\infty<p_x,p_y,p_y<\infty) \tag{12}$$

This is a continuous spectrum. It states that the probability of the particle to appear at any point in the space is the same, thus the microscopic particle propagates and distributes freely in a wave in total space, this means it cannot be localized and have nothing about corpuscle feature.

If the free particle is artificially confined in a small finite space, such as, a rectangular box of dimension a, b and c, then the solution of Eq.(7) is a standing waves as follows

$$\psi\left(x,y,z,t\right)=A\sin\left(\frac{n_1\pi x}{a}\right)\sin\left(\frac{n_2\pi y}{b}\right)\sin\left(\frac{n_3\pi z}{c}\right)e^{-iEt/\hbar} \tag{13}$$

In such a case, this microscopic particle is still localized, it appears still at each point in the box with a determinant probability. Difference from Eq.(12) is that the eigenenergy of the particle in this case is quantized as follows

$$E=\frac{\pi^2\hbar^2}{2m}\left(\frac{n_1^2}{a^2}+\frac{n_2^2}{b^2}+\frac{n_3^2}{c^2}\right), \tag{14}$$

the corresponding momentum is also quantized. This means that the wave feature of microscopic particle has be not changed because of the variation of itself boundary condition.

If the potential field is further varied, for example, the microscopic particle is subject to a conservative time-independent field, $U\left(\vec{r},t\right)=U\left(\vec{r}\right)\neq 0$, then the microscopic particle satisfies the time-independent linear SchrÖdinger equation

$$-\frac{\hbar^2}{2m}\nabla^2\psi'+V\left(\vec{r}\right)\psi'=E\psi' \tag{15}$$

where

$$\psi=\psi'\left(\vec{r}\right)e^{-iEt/\hbar} \tag{16}$$

When $V=\vec{F}\cdot\vec{r}$, here $\vec{F}$ is a constant field, such as, a one dimensional uniform electric field $V(x)=-e\varepsilon x$, the solution of Eq.(15) is $\psi'=A\sqrt{\xi}H_{1/2}^{(1)}\left(\frac{2}{3}\xi^{3/2}\right),\left(\xi=\frac{x}{l}+\lambda\right)$, where $H^{(1)}(x)$ is the first kind Hankel function, A is a normalized constant, l is the characteristic length and λ is a dimensionless quantity. The solution is still a dispersed wave. When $\xi\to\infty$, it approaches $\psi'(\xi)=A'\xi^{-1/4}e^{-2\xi^{3/2}/3}$ to be a damped wave.

If $V(x)=Fx^2$, the eigenenergy and eigenwave function are $\psi'(x)=N_n e^{-a^2x^2/2}H_n(\alpha x)$, $E_n=(n+\frac{1}{2})\hbar\omega$, (n=0,1,2,…), respectively, here $H_n(\alpha x)$ is the Hermite polynomial. The solution obviously has a decaying feature, and so on.

The above practical examples show clearly that the solutions of linear SchrÖdinger equation (7) is only a wave and always have not the corpuscle feature whether or no changes of externally applied potentials. In such a case Born had to introduce the probability of $|\psi(\vec{r},t)|^2$ to represent the particulate feature of the particle, but which together with the hypothesis of average values of mechanical quantity results in turn in a controversy on the quantum mechanics which describes whether the law of motion for a single particle or for an assembly consisting of a great number of particles. These results indicate clearly that the essence of microscopic particles described by the quantum mechanics based on the above hypothesizes is just a wave, The wave feature of microscopic particles is fully incompatible and contradictory with the traditional concept of particles[7-9] and cannot be changed by the externally applied potentials. Just so, a series of difficulties and questions of quantum mechanics occur subsequently, such as, the uncertainty relation between the position and momentum, the probability interpretation of wave function, the concept of statistical average of the mechanical quantities as mentioned above, and so on. This shows clearly that these difficulties and contradictions in quantum mechanics are the intrinsic and inherent, or speaking cannot overcome.

Very obviously, the roots or reason generating these difficulties and contradictions in quantum mechanics should focus on the fundamental hypothesizes of dynamic equation of microscopic particles in Eq. (7) and Hamiltonian of the systems in Eq.(8)[12-15]. They are too simple to useful to represent a realistic physical systems. As far as Hamiltonian operator in Eq.(8) and dynamic equation (7) are concerned, they consist only of externally applied potential term, $V(\vec{r})$, and kinetic energy term, $(h^2/2m)\nabla^2 = \hat{p}^2/2m$, of particles. The former is not related to the state or wave function of the particle, so it cannot change the natures, only can vary the shapes and outlines of the particle, such as amplitude and velocity. The nature of the particles are mainly determined by the kinetic energy term in Eqs.(7)-(8). However, the effect of the kinetic energy term is a dispersive effect and it makes the particle be permanently in motion. The dispersive effect cannot be balanced and suppressed by an external potential field $V(\vec{r},t)$ in Eq.(7). Thus the microscopic particle has only a wave feature in quantum mechanics. Therefore, the root generating these difficulties, contradictions and disputations are just the simplicity of quantum mechanics, or speaking, the dynamic equation (7) and Hamiltonian in Eq.(8) of the particles composed only of externally applied potential and kinetic energy terms are the basic reasons giving rise to these difficulties, contradictions and disputations in quantum mechanics. In fact, in quantum mechanical calculation including the systems of many-particles and many-bodies we separate always the studied particle from other particles, ignore further the real and complicated interactions including some nonlinear interactions among the particles or between the particle and background field, such as, lattices, and replace artificially these complicated interactions among these particles by an averagely external applied-potential unrelated to the wave function of the particle in virtue of various approximation methods in quantum mechanics. Or else, quantum mechanics cannot use to investigate these quantum systems at all. However, plenty of basic natures of the microscopic particles have been blotted out and denied in this calculation. In such a case the microscopic particles cannot be also localized. Therefore, all microscopic particles have only wave or dispersive feature, not corpuscle nature in quantum mechanics whether the particle is in what systems or accepted how much interactions. The character of quantum mechanics is intrinsic and inherent and cannot be permanently changed. This is just the essence of quantum mechanics. It is also the roots that the microscopic particles have only a wave feature, not the corpuscle feature at all.

II. The Considerable and Essential Changes of Nature and Properties of the Microscopic Particles Depicted by the Nonlinear Schrödinger Equation

a) *The establishments of nonlinear SchrÖdinger equation with nonlinear interaction*

i. *The nonlinear interaction between the particles and establishment of nonlinear SchrÖdinger equation*

From the above investigation we sought the roots that the microscopic particles have only a wave feature, not the corpuscle feature, or the reasons generating plenty of difficulties and centenary disputations in quantum mechanics. It is just due to simple dynamic equation (7) and Hamiltonian operator in Eg.(8). At the same time, we know that the wave feature of microscopic particle cannot be permanently changed, the difficulties and constructions of quantum mechanics are intrinsic and inherent, and cannot be overcome and solved in itself framework. If these difficulties and constructions want solve, then we must break through some basic hypothesizes and fundamental framework of quantum mechanics, such as, independence of Hamiltonian operator of the systems on the states of particles, and seek a interaction, which can inhibit and suppress the dispersive effect of kinetic energy term in Eqs.(7)-(8), to make the particles be localized in virtue of taking into account these interactions, especially the nonlinear interactions, among the particles or between the particle and background field[16-20]. The above roots and reasons arising from the difficulties in quantum mechanics awakens and evokes also us to rivet one's attention on the interaction related to the states of microscopic particles among the particles or between the particle and background field. I expect that the natures of the microscopic particles can be changed hugely, when these nonlinear interactions are considered in dynamic equation of the particles and Hamiltonian operator of the systems[18-22].

In accordance with this idea we study the dynamic features of microscopic particles in nonlinear interaction systems. As known, the interaction among the particles or between the particle and background field is, in general, described by virtue of a model of interaction of two bodies. When the interaction between the two bodies is considered, their dynamical equations of the two microscopic particles can be often represented, respectively, by

$$i\hbar\frac{\partial}{\partial t}\phi=-\frac{\hbar^2}{2m}\nabla^2\phi+V(x,t)+\chi\phi\frac{\partial F}{\partial x} \tag{17}$$

and

$$\frac{\partial^2 F}{\partial t^2}-v_0^2\frac{\partial^2 F}{\partial x^2}=-\chi\frac{\partial}{\partial x}|\phi|^2, \tag{18}$$

where ϕ denotes the state of a studied microscopic particle, equation (17) describes then the dynamics of the microscopic particle having a coupling interaction with other particle or field. F is the state of a background field, such as a lattice or another particle, such as a phonon, equation (18) expresses its dynamics, or , a forced vibration of the background field or another particle with velocity v_0 due to the interaction arising from the changes of state of the studied microscopic particle studied[18-22]. χ represents just the coupling interaction effect between them. This coupling can change the states and natures of both the studied particle and other particle. This implies that we replaced not the practical interaction between them by an averagely external-applied potential, but treated and described the dynamics of two particles in same way in virtue of the coupling interaction between them. This is a new investigated idea and method, which differs completely from of those of quantum mechanics. From Eq.(18) we can obtain

$$\frac{\partial F}{\partial x}=-\frac{\chi}{v^2-v_0^2}|\phi|^2 \tag{19}$$

Inserting Eq.(19) into Eq.(17) yields

$$i\hbar\frac{\partial}{\partial t}\phi=-\frac{\hbar^2}{2m}\nabla^2\phi+V(x,t)-b|\phi|^2\phi \tag{20}$$

where $b=\frac{\chi^2}{v^2-v_0^2}$ is a nonlinear interaction coefficient. This equation is just so-called nonlinear SchrÖdinger equation relative to the linear SchrÖdinger equation (7). It is just the new dynamic equation of the microscopic particle in the system with nonlinear interactions among the particles or between the particle and a background field. we see clearly from Eq.(20) that this coupling among the particles or between the particle and background field result in a nonlinear interaction, $b|\phi|^2\phi$, related to the wave function of the particles to occur. This shows clearly the nonlinear interaction comes from the interactions among the particles or between the particles and background field In such a case the states of the microscopic particles are no longer described by the linear SchrÖdinger equation (7), but by the nonlinear SchrÖdinger equation (20).

In general, the nonlinear interactions can be produced by the following three mechanisms by means of the interaction among particles and between the medium and the particles[18-22]. In the first mechanism, the attractive effect is due to interactions between the microscopic particle and other particles. This is called a self-interaction. A familiar example is the Bose-Einstein condensation mechanism of microscopic particles because of an attraction among the Bose particles. Here the mechanism is referred to as self-condensation. In the second mechanism, the medium has itself anomalous dispersion effect (*i.e.* $k''=\partial^2k/\partial\omega^2\big|_{\omega_0<0}$) and nonlinear features resulting from its anisotropy and nonuniformity. Motion of the microscopic particles in the system are modulated by these nonlinear effects. This mechanism is called self-focusing. The third mechanism is called self-trapping. It is produced by interaction between the microscopic particles and background, such as, lattice or medium as mentioned above.

If other complicated interactions and damping effect of medium are considered, then equation (20) should be replaced by the following nonlinear SchrÖdinger equations[18-19]:

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$$i\hbar\frac{\partial\phi}{\partial t}=-\frac{\hbar^2}{2m}\nabla^2\phi\pm b|\phi|^2\phi+V(\vec{r},t)\phi+A(\phi), \tag{21}$$

or

$$\mu\frac{\partial\phi}{\partial t}=-\frac{\hbar^2}{2m}\nabla^2\phi\pm b|\phi|^2\phi+V(\vec{r},t)\phi+A(\phi) \tag{22}$$

where A(ϕ) represents the complicated interactions among the particles related to wave function $\phi(\vec{r},t)$ of the particles, μ is a complex number, equation (22) is often used to depict the motion of microscopic particles in damping medium. The wave function, $\phi(\vec{r},t)$, can be written as

$$\phi(\vec{r},t)=\varphi(\vec{r},t)e^{i\theta(\vec{r},t)} \tag{23}$$

where both the amplitude $\varphi(\vec{r},t)$ and phase $\theta(\vec{r},t)$ of the wave function are functions of space and time.

We here should point out that physicists and mathematicians derived plenty of nonlinear SchrÖdinger equation with different forms from different systems and conditions[20-29], at present, but we obtain the nonlinear SchrÖdinger equations (20)-(22) from features of motion and interaction of microscopic particles. They are some special nonlinear SchrÖdinger equations, have the symmetry of time-space, thus are quite appropriate to the microscopic particles[18-22].

ii. *The effects of nonlinear interaction on the states of particles*

In Eqs.(21)-(22) there are also the nonlinear interaction term, $b|\phi|^2\phi$. Since it relates always to the states of particles, then the nature of the particles must be changed under its action. We expect that the nonlinear interaction can balance and suppress the dispersion effect of the kinetic term in Eq. (20) to make the particles be localized[18-19,21-22], eventually makes the particle becomes a soliton with wave-corpuscle duality. Why? This is due to the fact that the interaction can distort and collapse the dispersive wave, thus can obstruct and suppress the dispersive effect of kinetic energy and make the microscopic particles to be eventually localized.

To see clearly this, we now study carefully the motion of water wave in sea. When a water wave approaches the beach, its shape variants gradually from a sinusoidal cross section to triangular, and eventually a crest which moves faster than the rest. This is a result of the nonlinear nature of wave. As the water wave approaches the beach the wave will be broken up due to the fact that the nonlinear interaction is enhanced. Since the speed of wave propagation depends on the height of the wave in such a case, so, this is a nonlinear phenomenon. If the phase velocity of the wave, v_c, depends weakly on the height of the wave, *h*, then $v_c=\frac{\omega}{k}=v_{co}+\Theta_1 h,$ where $\Theta_1=\frac{\partial v_c}{\partial h}\Big|_{h=h_0}$, h_0 is the average height of the wave surface, v_{co} is the linear part of the phase velocity of the wave, Θ_1 is a coefficient denoting the nonlinear effect. Therefore, the nonlinear interaction results in changes in both form and velocity of waves. This is the same for the dispersion effect, but their mechanism and rules are different. When the dispersive effect is weak, the velocity of a wave is denoted by $v_c=\frac{\omega}{k}=v_{co}^{'}+\Theta_2 k^2$, where v_{co} is a dispersionless phase velocity, $\Theta_2=\frac{\partial^2 v_c}{\partial k^2}\Big|_{k=k_0}$ is the coefficient of the dispersion feature of the wave. Generally speaking, the lowest order dispersion occurring in the phase velocity is proportional to k^2, and the term proportional to *k* gives rise to the dissipation effect. If the two effects act simultaneously on a wave, then it is necessary to change the nature of the wave.

To further explore the effects of nonlinear interaction on the behaviors of microscopic particles, we consider a simple motion as follows

$$\phi_e+\phi\phi_x=0 \tag{24}$$

where $\phi\phi_x$ is a nonlinear interaction. There is no dispersive term in this equation. It is easy to verify that $\phi=\Phi^{'}(x-\phi t)$ satisfies Eq.(24). This solution indicates that as time elapses, the front side of wave gets steeper and steeper, until it becomes triple-valued function of *x* due to the nonlinear interaction, which does not occur for a general wave equation. This is a deformation effect of wave resulting from the nonlinear interaction. If let $\phi=\Phi^{'}=\cos\pi x$ at $t=0$, then at $x=0.5$ and $t=\pi^{-1},\phi=0$ and $\phi_x=\infty$. The time $t_B=\pi^{-1}$ at which the wave becomes very steep is called destroyed period of the wave. However, the collapsing phenomenon can be suppressed by adding a dispersion term ϕ_{xxx} as in the KdV equation[13-14]. Then, the system has a stable soliton, $\sec h^2(X)$, in such a case. Therefore, a stable soliton, or a localization of particle can occur only if the nonlinear interaction and dispersive effect exist simultaneously in the system, and can be balanced and canceled each other. Otherwise, the particle cannot be localized, and a stable soliton cannot be formed.

However, if ϕ_{xxx} is replaced by ϕ_{xx}, then Eq. (24) becomes

$$\phi_t + \phi\phi_x = v\phi_{xx}, (v > 0) \tag{25}$$

This is the Burgur's equation. In such a case, the term $v\phi_{xx}$ cannot suppress the collapse of the wave, arising from the nonlinear interaction $\phi\phi_{xx}$. Therefore, the wave is damped. In fact, utilizing the Cole-Hopf transformation $\phi = -2\gamma \frac{d}{dx}(\log\psi')$, equation (48) becomes $\frac{\partial\psi'}{\partial t} = v\frac{\partial^2\psi'}{\partial x^2}$. This is a linear equation of heat conduction or diffusion equation, which has a damping solution. Therefore, the Burgur's equation (25) is not a equation with soliton solution[13-17].

This example tells us that the deformational effect of nonlinearity on the wave can suppress its dispersive effect, thus a soliton solution of dynamic equations can then occur in such a case [18-19]. The nonlinear term in nonlinear SchrÖdinger equation (20) sharpens the peak, while its dispersion term has the tendency to leave it off, thus Eq.(20) has a soliton solution, then the microscopic particle described by the nonlinear SchrÖdinger equation (20) can be localized in such a case. This example also verifies sufficiently that a stable soliton or localization of particle cannot occur in the absence of nonlinear interaction and dispersive effect or weak nonlinear interaction relative to the dispersive effect in the nonlinear SchrÖdinger equation in Eq.(20).

However, Whether can these phenomena occur for the above nonlinear SchrÖdinger equations in Eqs.(20)-(22)? Or speaking, what are the changes of states and properties of microscopic particles under action of the nonlinear interaction on earth? What are the influences on quantum mechanics when the states and properties of microscopic particles are described by the above nonlinear SchrÖdinger equations? These are both some very interesting and challenged problems and worth studying carefully and completely. In the following we study deeply these problems.

b) Display and exhibition of wave-corpuscle duality of microscopic particle described by the nonlinear SchrÖdinger equation

i. *The solutions of nonlinear SchrÖdinger equation and wave-corpuscle duality of particles*

In the one-dimensional case, the equation (20) at V(x,t)= 0 becomes as

$$i\phi_{t'} + \phi_{x'x'} + b|\phi|^2\phi = 0 \tag{26}$$

where $x' = x/\sqrt{\hbar^2/2m}$, $t' = t/\hbar$. We now assume the solution of Eq.(26) to have the form of Eq.(23). Inserting Eq.(23) into Eq.(26) we can obtain

$$\varphi_{x'x'} - \varphi\theta_{t'} - \varphi\theta_{x'}^2 - b\varphi^2\varphi = 0 \ldots . (b > 0) \ldots\ldots\ldots \tag{27}$$

$$\varphi\theta_{x'x'} + 2\varphi_{x'}\theta_{x'} + \varphi_{t'} = 0 \ldots\ldots\ldots\ldots\ldots\ldots \ldots \tag{28}$$

If let $\theta = \theta(x' - v_c t'), \varphi = \varphi(x' - v_e t'),$ then Eqs.(27)-(28) become as

$$\varphi_{x'x'} - v_c\varphi\theta_{t'} - \varphi\theta_{x'}^2 - b\varphi^3 = 0 \ldots\ldots\ldots\ldots\ldots\ldots \tag{29}$$

$$\varphi\theta_{x'x'} + 2\varphi_{x'}\theta_{x'} - v_e\varphi_{t'} = 0 \ldots\ldots\ldots\ldots\ldots\ldots \tag{30}$$

If fixing the time t' and further integrating Eq.(30) with respect to x' we can get

$$\varphi^2(2\theta_{x'} - v_e) = A(t') \tag{31}$$

Now let integral constant A(t')=0, then we can get $\theta_{x'} = v_e/2$. Again substituting it into Eq.(29), and further integrating this equation we then yield[23-24]

$$\int_{\varphi_0}^{\varphi} \frac{d\varphi}{\sqrt{Q(\varphi)}} = x' - v_e t' \tag{32}$$

where $Q(\varphi) = -b\varphi^4/2 + (v_e^2 - 2v_c v_e)\varphi^2 + c'$.

When c'=0, $v_e^2 - 2v_c v_e > 0$, then $\varphi = \pm\varphi_0, \varphi_0 = [2(v_e^2 - 2v_c v_e)/b]^{1/2}$ is the root of $Q(\varphi) = 0$ except for $\varphi = 0$. Thus from Eq.(32) we obtain the solution of Eqs.(27)-(28) to be

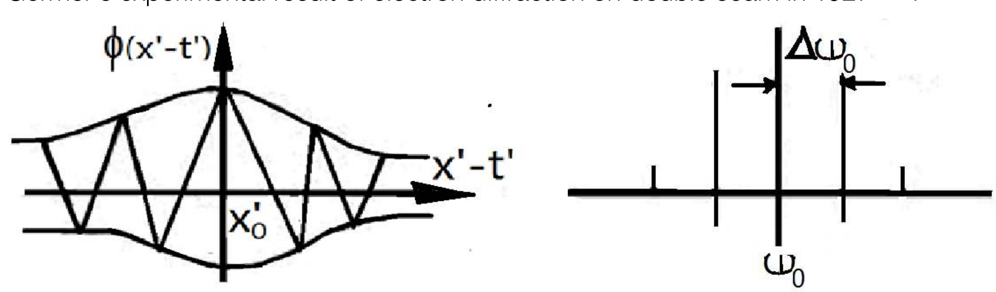
$$\varphi(x',t') = \varphi_0 \sec h[\sqrt{\frac{b}{2}}\varphi_0(x' - v_e t')] \tag{33}$$

Then the solution of nonlinear SchrÖdinger equation (20) eventually is of the form

$$\phi(x,t) = A_0 \sec h\left\{\frac{A_0\sqrt{b}}{\sqrt{2}\hbar}\left[\sqrt{2m}\left(x - x_0\right) - v_e t\right]\right\} e^{iv_e\left[\sqrt{2m}(x-x_0)-v_c t\right]/2\hbar} \tag{34}$$

where $A_0 = \sqrt{\frac{v_e^2 - 2v_c v_e}{2b}}$. The solution of Eq.(34) can be also found by the inverse scattering method[25-26]. This solution is completely different from Eq.(11), and contains a envelop and carrier waves, the former is $\varphi(x,t) = A_0 \sec h\left\{A_0\left[\sqrt{2m}(x - x_0) - v_e t\right] \big/ \sqrt{2}\hbar\right\}$ and a bell-type non-topological soliton with an amplitude A_0, the latter is the $\exp\left\{iv_e\left[\sqrt{2m}(x - x_0) - v_e t\right]/2\hbar\right\}$. v_e is the group velocity of the particle, v_c is the phase speed of the carrier wave. This solution is shown in Fig.1. Therefore, the microscopic particle described by nonlinear SchrÖdinger equation (20) is a soliton[18-19,23-24]. The envelop φ(x,t) is a slow varying function and the mass center of the particle, the position of the mass center is just at x_0, A_0 is its amplitude, and its width is given by $W = 2\pi\hbar/(\sqrt{mb}A_0)$.Thus, the size of the particles is $A_0 W = 2\pi\hbar/\sqrt{mb}$ and a constant. This shows that the particle has exactly a mass centre and determinant size, thus is localized at x_0. For a certain system, v_e, v_c and size of the particle are determinant and do not change with time. According to the soliton theory [18-19,23-24], the bell-type soliton in Eq.(34) can move freely over macroscopic distances in a uniform velocity v_e in space-time retaining its form, energy, momentum and other quasi-particle properties. Just so, the vector $\vec{r}$ or x denotes exactly the positions of the microscopic particles at time t. Then, the wavefunction $\phi(\vec{r},t)$or φ(x,t) can represent exactly the states of the particle at the position $\vec{r}$ or x and time t. These features are consistent with the concept of particles. Thus the feature of corpuscle of microscopic particles is displayed clearly and outright.

However, the envelope of the solution in Eq.(19) is a solitary wave. It has a certain wavevector and frequency as shown in Fig. 1(b), and can propagate in space-time, which is accompanied with the carrier wave. The feature of propagation depends only on the concrete nature of the particle. Figure 1(b) shows the width of the frequency spectrum of the envelope φ(x,t), the frequency spectrum has a localized structure around the carrier frequency ω_0. Therefore, the microscopic particle has exactly a wave-particulate duality[18,27-34]. This consists of Davisson and Germer's experimental result of electron diffraction on double seam in 1927[8-12].



(a) (b)

Fig. 1: The solution in Eq. (34) at V=0 in Eq. (20) and its features

We can verify that this nature of wave-corpuscle duality of microscopic particles is not changed with varying the externally applied potentials. As a matter of fact, for $V(x') = \alpha x' + c$ in Eq.(20) , where α and c are some constants. In this case equation(28) is replaced by

$$\varphi_{x'x'} - \varphi\theta_{t'} - \varphi\theta_{x'}^2 - b\varphi^2\varphi = \alpha x' + c. \tag{35}$$

Now let[23-24,27-32]

$$\varphi(x',t')=\varphi(\xi),\xi=x'-u(t'),u(t')=-\alpha(t')^2+vt'+d \tag{36}$$

where $u(t')$ describes the accelerated motion of $\varphi(x'.t')$. The boundary condition at $\xi\to\infty$ requires $\varphi(\xi)$ to approach zero rapidly. Equation (29) in such a case can be written as

$$-\dot{u}\frac{\partial\varphi}{\partial\xi}+2\frac{\partial\varphi}{\partial\xi}\frac{\partial\theta}{\partial\xi}+\varphi\frac{\partial^2\theta}{\partial\xi^2}=0 \tag{37}$$

where $\dot{u}=\frac{du}{dt'}$. If $2\partial\theta/\partial\xi-\dot{u}\neq 0$, Equation (37) may be written as

$$\varphi^2=\frac{g(t')}{(\partial\theta/\partial\xi-\dot{u}/2)} \text{ or } \frac{\partial\theta}{\partial x'}=\frac{g(t')}{\varphi^2}+\frac{\dot{u}}{2} \tag{38}$$

Integration of Eq.(38) yields

$$\theta(x',t')=g(t')\int_0^{x'}\frac{dx'}{\varphi^2}+\frac{\dot{u}}{2}x'+h(t') \tag{39}$$

where $h(t')$ is an undetermined constant of integration. From Eq.(39) we can get

$$\frac{\partial\theta}{\partial t'}=\dot{g}(t')\int_0^{x'}\frac{dx'}{\varphi^2}-\frac{g\dot{u}}{\varphi^2}+\frac{g\dot{u}}{\varphi^2}\Big|_{x'=0}+\frac{\ddot{u}}{2}x'+\dot{h}(t') \tag{40}$$

Substituting Eqs. (29) and (30) into Eq.(35) ,we have

$$\frac{\partial^2\varphi}{\partial(x')^2}=[(\alpha x'+c)+\frac{\ddot{u}}{2}x'+\dot{h}(t')+\frac{\dot{u}^2}{4}+\dot{g}\int_0^{x'}\frac{dx'}{\varphi^2}+\frac{g\dot{u}}{\varphi^2}\Big|_{x'=0}]\varphi-b\varphi^3+\frac{g^2}{\varphi^3} \tag{41}$$

Since $\frac{\partial^2\varphi}{\partial(x')^2}=\frac{d^2\varphi}{d\xi^2}$ is a function of ξ only, in order for the right-hand side of Eq. (41) to be also a function of ξ only, it is necessary that $g(t')=g_0=\text{const}$,

$$(\alpha x'+c)+\frac{\ddot{u}}{2}x'+\dot{h}(t')+\frac{\dot{u}^2}{4}+\frac{g\dot{u}}{\varphi^2}\Big|_{x'=0}=\overline{V}(\xi) \tag{42}$$

Next, we assume that $V_0(\xi)=\overline{V}(\xi)-\beta$ where β is real and arbitrary. Then

$$\alpha x'+c=V_0(\xi)-\frac{\ddot{u}}{2}x'+[\beta-\frac{g\dot{u}}{\varphi^2}\Big|_{x'=0}-\dot{h}(t')-\frac{\dot{u}^2}{4}] \tag{43}$$

Clearly, in the case being discussed , $V_0(\xi)=0$, and the function in the brackets in Eq. (43) is a function of t'. Substituting Eqs.(42) and (43) into Eq.(41) ,we can get

$$\frac{\partial^2\tilde{\varphi}}{\partial\xi^2}=\beta\tilde{\varphi}-b\tilde{\varphi}^3+\frac{g_0^2}{\tilde{\varphi}^3} \tag{44}$$

This shows that $\tilde{\varphi}=\varphi(\xi)$ is the solution of Eq.(44) when β and g are constant. For large $|\xi|$, we may assume that $|\tilde{\varphi}|\leq\beta/|\xi|^{1+\Delta}$, when Δ is a small constant. To ensure that $d^2\tilde{\varphi}/d\xi^2$, and $\tilde{\varphi}$ approach zero when $|\xi|\to\infty$, only the solution corresponding to $g_0=0$ in Eq.(44) is kept to be stable. Therefore we choose $g_0=0$ and obtain the following from Eq. (38)

$$\frac{\partial \theta}{\partial x'} = \frac{\dot{u}}{2} \tag{45}$$

Thus, we obtain from Eq. (43)

$$\alpha x' + c = -\frac{\ddot{u}}{2} x' + \beta - \dot{h}(t') - \frac{\dot{u}^2}{4}$$

$$h(t') = (\beta - c - \frac{1}{4}\upsilon^2)t' - \frac{1}{3}\alpha^2 (t')^3 + \upsilon\alpha(t')^2 / 2 \tag{46}$$

Substituting Eq.(46) into Eqs.(29) and (30), we obtain

$$\theta = (-\alpha t' + \frac{1}{2}\upsilon)x' + (\beta - c - \frac{1}{4}\upsilon^2)t' - \frac{1}{3}\alpha^2 (t')^3 + \upsilon\alpha(t')^2 / 2 \tag{47}$$

Finally, substituting the above into Eq.(44), we can get

$$\frac{\partial^2 \varphi}{\partial \xi^2} - \beta\varphi + b\varphi^3 = 0 \tag{48}$$

When $\beta > 0$, the solution of Eq.(48) is of the form[18-19,23-24,,33-34]

$$\varphi = \sqrt{\frac{2\beta}{b}} \sec h(\sqrt{\beta}\xi) \tag{49}$$

Thus

$$\phi = \sqrt{\frac{2\beta}{b}} \sec h[\sqrt{\beta}(\sqrt{\frac{2m}{\hbar^2}}(x - x_0) + \frac{\alpha t^2 - \upsilon t - d}{\hbar})] \times \exp\{i[(\frac{-\alpha t}{\hbar} + \frac{\upsilon}{2})\sqrt{\frac{2m}{\hbar^2}} x + (\beta - c - \frac{1}{4}\upsilon^2)\frac{t}{\hbar} - \frac{\alpha^2 t^3}{3\hbar^3} + \frac{\upsilon\alpha t^2}{2\hbar}]\} \tag{50}$$

This is also soliton solution. If V(x')=c, the solution can represent as

$$\phi = \sqrt{\frac{2\beta}{b}} \sec h\left\{\sqrt{\beta}[(x' - x_0') - v_e(t - t_0)]\right\} \exp i\left\{\frac{v_e}{2\hbar}[(x' - x_0') - (\beta - \frac{v_e^2}{4} - C)]t)\right\} \tag{51}$$

If $V(x') = ax'$ and $b = 2$, the solution can represent by

$$\phi = 2\eta \operatorname{sech}\left[2\eta\left(x' - x_0' - 4\xi t' + 2\alpha t'^2\right)\right] \times$$

$$\exp\left\{-i\left[2\left(\xi - \alpha t'\right)x' + \frac{4\alpha^2 t'^3}{3} - 4\alpha\xi t'^2 + 4\left(\xi^2 - \eta^2\right)t' + \theta_0\right]\right\} \tag{52}$$

In this calculation we used the transformation [35-36] :

$$\phi\left(x', t'\right) = \phi'\left(\tilde{x}', \tilde{t}\right) e^{-i\alpha\tilde{x}\tilde{t} - i\alpha^2 (\tilde{t})^3 / 3},\ x' = \tilde{x}' - \alpha\tilde{t}'^2,\ t' = \tilde{t}', \tag{53}$$

Under this transformation and in this case thus Eq. (20) becomes

$$i\phi'_{\tilde{t}'}+\phi'_{\tilde{x}'\tilde{x}'}+2|\phi'|^2\phi'=0,$$

Utilizing Eq.(44), its solution in Eq.(52) then can be obtained immediately.

For a more complicated potential $V(x)$ in Eq.(20), for example, $V(x)=kx^2+A(t)x+B(t)$, utilizing the above method the soliton solution in Eq.(27) of Eq. (20) can be written as[18-19,23-24]

$$\phi=\varphi(x-u(t))e^{i\theta(x,t)} \tag{54}$$

where $\varphi(x-u(t))=\sqrt{\frac{2B}{b}}\sec h(a[(x-x_0)-u(t)]), u(t)\equiv 2\cos(2\sqrt{kt}+\beta)+u_0(t)$

$$\theta(x,t)=\left[-2\sqrt{k}\sin(2\sqrt{kt}+\beta)+\frac{u_0}{2}\right]+\lambda_0 t+g_0$$

$$-\int_0^1\left\{\left[u_0(t^{'})-k(2\cos(2-\sqrt{kt^{'}}+\beta))\right]^2+B(t^{'})+\left[\frac{u_0}{2}-2\sqrt{k}\sin(2\sqrt{kt^{'}}+\beta)\right]\right\}dt^{'}$$

When $A(t)=B(t)=0$, $u(t)=2\cos(2\sqrt{kt})+u_0(t)$,

$$\theta(x,t)=-2\sqrt{k}\sin(2\sqrt{kt}+\frac{u_0}{2}x)+g_0$$

$$-\int_0^1\left\{\left[-k(2\cos(2\sqrt{kt})+u_0(t)\right]^2+\left[\frac{u_0}{2}-2\sqrt{k}\sin(2\sqrt{kt^{'}})\right]\right\}$$

For the case of $V_0(x')=\alpha^2x'^2$, which is a harmonic potential, where α is constant. In this condition in accordance with above way the solution can be denoted by[35-36]

$$\phi=2\eta\, sec\,h\left\{2\eta(x'-x_0^{'})-\frac{4\xi\eta}{\alpha}sin\left[2\alpha\left(t'-t_0'\right)\right]\right\}\times$$

$$exp\left\{i\left[2\xi x' cos\,2\alpha\left(t'-t_0'\right)-\frac{\xi^2}{\alpha}sin\left[4\alpha\left(t'-t_0'\right)\right]+4\eta^2\left(t'-t_0'\right)+\theta_0'\right]\right\} \tag{55}$$

where $2\sqrt{2/b}\eta=A_0$, and $2\sqrt{2}\xi=v_c$ are the amplitude and group velocity of the particles in Eqs.(53) and (55), respectively. From Eqs.(51)-(53) and (55) we see clearly that these solutions of the nonlinear SchrÖdinger equation in Eq.(20) have all same shape as shown in Fig.1 or Eq.(27) or (54) and similar natures, such as, they contain a envelop and carrier waves, and are also some bell-type soliton with certain amplitude A_0 and the group velocity v_e and phase speed v_c. Meanwhile, these microscopic particles have also a mass center and possess an amplitude, width and sizes, thus are localized at x_0. Thus we can conclude that these microscopic particles have all the wave-corpuscle duality in the light of previous explanation. However, the differences among these solutions are only distinctions of the amplitude, velocity and frequency, the velocity for some particles are related to time, some frequencies is oscillatory. The above features indicate that the localization feature or wave-corpuscle duality of a microscopic particle cannot be changed with varying the external potential $V(x)$, the latter alters only the sizes of amplitude, velocity and frequency of microscopic particle, therefore its influence is secondary. This shows also that the fundamental nature of microscopic particles is mainly determined by the combined effect of dispersion forces and nonlinear interaction in such a case. It is the nonlinear interaction that makes dispersive microscopic particle become a localized soliton.

From the above results we see clearly that the microscopic particles are a soliton which can denote all by $\phi(x',t')=\varphi(x',t')e^{i\theta(x',t')}$ in Eq.(23). According to the soliton theory [18-20], the bell-type soliton in Eq.(34) can move freely over macroscopic distances in a uniform velocity v_e in space-time retaining its shape, energy, momentum and other quasi-particle properties. This means that its mass, momentum and energy are constants, and can be represented by [18-19,23-24]

$$N_s = \int_{-\infty}^{\infty} |\phi|^2 dx' = 2\sqrt{2}A_0$$

$$p = -i\int_{-\infty}^{\infty} \left(\phi^* \phi_{x'} - \phi\phi^*_{x'}\right) dx' = 2\sqrt{2}A_0 v_e = N_s v_e = const$$

$$E = \int_{-\infty}^{\infty} \left[|\phi_{x'}|^2 - \frac{1}{2}|\phi|^4 \right] dx' = E_0 + \frac{1}{2} M_{sol} v_e^2 \tag{56}$$

where $x' = x/\sqrt{\hbar^2/2m}$, $t' = t/\hbar$, and $M_{sol} = N_s = 2\sqrt{2}A_0$ is just effective mass of the microscopic particle, which is a constant. Obviously, the energy, mass and momentum of the particle cannot be dispersed in its motion. Just so, the position vector $\vec{r}$ or position *x* in Eq.(20) or (26) has definitively physical significance, and denotes exactly the positions of the particles at time *t*. Thus, the wave function $\phi(\vec{r},t)$ or φ(x,t) can represent exactly the states of microscopic particles at the position $\vec{r}$ or *x* and time *t*. This is consistent with the concept of classical particles or corpuscles.

In the light of this method and formulae we can find out the effective masses, momentums and energies of the microscopic particles described by Eq.(36) at A(ϕ)=0, V(x)=c, $V(x') = \alpha x'$, $V(x') = \alpha x' + c$, $V_0(x') = \alpha^2 x'^2$ and $V(x) = kx^2 + A(t)x + B(t)$, respectively.

ii. *The linear SchrÖdinger equation is a special case at the nonlinear interaction to equal to zero*

However, we also demonstrate that the solution of Eq.(20) is not the solution Eq.(11) of linear SchrÖdinger equation in Eq.(7), even though the nonlinear interaction approaches to zero. To see this clearly, we first examine the velocity of the skirt of the soliton given in Eq.(34). For weak nonlinear interaction (b<<1) and small skirt $\phi(x',t')$, it may be approximated by (for $x > \upsilon_e t$)

$$\phi = 2\sqrt{2/b}ke^{-\sqrt{2}k(x'-\upsilon_e t')}e^{i\upsilon_e(x'-\upsilon_c t')/2} \tag{57}$$

where $2^{3/2}k/b^{1/2} = A_0$. Thanks to the small term b$|\phi|^2 \phi$, then Eq. (11) can be approximated by

$$i\phi_{t'} + \phi_{x'x''} \approx 0 \tag{58}$$

Substituting Eq. (57) into Eq. (58), we get $\upsilon_e \approx 2\sqrt{2}k$, which is the group speed of the particle. (Near the top of the peak, we must take both the nonlinear and dispersion terms into account because their contributions are of the same order. The result is the group speed.). Here, we have only checked the formula for the region where $\phi(x,t)$ is small; that is, when a particle is approximated by Eq.(49), it satisfies the approximate wave equation (50) with $\upsilon_e \approx 2\sqrt{2}k$.

However, if Eq.(50) is treated as a linear SchrÖdinger equation, its solution is of the form:

$$\phi'(x,t) = Ae^{i(kx-\omega t)} \tag{59}$$

We now have $\omega = k^2$, which gives the phase velocity ω/k as $\upsilon_c = k$ and the group speed $\partial\omega/\partial k = \upsilon_{gr} = k$. Apparently, this is different from $\upsilon_e = 2\sqrt{2}k$. This is because the solution Eq. (57) is essentially different from Eq. (59). Therefore, the solution Eq. (59) is not the solution of nonlinear SchrÖdinger equation (20) with V(x,t)= 0 in the case of weak nonlinear interactions. Solution Eq.(57) is a “divergent solution” ($\phi(x,t) \to \infty$ at $x \to -\infty$), which is not an “ordinary plane wave”. The concept of group speed does not apply to a divergent wave. Thus, we can say that the soliton is made from a divergent solution, which is abandoned in the linear waves. The divergence develops by the nonlinear term to yield waves of finite amplitude. When the nonlinear term is very weak, the soliton will diverge; and suppression of divergence will result in no soliton. These circumstances are clearly seen from the soliton solution in Eq.(34) in the case of nonlinear coefficient $b \neq 1$. If the nonlinear term approaches zero ($b \to 0$), the solitary wave diverges $\left(\phi(x,t) \to \infty\right)$. If we want to suppress the divergence, then we have to set $k = 0$. In such a case, we get Eq. (59) from Eq.(34). This illustrates that the nonlinear SchrÖdinger equation can reduce to the linear

SchrÖdinger equation if and only if the nonlinear interaction and the group speed of the particle are zero. Therefore, we can conclude that the microscopic particles described by the nonlinear SchrÖdinger equation in the weak nonlinear interaction limit is also not the same as that in linear SchrÖdinger equation in quantum mechanics. Only if the nonlinear interaction is zero, the nonlinear SchrÖdinger equation can reduce to the linear SchrÖdinger equation. However, real physical systems or materials are made up of a great number of microscopic particles, and nonlinear interactions always exist in the systems. The nonlinear interactions arise from the interactions among the microscopic particles or between the microscopic particles and the environment as mentioned above. The nonlinear SchrÖdinger equation should be the correct and more appropriate theory for real systems. It should be used often and extensively, even in weak nonlinear interaction cases. However, the linear SchrÖdinger equation in quantum mechanics is an approximation to the nonlinear SchrÖdinger equation and can be used to study motions of microscopic particles in systems in which there exists only very weak and negligible nonlinear interactions.

iii. *The reason for localization of the microscopic particles*

However, how could a microscopic particle be localized in such a case? In order to shed light on the conditions for localization of microscopic particle in the nonlinear SchrÖdinger equation, we return to discuss the property of nonlinear SchrÖdinger equation (20). The time-independent solution of Eq.(20) is assumed to have the form of[18-19,23-24,33-34]

$$\phi(x,t) = \varphi'(x,t)e^{-iEt/\hbar} \tag{60}$$

then Equation(20) becomes as

$$-\frac{\hbar^2}{2m}\nabla^2\varphi' + \left[V(\vec{r}) - E\right]\varphi' - b|\varphi'|^2\varphi' = 0. \tag{61}$$

For the purpose of showing clearly the properties of this system, we here assume that $V(\vec{r})$ and *b* are independent on $\vec{r}$. Then in one-dimensional case, equation (61) may be written as

$$\frac{\hbar^2}{2m}\frac{\partial^2\varphi'}{\partial x^2} = -\frac{d}{d\varphi'}V_{eff}(\varphi') \tag{62}$$

with

$$V_{eff}(\varphi') = \frac{1}{4}b|\varphi'|^4 - \frac{1}{2}(V-E)|\varphi'|^2. \tag{63}$$

When $V > E$ and $V < E$, the relationship between $V_{eff}(\varphi')$ and φ' is shown in Fig.2. From this figure we see that there are two minimum values of the potential, corresponding to two ground states of the microscopic particle in the system, *i.e.* $\varphi_0' = \pm\sqrt{\frac{V-E}{b}}$. This is a double-well potential, and the energies of the two ground states are $-(V-E)^2/4b \le 0$. This shows that the microscopic particle can be localized due to the fact that the microscopic particle has negative binding energy. This localization is achieved through repeated reflection of the microscopic particle in the double-well potential field. The two ground states limit the energy diffusion, thus the energy of the particle is gathered, soliton is formed, the particle is eventually localized.. Obviously, this is s result of the nonlinear interaction because the particle is in an expanded state if *b*=0. In the latter, there is only one ground state of the particle which is $\varphi' = 0$. Therefore, only if $b \neq 0$, the system can have two ground states, and the microscopic particle can be localized. Its binding energy, which makes the particle to be localized, is provided by the attractive nonlinear interaction , -b$(\varphi'\varphi'^*)^2$, in the systems.

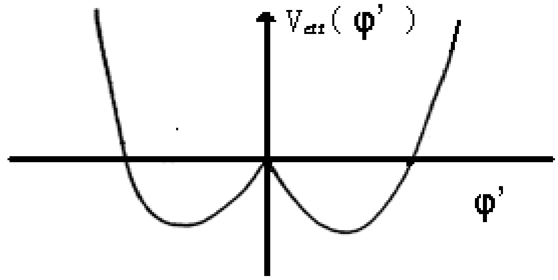


Fig. 2: The effective potential of nonlinear SchrÖdinger equation

From Eq. (63), we know that when $V>0$, $E>0$ and $V<E$, or $|V|>E$, $E>0$ and $V<0$, for $b>0$, the microscopic particle may not be localized by the mechanisms mentioned above. On the other hand, we see from (61)-(63) that if the nonlinear self-interaction is of repelling type (*i.e,* $b<0$.), then, equation (20) becomes

$$i\hbar\frac{\partial}{\partial t}\phi+\frac{\hbar^2}{2m}\frac{\partial^2\phi}{\partial x^2}-|b||\phi|^2\phi=V(x,t)\phi. \tag{64}$$

It is impossible to obtain a bell-type soliton solution, with full matter features, of this equation. However, if $V(x,t)=V(x)$ or a constant, solution of kink soliton type exists. In this case inserting (60) into (64), we can get

$$\frac{\hbar^2}{2m}\frac{\partial^2\varphi'}{\partial x^2}-|b|\varphi'^3+\left[E-V(x)\right]\varphi'=0. \tag{65}$$

If V is independent of *x* and $0<V<E$, equation (64) has the following solution

$$\varphi'=\frac{\sqrt{2(E-V)}}{|b|}\tanh\left[\sqrt{\frac{2(E-V)}{h^2}}(x-x_0)\right]. \tag{66}$$

This is the kink soliton solution when $|V|>E$ and $V<0$. In the case of $V(x)=0$, Zakhorov and Shabat et al[25-26] obtained dark soliton solution which was experimentally observed in optical fiber and was discussed in the Bose-Einstein condensation model .

c) The stability of wave-corpuscle duality of microscopic particles

i. *The instability of microscopic particles in quantum mechanics*

As mentioned above, the microscopic particles depicted by linear SchrÖdinger equation (7) are always dispersive, thus also unstable. What is so-called dispersion effect? The concept of dispersion comes from optics. We know from optics that so-called dispersion of light is just a beam white light to split into several beams of lights with different velocities, when the beam passes through a prism, in which the matter the light wave is propagated is referred to as a dispersive medium. The relationship between the wave length and frequency of the light (wave) in this phenomenon is called a dispersed relation, which can be expressed as $\omega=\omega(\vec{k})$ or $G(\omega,\vec{k})=0$, where $\det\frac{\partial^2\omega}{\partial k_i\partial k_j}\neq 0$ or $\frac{\partial^2\omega}{\partial^2 k^2}\neq 0$ in one-dimensional case. It specifies how the velocity of frequency of the wave (light) depends on its wavelength or wavevector. The equation depicts a wave propagation in a dispersive median and is called as dispersion equation. The linear SchrÖdinger equation (1) in quantum mechanics is a dispersion equation[8-12]. If Eq.(11) is inserted into Eq.(7), we can get $\omega=\hbar k^2/2m$, here $E=\hbar\omega, \vec{p}=\hbar\vec{k}$. The quantity $v_e=\omega/k$ is called the phase velocity of the microscopic particle (wave), but the wave vector $\vec{k}$ is a vector designating the direction of the wave propagation. Thus the phase velocity is given by $\vec{v_e}=(\omega/k^2)\vec{k}$. This is a standard dispersion relation. Thus, the solutions of the linear SchrÖdinger equation (1) are a dispersive wave[8-12].

But how does the dispersive effect influence the state of a microscopic particle? To this end, we consider the dispersive effect of a wave-packet which is often used to explain the corpuscle feature of microscopic particles in quantum mechanics. The wave-packet is formed from a linear superposition of several plane waves in Eq.(11) with wavevector *k* distributed in a range of $2\Delta k$. In the one dimensional case, a wave-packet is can be expressed as[8-12]

$$\Psi(x,t) = \frac{1}{2\pi}\int_{k_0-\Delta k}^{k_0+\Delta k} \psi(k,t) e^{i(kx-\omega t)} dk . \tag{67}$$

We now expand the angular frequency at ω_0 by

$$\omega = \omega_0 + (\frac{d\omega}{dk})_{k_0} \Delta k + \frac{1}{2!}(\frac{d^2\omega}{dk^2})_{k_0} (\Delta k)^2 + \cdots \tag{68}$$

If we consider only the first two terms in the dispersive relation, *i.e.* $\omega = \omega_0 + (\frac{d\omega}{dk})_{k_0}\xi$, here $\xi = \Delta k = k - k_0$, then

$$\Psi(x,t) = \psi(k_0) e^{i(k_0 x - \omega_0 t)} \int_{-\Delta k}^{\Delta k} d\xi e^{i\left[x-(d\omega/dk)_{k_0} t\right]\xi}$$

$$= 2\psi(k_0) \frac{\sin\left\{\left[x-(\frac{d\omega}{dk})_{k_0} t\right]\Delta k\right\}}{x-(\frac{d\omega}{dk})_{k_0} t} e^{i(k_0 x-\omega_0 t)}, \tag{69}$$

where the coefficient of $e^{i(k_0 x-\omega_0 t)}$ is the amplitude of the wave-packet. Its maximum is $2\psi(k_0)\Delta k$ which occurs at x=0, but it is zero at $x = x_n = n\pi/\Delta k\,(n = \pm 1, \pm 2\cdots)$. Obviously, the amplitude of the wave-packet decreases with increasing distance of propagation due to the dispersion effect. Hence, the dispersion effect results directly in damping of the microscopic particle (wave). This means that a wave-packet could eventually collapse with increasing transported time. Thus a wave-packet is unstable and cannot express the corpuscle feature of particles Therefore, the microscopic particles are instable in quantum mechanics[9-12]. Obviously, this is due to the dispersion effect of the kinetic energy term $(h^2/2m)\nabla^2 = \hat{p}^2/2m$ in Eq.(7) or Eq.(8), which cannot always be balanced and suppressed by an external potential field $V(\vec{r},t)$.

ii. *The stability of microscopic particles depicted by nonlinear SchrÖdinger equation*

As known, stability of particle designates its corpuscle feature, in classical physics the particles are stable. However, whether is the above wave-corpuscle duality of microscopic particles depicted by nonlinear SchrÖdinger equation stable? This need to prove further. In the absence of an externally applied field, the stability of the microscopic particles can be demonstrated by means of the initial and structural stabilities[18-20]. However, how does the stability of macroscopic particles exposed in an externally applied field be proved ? If the motion of a macroscopic particles is located in a finite range where the potential is lowest, we can say that the particle is stable according to the minimum theorem of energy. As a matter of fact, when there are a lot of particles with complicated interactions in the system, then we are very difficult to define the individual behavior of each particles in this case. Thus we cannot use again same strategies as those used in the discussions of initial stability and collision of particles to determine their stability[18-19,23-24,37]. Instead, we apply the fundamental work- energy theorem in classical physics to determine their stability. The theorem of minimum energy can be desribed as follows. If a mechanical system is in a state of minimal energy, then we can say it is stable because in order to change this state, external energy must be supplied. We apply this fundamental concept to demonstrate the stability of the microscopic particles described by the nonlinear SchrÖdinger equation (20), which is outlined in the following.

Let $\phi(x,t)$ represent the field of the particle, and assume that it has derivatives of all orders, and all integrations, and is convergent and finite. The Lagrange density function corresponding to the nonlinear SchrÖdinger equation (20) is as follows:

$$\mathcal{L} = \frac{i\hbar}{2}(\phi^*\phi_t - \phi\phi_t^*) - \frac{\hbar^2}{2m}(\nabla\phi.\nabla\phi^*) - V(x)\phi^*\phi + \frac{b}{2}(\phi^*\phi)^2 \tag{70}$$

The momentum density of this field is defined as p= $\partial L/\partial\phi$. Thus, the Hamiltonian density of the field is as follows

$$\mathcal{H} = \frac{i\hbar}{2}\left(\phi^*\partial_t\phi - \phi\partial_t\phi^*\right) - \mathcal{L} = \frac{\hbar^2}{2m}(\nabla\phi.\nabla\phi^*) + V(x)\phi^*\phi - \frac{b}{2}(\phi^*\phi)^2 \tag{71}$$

From Eqs.(70)-(71), we see clearly that the Lagrange and Hamiltonian operators of the systems corresponding to Eq. (20) are all related to the state wave function of particles and involve the nonlinear interactional energy, b$(\phi\phi^*)^2$ related to the states of microscopic particles. This is in essence different from the Hamiltonian operator in Eq.(8) in quantum mechanics. Then the natures and features of microscopic particles should be together determined by the kinetic and nonlinear interaction terms in this case. Just so, there is a force or energy to obstruct and suppress the dispersing effect of kinetic energy in the system, thus the microscopic particles cannot disperse and propagate again in total space, and eventually is localized all the time. This is just the essential reason that the microscopic particles have a particulate nature or corpuscle-wave duality as mentioned above. Therefore, we can say that the systems described by the nonlinear SchrÖdinger equation (20) and correspond- ding Lagrange and Hamiltonian in Eqs.(70)-(71) breaks through the fundamental hypothesis for the independence of Hamiltonian operator with the wave function of the particles in the quantum mechanics[18-19]. This is a new development of quantum mechanics.

In the general case, the total energy of the particles is a function of t' and is represented by

$$E(t')=\int_{-\infty}^{\infty}\left[\left|\frac{\partial\phi}{\partial x'}\right|^2-\frac{b}{2}\left|\phi\phi^*\right|^2+V(x')|\phi|^2\right]dx' \tag{72}$$

However, in this case, b and $V(x')$ are not functions of t'. So, the total energy of the systems is a conservative quantity, i.e., $E(t')$=E=const.. We can demonstrate that when $x'\to\pm\infty$, the solutions of Eq.(20) and $\phi(x',t')$should tend to zero rapidly, i.e.[18-19,37-41],

$$\underset{|x'|\to\infty}{Lim}\,\phi(x',t')=\underset{|x|\to\infty}{Lim}\frac{\partial\phi}{\partial x'}=0$$

Then

$$\int_{-\infty}^{\infty}\phi^*\phi dx'=const.\text{ or a function of } t'$$

The position of mass centre of microscopic particle can be represented by

$$\langle x'\rangle=x'_g=x_0=\int_{-\infty}^{\infty}\phi'^*x'\phi dx'/\int_{-\infty}^{\infty}\phi^*\phi dx' \tag{73}$$

Thus, the velocity of mass centre of microscopic particle can be denoted by

$$v_g=\frac{d\langle x'\rangle}{dt'}=\frac{d}{dt'}\left\{\frac{\int\phi*x'\phi dx'}{\int\phi*\phi dx'}\right\}=-2i\frac{\int_{-\infty}^{\infty}\phi*\frac{\partial\phi'}{\partial x'}dx'}{\int\phi*\phi dx'} \tag{74}$$

However, for different solutions of the same nonlinear SchrÖdinger equation (20), $\int_{-\infty}^{\infty}\phi^*\phi dx'$, $\langle x'\rangle$ and dx'/dt' can have different values. Therefore, it is unreasonable to compare the energy between a definite solution and other solutions. We should compare the energy of one particular solution to that of another solution. The comparison is only meaningful for many microscopic particle systems that have the same values of $\int_{-\infty}^{\infty}\phi^*\phi dx'=k.$, $\langle x'\rangle=u$ and $d<x'>/dt'=\dot{u}$ at the same time t'_0. Based on these, we can determine the stability of the solutions of Eq.(20), for example, Eq.(34). Thus, we assume that the different solutions of the nonlinear SchrÖdinger equation (20) satisfy the following boundary conditions at definite time t'_0:

$$\int_{-\infty}^{\infty}\phi^*\phi dx'=k,\ \langle x'\rangle\Big|_{t'=t'_0}=u(t'_0),\ \left.\frac{d<x'>}{dt'}\right|_{t'=t'_0}=\dot{u}(t'_0), \tag{75}$$

Now we assume the solution of nonlinear SchrÖdinger equation (20) to have the form of Eq.(23).
Substituting Eq.(23) into Eq.(72), we obtain the energy formula:

$$E=\int_{-\infty}^{\infty}\left[\left(\frac{\partial\varphi}{\partial x'}\right)^2+\varphi^2\left(\frac{\partial\theta}{\partial x'}\right)^2-b\varphi^4+V(x')\varphi^2\right]dx' \tag{76}$$

At the same time, equation (24) becomes

$$\int_{-\infty}^{\infty}\varphi^2 dx'=k\ ,\quad \frac{\int_{-\infty}^{\infty}x'\varphi^2 dx'}{\int_{-\infty}^{\infty}\varphi^2 dx'}=u\left(t_0{}'\right),\quad \frac{2\int_{-\infty}^{\infty}\varphi^2\frac{\partial\theta}{\partial x'}dx'}{\int_{-\infty}^{\infty}\varphi^2 dx'}=\dot{u}(t_0') \tag{77}$$

Finding the extreme value of the functional Eq.(76) under the boundary conditions Eq. (77) by means of the Lagrange uncertain factor method, we obtain the following Euler equations:

$$\frac{\partial^2\varphi}{\partial(x')^2}=\begin{Bmatrix}V(x')+C_1(t_0')C_2(t_0')[x'-u(t_0')]+\\ C_3(t_0')\left[2\frac{\partial\theta}{\partial t'}-\dot{u}(t_0')\right]+\left(\frac{\partial\theta}{\partial t'}\right)^2\end{Bmatrix}\varphi-b\varphi^3=0 \tag{78}$$

$$\frac{\partial^2\varphi}{\partial(x')^2}\varphi^2+2\frac{\partial\theta}{\partial t'}\varphi\frac{\partial\varphi}{\partial t'}+2C_3(t_0')\varphi\frac{\partial\varphi}{\partial t'}=0 \tag{79}$$

where the Lagrange factors C_1, C_2 and C_3 are all functions of t'. Now, let $C_3(t_0')=-\frac{1}{2}\dot{u}(t_0')$

If $$2\frac{\partial\theta}{\partial x'}-\dot{u}(t_0')\neq 0$$

we can get from Eq.(79)

$$\frac{2}{\varphi}\frac{\partial\varphi}{\partial x'}=\frac{-\frac{\partial^2\theta}{\partial x'^2}}{-\frac{\partial\theta}{\partial x'}-\frac{1}{2}\dot{u}(t_0')}$$

Integration of the above equation yields

$$\varphi^2=\frac{g(t')}{\frac{\partial\theta}{\partial x'}-\frac{1}{2}\dot{u}(t_0')}\quad \text{or}\quad \left.\frac{\partial\theta}{\partial x'}\right|_{t'=t_0'}=\frac{g(t_0')}{\varphi^2}+\frac{\dot{u}(t_0')}{2} \tag{80}$$

where $g(t_0')$ is an integral constant. Thus,

$$\theta(x',t')=g(t_0')\int_0^x\frac{dx'}{\varphi^2}+\frac{\dot{u}(t_0)}{2}x'+M(t_0') \tag{81}$$

Here, $M(t_0')$ is also an integral constant. Again let

$$C_2(t_0')=\frac{1}{2}\ddot{u}(t_0') \tag{82}$$

Substituting Eqs.(80)-(82) into Eq.(79), we obtain

$$\frac{\partial^2\varphi}{\partial(x')^2}=\left\{V(x')+\frac{\ddot{u}(t_0')}{2}x'+\left[C_1(t_0')-\frac{\ddot{u}(t_0')}{2}u(t_0')+\frac{u^2(t_0')}{4}\right]\right\}\varphi-b\varphi^3+\frac{g^2(t_0')}{\varphi^3} \tag{83}$$

Letting

$$C_1(t_0')=\frac{u(t_0')\ddot{u}(t_0')}{2}-\frac{\dot{u}^2(t_0')}{2}+M(t_0')+\beta' \tag{84}$$

where β' is an undetermined constant, which is a function of t'-independent, and assuming $Z=x'-u(t_0')$, then $\frac{\partial^2\varphi}{\partial(x')^2}=\frac{\partial^2\varphi}{\partial Z^2}$ is only a function of Z. To make the right-hand side of Eq.(34) be also a function of Z, the coefficients of φ, φ^3 and $1/\varphi^3$ must also be functions of Z, thus, $g(t_0')=g_0=const,$ and

$$V(x')+\frac{\ddot{u}(t_0')}{2}x'+M(t_0')-\frac{u^2(t)}{4}=\tilde{V}_0(Z)$$

Then, equation (83) becomes

$$\frac{\partial^2\varphi}{\partial(x')^2}=\{\tilde{V}[x'-u(t_0')]+\beta'\}\varphi-b\varphi^3+\frac{g^2(t_0')}{\varphi^3} \tag{85}$$

Since $\tilde{V}(Z)=\tilde{V}_0[x'-u(t_0')]=0$ in the present case. Hence, equation(85) becomes

$$\frac{\partial^2\varphi}{\partial(x')^2}=\beta'\varphi-b\varphi^3+\frac{g^2(t_0')}{\varphi^3} \tag{86}$$

Therefore, φ is the solution of Eq.(86) for the parameters β' =constant and $g(t_0')$=constant. For sufficiently large $|Z|$ we may assume[18,19,37-41] that $|\varphi|\le\tilde{\beta}/|Z|^{1+\Delta}$, where Δ is a small constant. However, in Eq.(86) we can only retain the solution $\varphi(Z)$ corresponding to $g(t_0')$ to ensure that $Lim_{|\varepsilon|\to\infty}d^2\varphi/dZ^2=0$, thus, Eq. (86) becomes

$$\frac{\partial^2\varphi}{\partial(x')^2}=\beta'\varphi-b\varphi^3 \tag{87}$$

As a matter of fact, if $\partial\theta/\partial t'=\dot{u}/2,$ and considering Eqs.(84)-(85) we can verify that the solution in Eq.(34) can satisfy Eq.(87). In such a case, it is not difficult to show that the energy corresponding to the solution Eq.(34) of Eq.(87) has a minimal value under the boundary conditions of Eq.(87). Thus, we can conclude that the solution of Eq. (20), or the wave-corpuscle duality of microscopic particles depicted by nonlinear SchrÖdinger equation (20) is stable in such a case.. This indicates the microscopic particles have a feature of classical particles.

d) The classical features of motion of microscopic particles

i. *The feature of Newton's motion of microscopic particles*

Since the microscopic particle described by the nonlinear SchrÖdinger equation (20) has a corpuscle feature and is also quite stable as mentioned above. Thus its motion in action of a potential field in space-time should have itself rules of motion. We now study this rule of motion.
Now utilizing Eq. (20) and its conjugate equation as follows:

$$-i\hbar\frac{\partial\phi^*}{\partial t}=-\frac{\hbar^2}{2m}\nabla^2\phi^*\pm b|\phi|^2\phi^*+V(\vec{r},t)\phi^*, \tag{88}$$

we can obtain[18,37-41]

$$\frac{d}{dt'}\int_{-\infty}^{\infty}\phi^*\phi_{x'}dx'=\int_{-\infty}^{\infty}\phi_{t'}^*\phi_{x'}dx'+\int_{-\infty}^{\infty}\phi^*(\phi_{t'})_{x'}dx'=i\int_{-\infty}^{\infty}\{\phi^*\frac{\partial}{\partial x'}[\phi_{x'x'}+b\phi^*\phi^2$$

$$-V\phi]-[\phi_{x'x'}^*-b\phi(\phi^*)^2-V\phi^*]\phi_{x'}\}dx'=i\int_{-\infty}^{\infty}\phi^*\frac{\partial V}{\partial x'}\phi dx' \tag{89}$$

where $x'=x/\sqrt{\hbar^2/2m}$, $t'=t/\hbar$. We here utilize the following relations and the boundary conditions:

$$\int_{-\infty}^{\infty}(\phi^*\phi_{x'x'x'}-\phi^*_{x'x'}\phi_{x'})dx'=0,\int_{-\infty}^{\infty}b(\phi^{*2}\phi\phi_{x'}+\phi^*\phi^2\phi^*_{x'})dx'=0$$

$$\underset{|x'|\to\infty}{Lim}\phi(x',t')=\underset{|x'|\to\infty}{\lim}\phi_{x'}(x',t')=0 \text{ and } \int_{-\infty}^{\infty}\phi^*\phi dx'=const.\underset{|x'|\to\infty}{Lim}\phi^*x'\phi_{x'}=\underset{|x'|\to\infty}{Lim}\phi^*_{x'}x'\phi=0$$

where $\phi_{x'}=\dfrac{\partial\phi}{\partial x'},\phi_{x'x'x'}=\dfrac{\partial^3\phi}{\partial x'^3}$. Thus, we can get

$$\frac{d}{dt'}\int_{-\infty}^{\infty}\phi^*x'\phi dx'=\int_{-\infty}^{\infty}(\frac{\partial\phi^*}{\partial t'}x'\phi+\phi^*x'(\frac{\partial\phi}{\partial t'})dx'=-2i\int_{-\infty}^{\infty}\phi^*\phi_{x'}dx' \tag{90}$$

In the systems, the position of mass centre of microscopic particle can be represented by Eq.(73), thus the velocity of mass centre of microscopic particle is represented by Eq.(74). Then, the acceleration of mass centre of microscopic particle can also be denoted by

$$\frac{d^2}{dt'^2}<x'>=-2i\frac{d}{dt'}\{\int_{-\infty}^{\infty}\phi^*\phi_{x'}dx'/\int_{-\infty}^{\infty}\phi^*\phi dx'\}=-2\int_{-\infty}^{\infty}\phi^*V_{x'}\phi^*dx'=-2<\frac{\partial V}{\partial x'}> \tag{91}$$

If ϕ is normalized, i.e., $\int_{-\infty}^{\infty}\phi^*\phi dx'=1$, then the above conclusions also are not changed.

We expand $\dfrac{\partial V}{\partial x'}$ at the mass centre $x'=<x'>=x_0'$ as[18,37-41]

$$\frac{\partial V(x')}{\partial x'}=\frac{\partial V(<x'>)}{\partial<x'>}+(x'-<x'>)\frac{\partial^2V(<x'>)}{\partial<x'>^2}+\frac{1}{2!}(x'-<x'>)^2\frac{\partial^3V(<x'>)}{\partial<x'>^3}+\cdots$$

Finding the expectation value to the above formula, thus we get

$$\left\langle\frac{\partial V(x')}{\partial x'}\right\rangle=\frac{\partial V(<x'>)}{\partial<x'>}+\frac{1}{2!}<(x'-<x'>)^2>\frac{\partial^3V(<x'>)}{\partial<x'>^3}$$

For the microscopic particle described by Eq.(20) or Eq.(26), the position of the mass center of the particle is known and determinant, which is just $<x'>=x_0'$ =constant, or 0. Since we here study only the rule of motion of the mass centre x_0, which means that the terms containing x_0' in $<x'^2>$ are effective, thus $<x'^2>$ =, $<x'><x'>$, then $<(x'-<x'>)^2>$ =0 can yield. Thus

$$\left\langle\frac{\partial V(x')}{\partial x'}\right\rangle=\frac{\partial V(<x'>)}{\partial<x'>} \tag{92}$$

Finally, we can get the acceleration of the mass center of the particle to be of the form

$$\frac{d^2}{dt'^2}<x'>=-2\frac{\partial V(<x'>)}{\partial<x'>} \quad \text{or} \quad m\frac{d^2x_0}{dt^2}=-\frac{\partial V}{\partial x_0} \tag{93}$$

where x_0'=<x'> is the position of the mass centre of microscopic particle. Equation (93) is a Newton-type classical equation of motion. This shows clearly that the motion of the mass centre of microscopic particles satisfies the Newton law, when the microscopic particles are described by the nonlinear SchrÖdinger equation in Eq.(20). Therefore, we can say that the microscopic particle has some properties of the classical particle.

The above equation of motion of microscopic particles can also be derived from the nonlinear *SchrÖdinger* equation (20) by another method. As is known, the momentum of microscopic particle depicted by Eq.(20) is denoted by $P=\dfrac{\partial L}{\partial\phi}=-i\int_{-\infty}^{\infty}\left(\phi^*\phi_{x'}-\phi^*_{x'}\phi\right)dx'$. The energy $E(t')=\int_{-\infty}^{\infty}\left[\left|\dfrac{\partial\phi}{\partial x'}\right|^2-\dfrac{b}{2}|\phi\phi^*|^2+V(x')|\phi|^2\right]dx'$ and quantum number

$N_s = \int_{-\infty}^{\infty} |\phi|^2 dx'$ in this system are integral invariant. However, the momentum P is not conserved. From Eq.(20) we has

$$\frac{dP}{dt'} = \int_{-\infty}^{\infty} 2V(x') \frac{\partial}{\partial x'} |\phi|^2 dx' = -2\int_{-\infty}^{\infty} \frac{\partial V}{\partial x'} |\phi|^2 dx' = -2 \left\langle \frac{\partial V(x')}{\partial x'} \right\rangle \tag{94}$$

where the boundary condition is $\phi(x') \to 0$ as $|x'| \to \infty$. Utilizing again Eqs.(88) and (92) we can get thet the acceleration of the mass center of the particle to be

$$\frac{dP}{dt'} = -2\frac{\partial V(x_0')}{\partial x_0'} \quad \text{or} \quad m\frac{d^2 x_0}{dt^2} = -\frac{\partial V}{\partial x_0} \tag{95}$$

where x_0' is the position of the center of the mass of the macroscopic particle. This is the same as Eq. (93). It resembles the Newton's equation for a classical particle.

ii. *Lagrangian and Hamilton Equations of microscopic particle*

Using the above variables ϕ and ϕ^* one can determine the Poisson bracket and write further the equations of motion of microscopic particles in the form of Hamilton's equations. For Eq. (20) with $V(\vec{r},t) = 0$, the variables ϕ and ϕ^* satisfy the Poisson bracket [42] :

$$\left\{\phi^{(a)}(x), \phi^{(b)}(y)\right\} = i\delta^{ab}\delta(x-y) \tag{96}$$

where
$$\{A, B\} = i\int_{-\infty}^{\infty} \left(\frac{\delta A}{\delta \phi} \frac{\delta B}{\delta \phi^*} - \frac{\delta B}{\delta \phi} \frac{\delta A}{\delta \phi^*} \right)$$

The corresponding Lagrangian density $\mathcal{L}$ in Eq. (70) associated with Eq. (20) can be written in terms of $\phi(x,t)$ and its conjugate ϕ^* viewed as independent variables. The action of the system can be written as

$$S(\phi, \phi^*) = \int_{t_b}^{t_1} \int_D L' dx dt \tag{97}$$

and its variation for infinitesimal $\delta\phi$ and $\delta\phi^*$ is of the form[42]

$$\delta S = \int_{t_B}^{t} \int_D \left[\frac{\partial L'}{\partial \phi} \delta\phi + \frac{\partial L'}{\partial \nabla \phi} \delta \nabla \phi + \frac{\partial L'}{\partial \phi_t} \delta \phi_t \right] dx\, dt + \text{c.c.} \tag{98}$$

where $L' = \mathcal{L}$, $\partial L'/\partial(\nabla\varphi)$ denotes the vector with components $\partial L'/\partial(\partial_i \phi)(i = 1,2,3)$. After integrating by parts, we get

$$\delta S = \int_{t_b}^{t} \int_D \left[\frac{\partial L'}{\partial \phi} - \nabla \cdot \left(\frac{\partial L'}{\partial \nabla \phi} \right) - \partial_t \left(\frac{\partial L'}{\partial \phi_t} \right) \right] \delta\phi dx dt + \left[\frac{\partial L'}{\partial \phi_t} \delta\phi \right]_{t_0}^{t_1} + \text{c.c.} \tag{99}$$

A necessary and sufficient condition for a function $\phi(x,t)$ with known values $\phi(x,t_0)$ and $\phi(x,t_1)$ to yield an extremum of the action S is that it must satisfy the Euler-Lagrange equation:

$$\frac{\partial L'}{\partial \phi} = \nabla \cdot \left(\frac{\partial L'}{\partial \nabla \phi} \right) + \partial_t \left(\frac{\partial L'}{\partial \phi_t} \right) \tag{100}$$

Equation(100) can give the nonlinear SchrÖdinger equation (20) if the Lagrangian density Eq. (70) is used. Therefore, the dynamic equation, or the nonlinear *SchrÖdinger* equation can be derived from the Euler-Lagrange equation, if the Lagrangian function of the system is known. This is different from quantum mechanics, in which a dynamic equation, or the linear SchrÖdinger equation, cannot be obtained from the Euler-Lagrange equation.

The above derivation of the nonlinear *SchrÖdinger* equation based on the variational principle is a foundation for other methods, such as, the “the collective coordinates”, the “variational approach”, and the “Rayleigh-Ritz optimization principle”, where a solution is assumed to maintain a prescribed approximate profile (often bell-type)[10-12]. Such methods greatly simplify the problem, reducing it to a system of ordinary differential equations for the evolution of a few characteristics of the systems.

The Hamiltonian density H corresponding to Eq.(20) is Eq.(71)[42]. Introducing the canonical variables,

$$q_1=\frac{1}{2}\left(\phi+\phi^*\right),\quad p_1=\frac{\partial L'}{\partial\left(\partial_t q_1\right)};q_2=\frac{1}{2i}\left(\phi-\phi^*\right),\quad p_2=\frac{\partial L'}{\partial\left(\partial_t q_2\right)}$$

where L’ $=\mathcal{L}$, the Hamiltonian density takes the form

$$\mathcal{H}=\sum_i p_i\partial_t q_i - \mathcal{L}$$

and the corresponding variation of the Lagrangian density $\mathcal{L}$ = L’ can be written as

$$\delta L' = \sum_i \frac{\delta L'}{\delta q_i}\delta q_i + \frac{\delta L'}{\delta\left(\nabla q_i\right)}\delta\left(\nabla q_i\right)+\frac{\delta L'}{\delta\left(\partial_t q_i\right)}\delta\left(\partial_t q_i\right) \tag{101}$$

From Eq.(101), the definition of p_i, and the Euler-Lagrange equation,

$$\frac{\partial L'}{\partial q_i}=\nabla.\frac{\partial L'}{\partial\nabla q_i}+\frac{\partial p_i}{\partial t}$$

one obtains the variation of the Hamiltonian in the form of

$$\delta H=\sum_i\int\left(\partial_t q_i\delta p_i-\partial_t p_i\delta q_i\right)dx$$

Thus, the Hamilton equation can be derived:

$$\frac{\partial q_i}{\partial t}=\delta\mathcal{H}\big/\delta p_i,\qquad \frac{\partial p_i}{\partial t}=-\delta\mathcal{H}\big/\delta q_i \tag{102}$$

or in complex form:

$$i\hbar\frac{\partial\phi}{\partial t}=\frac{\delta H'}{\delta\phi*},\text{ or } i\hbar\frac{\partial\phi*}{\partial t}=-\frac{\delta H'}{\delta\phi}$$

This is interesting. It shows that the nonlinear *SchrÖdinger* equation describing the dynamics of microscopic particle can be also obtained from the classical Hamilton equation in the case, if the Hamiltonian of the system is known. Obviously, such methods of finding dynamic equations are impossible in the quantum mechanics. As is known, the Euler-Lagrange equation and Hamilton equation are important equations in classical theoretical (analytic) mechanics, and were used to describe laws of motions of classical particles. These equations are now used to depict properties of motions of microscopic particles. This shows sufficiently the classical features of microscopic particles described by nonlinear SchrÖdinger equation. On the other hand, from this study, we seek new ways of finding the equation of motion of the microscopic particles in nonlinear systems, i.e., if the Lagrangian or Hamiltonian of the system is known in the coordinate representation, then we can obtain the equation of motion of microscopic particles from the Euler-Lagrange or Hamilton equations.

On the other hand, from de Broglie relation[8-12] $E=h\upsilon=\hbar\omega$ and $\vec{p}=\hbar\vec{k}$ for microscopic particles which represent the wave-corpuscle duality in quantum theory, the frequency ω retains its role as the Hamiltonian of the system even in this complicated and nonlinear systems and

$$\frac{d\omega}{dt'}=\frac{\partial\omega}{\partial k}\bigg|_{x'}\frac{dk}{dt}+\frac{\partial\omega}{\partial x'}\bigg|_{k}\frac{\partial x'}{\partial t'}=0$$

as in the usual stationary media[18-19]. From the above result we also know that the usual Hamilton equation in Eq. (102) for the nonlinear systems remain valid for the microscopic particles. Thus, the Hamilton equation in Eq. (102) can be now represented by another form:

$$\frac{dk}{dt'}=-\frac{\partial\omega}{\partial x'}\Big|_k \text{ and } \frac{dx'}{dt'}=\frac{\partial\omega}{\partial k}\Big|_{x'} \tag{103}$$

in the energy picture, where $k=\partial\theta/\partial x'$ is the time-dependent wave number of the microscopic particle, $\omega=-\partial\theta/\partial t'$ is its frequency, θ is the phase of the wave function of the microscopic particles.

iii. *Confirmation of correctness of the above conclusions*

We now use some concrete examples to verify the correctness of the above laws of motion of microscopic particles.

(1). For $V=0$ or constants as shown in Eq.(34) we can get from Eq.(93) that $m\frac{d^2}{dt'^2}<x>=-\frac{\partial V(<x>)}{\partial <x>}=0$. This shows that the acceleration of the mass centre of microscopic particle is zero, the velocity of the particle is a constant. In fact, if inserting Eq. (34) into Eq.(93) we can obtain $v_g= d<x'>/dt'=v_e=$constant, i.e., the microscopic particle moves exactly in uniform velocity in space-time in this case, the velocity is just the group velocity of the soliton. This shows that the energy and momentum of microscopic particle can be retained in the motion process.

On the other hand, from Eqs .(103) and (34) we can also get

$$\frac{dk}{dt}=0 \text{ and } \frac{dx}{dt}=v_e$$

where

$$\omega=-\partial\theta/\partial t'=v_e v_c/2,\quad k=\partial\theta/\partial x'=v_c/2,\ \theta=v_c\left[\sqrt{2m}\left(x-x_0\right)-v_e t\right]\Big/2\hbar$$

This result indicates that the acceleration of microscopic particle is zero, its velocity is a constant. This is same with those obtained from Eqs.(90) and (93). Thus the correctness of Eqs.(90), (102)- (103) and (93), or (95) are affirmed.

(2). For $V\left(x'\right)=\alpha x'$ in Eq.(20), its solution is Eq.(52).This solution has also a envelop, carrier wave and mass centre x'_0, which is the localized position of the particle. The characteristics of motion of the microscopic particle can be determined according to Eq. (93). Its accelerations of the center of mass is given by

$$\frac{\mathrm{d}^2x_0'}{\mathrm{d}t'^2}=-2\frac{\partial \mathrm{V}\left(\left\langle \mathrm{x}'\right\rangle\right)}{\partial\left\langle \mathrm{x}'\right\rangle}=-2\alpha=\text{constant} \tag{104}$$

From Eq. (52) we know that

$$\theta=2\left(\xi-\alpha t'\right)x'+\frac{4\alpha^2t'^3}{3}-4\alpha\xi t'^2+4\left(\xi^2-\eta^2\right)t'+\theta_0, \tag{105}$$

From Eq.(103) we can find

$$k=2(\xi-at'),$$

$$\omega=2ax'-4\left(2\xi-at'\right)^2+\left(2\eta\right)^2=2ax'-k^2+\left(2\eta\right)^2.$$

Thus, the group velocity of the microscopic particle is

$$\upsilon_{\mathrm{g}}=\frac{d\tilde{x}'}{dt'}=\frac{\partial\omega}{\partial k}\bigg|_{x'}=4\left(2\xi-at'\right), \tag{106}$$

and its acceleration is given by

$$\frac{d^2\tilde{x}'}{dt'^2}=\frac{dk}{dt'}=-2a=\text{cons t an t},\ \ \text{here}(x_0'=\tilde{x}') \tag{107}$$

Comparing Eq.(104) with Eq.(107) we find that they are same, which indicates that Eqs.(90), (102)- (103) and (93), or (95) are correct. In such a case the microscopic particle moves in uniform acceleration. This is similar with that of classical particle.

(3). For the case of $V_0\left(x'\right)=\alpha^2x'^2$, which is a harmonic potential, where α is constant, the solution of Eq.(20) is Eq.(55). This solution has also a envelop, carrier wave and mass centre x'_0, which is the localized position of the particle in such a condition. The properties of motion of the microscopic particle can be determined by Eq. (93). Then its accelerations of the center of mass is given by[35-36]

$$\frac{d^2x_0'}{dt'^2}=-4\alpha^2x_0' \tag{108}$$

From Eq. (55), we gain that

$$\theta=2\zeta x' \cos\left[2a\left(t'-t_0'\right)+\left(\frac{\zeta^2}{a}\right)\sin 4a\left(t'-t_0'\right)+\right]4\eta^2\left(t'-t_0'\right)+\theta_0', \tag{109}$$

From Eqs.(103) and (110) we can find

$$k=2\xi\cos 2\alpha\left(t'-t_0'\right),$$

$$\omega=4a\xi x'\sin 2\alpha\left(t'-t_0'\right)-4\xi^2\,\text{co}\ \ 4\alpha\left(t'-t_0'\right)\text{s}-4\eta^2$$

$$=2\alpha^{\,x}\left(4\xi^2-{}^{k_2}\right)^{1/2}-2^{\,k_2}+4\left(\xi^2-\eta^2\right),$$

Thus, the group velocity of the microscopic particle is

$$v_g=\left.\frac{\partial\omega}{\partial k}\right|_{x'}=\frac{\alpha x'}{\xi}\frac{k}{\sqrt{1-k^2/4\xi^2}}-2k=2\alpha x'\,\text{ctg}\left[2\alpha\left(t'-t_0'\right)\right]-4\xi\cos\left[2\alpha\left(t'-t_0'\right)\right],$$

while its acceleration is

$$\frac{dk}{dt'}=-\left.\frac{\partial\omega}{\partial x'}\right|_k=-2\alpha\sqrt{4\xi^2-k^2}=-4\xi\alpha\sin\left[2\alpha\left(t'-t_0'\right)\right]. \tag{110}$$

Since $\frac{d^2\tilde{x}'}{dt'^2}=\frac{dk}{dt'}$, here $\left(\tilde{x}'=x_0'\right)$, we have

$$\frac{dp}{dt'}=\frac{d^2\tilde{x}'}{dt'^2}=-4\zeta\alpha\sin\left[2\alpha\left(t'-t_0'\right)\right],$$

and

$$\tilde{x}'=\frac{2\xi}{\alpha}\sin\left[2\alpha\left(t'-t_0'\right)\right]. \tag{111}$$

Finally, the acceleration of the microscopic particle is

$$\frac{d^2\overline{x}'}{dt'}=\frac{dp^k}{dt'}=-4\alpha^2\overline{x}'. \tag{112}$$

We see clearly that Eq. (112) are exactly the same as Eq.(108). Thus we confirm the validity of Eqs.(90), (102)- (103) and (93), or (95) . In such a case the microscopic particle moves in harmonic form. This resembles also with the result of motion of classical particle.

Since quantum mechanics has a lot of difficult and troubles, when the linear SchrÖdinger equation is used to describe the microscopic particles. However, when a nonlinear SchrÖdinger equation is used to describe the microscopic particles we find their law of motion and properties are greatly changed relative to that of quantum mechanics. In such a case we find that the motion of microscopic particle satisfies classical rule and obeys the Hamiltonian principle, Lagrangian and Hamilton equations. We verify further the correctness of these conclusions by the results of nonlinear SchrÖdinger equation under actions of different externally applied potential. At the same time we discover that a macroscopic object moves with a uniform velocity at V(x')=0 or constant, moves in an uniform acceleration, when $V\left(x'\right)=ax'$, which corresponds to the motion of a charge particle in a uniform electric field, but when $V\left(x'\right)=\alpha^2 x'^2$ the macroscopic object performs localized vibration with a frequency of 2α and an amplitude of $2\xi/\alpha$, the corresponding classical vibrational equation is $x'=x_0' \sin\omega t'$, with $\omega=2a$ and $x_0'=\xi/\alpha$. The equations of motion of the macroscopic particles are consistent with Eq. (93) and Eqs. (102) – (103) for the center of mass of microscopic particles in nonlinear systems. These correspondence between a microscopic particle and a macroscopic object shows that microscopic particles described by the nonlinear SchrÖdinger equation have exactly the same properties as classical particles, and their motion satisfy the classical laws of motion. We have thus demonstrated clearly from the dynamic equations (nonlinear SchrÖdinger equation), the Hamiltonian or Lagrangian of the systems, and the solutions of equations of motion, systems, that microscopic particles described by the nonlinear SchrÖdinger equation in nonlinear systems really have the corpuscle property in both uniform and inhomogeneous. Therefore, we should use the nonlinear SchrÖdinger equation to describe microscopic particles and develop further a nonlinear quantum theory[18,28-34,].

e) The general conservation laws of motion of particles described by nonlinear SchrÖdinger equation

i. *Conservation laws of mass, energy and momentum of particles in Eq.(26)*

It is known from classical physics that the invariance and conservation laws of mass, energy and momentum and angular momentum are some elementary and universal laws of matter including classical particles in nature. We demonstrate here also that the microscopic particles described by the nonlinear SchrÖdinger equation also have such properties. They satisfy the conventional conservation laws of mass, momentum and energy. This shows that the microscopic particles in the nonlinear quantum mechanics have a corpuscle feature.

For the quantum systems described by nonlinear SchrÖdinger equation(20) we can define the number density, number current, densities of momentum and energy for the particle as[19,37-41]

$$\left.\begin{aligned}&\rho=|\phi|^2,\ p=-i\hbar(\phi^*\phi_x-\phi\phi_x^*)\\ &J=i\hbar(\phi^*\phi_x-\phi\phi_x^*), \in=\frac{\hbar^2}{2m}|\phi_x|^2-\frac{b}{2}|\phi\phi^*|^2+V(x)|\phi|^2\end{aligned}\right\} \tag{113}$$

where. $\phi_x=\frac{\partial}{\partial x}\phi(x,t), \phi_t=\frac{\partial}{\partial t}\phi(x,t)$. From Eq.(20) and its conjugate equation (88) as well as Eqs.(70)- (72) and (113) we can obtain

$$\frac{\partial p}{\partial t'}=\frac{\partial}{\partial x'}[2(\frac{\partial\phi}{\partial x'})^2+(b|\phi\phi^*|^2-2V|\phi|^2-(\phi^*\frac{\partial^2}{\partial x'^2}\phi+\phi\frac{\partial^2}{\partial x'^2}\phi^*)+2iV(\phi^*\frac{\partial\phi}{\partial x'})],$$

$$\frac{\partial\rho}{\partial t'}=\frac{\partial J}{\partial x'},\frac{\partial\in}{\partial x'}=\frac{\partial}{\partial x'}[\rho p+i(\frac{\partial\phi^*}{\partial x'}\frac{\partial^2\phi}{\partial x'^2}-\frac{\partial\phi}{\partial x'}\frac{\partial^2\phi^*}{\partial x'^2})-iV(\phi^*\frac{\partial\phi}{\partial x'}-\phi\frac{\partial\phi^*}{\partial x'})]$$

Thus, we get the following forms for the integral of motion

$$\frac{\partial}{\partial t'}M=\frac{\partial}{\partial t'}\int\rho dx'=0,\frac{\partial}{\partial t'}P=\frac{\partial}{\partial t'}\int p dx'=0,\frac{\partial E}{\partial t'}=\frac{\partial}{\partial t'}\int\in dx'=0, \tag{114}$$

These formulae represent just the conservation of mass, momentum and energy in such a case. This shows that the mass, momentum and energy of the microscopic particles described by the nonlinear SchrÖdinger equation in Eq.(20) in the quantum systems still satisfy conventional rules of conservation of matter including the classical particles in physics. Therefore, the microscopic particles described by the nonlinear SchrÖdinger equation in Eq.(20) reflects the common rules of motions of matter in nature. In the case of V(x,t)=0 or constant, we can find out easily the values of mass, momentum and energy of the particles of Eq.(26)or (34) [13-17] , as are shown in Eq.(56). These results show also that the microscopic particles in such a case have a corpuscle feature.

We understand clearly from the above investigations the really physical significance of wave function $\phi(\vec{r},t)$ in this case. It can represent in truth the states and properties of microscopic particles, the $|\phi(x,t)|^2$ represents the number or mass density of particles, instead of the probability occurred at a point in place-time in quantum mechanics. Although the representation in Eq.(23) can also seek in quantum mechanics, its physical significances are completely different from that described by the nonlinear SchrÖdinger equation in Eq.(20). The φ and θ are two independent physical quantities and denote the amplitude and phase of wave in quantum mechanics, respectively, but φ(x,t) and $\theta(x,t)$ in Eq.(23) represent the two different states of motion for envelope and carrier waves in the systems described by the nonlinear SchrÖdinger equation. From Eqs.(27)-(28) we see that the envelope and carrier waves are correlated with each other. Just the correlation the microscopic particles move in a soliton in the systems, thus wave-corpuscle duality of microscopic particles can occur. Therefore the wave functions of the particles have different physical significances in the two cases.

ii. *The invariance and conservation laws of particles in Eq.(20)*

We have learned from Eqs.(113)—(114) that some conservation laws for microscopic particles described by the nonlinear *SchrÖdinger* equation (20) are always related to the invariance of the action relative to several groups of transformations through the Noether theorem in light of Gelfand and Fomin's (1963) and Bulman and its Kermel's (1989) ideas (see C. Sulem and P. L. Sulem *et al*.'s book and references therein[42]). Therefore, we first give the Noether theorem for nonlinear *SchrÖdinger* equation.

To simplify the equation, we introduce the following notations:

$$\bar{\xi} = (t,x) = (\xi_0,\xi_1,\cdots,\xi_a)\ \partial_0 = \partial_t, \partial = (\partial_0,\partial_1,\cdots,\partial_d) \text{ and } \Phi = (\Phi_1,\Phi_2) = (\phi,\phi^*).$$

According to the Lagrangian Eq. (70) corresponding the nonlinear *SchrÖdinger* equation(20), then the action of the system[42]

$$S\{\phi\} = \int_{t_0}^{t_1}\int L'(\phi,\nabla\phi,\phi_t,\phi^*,\nabla\phi^*,\phi_t^*)\,dxdt$$

where L' = $\mathcal{L}$ is the Lagrange density function, now becomes

$$S\{\phi\} = \int_D\int_{x'}^{\infty} L'(\Phi,\partial\Phi)\,d\bar{\xi} \tag{115}$$

Under the action of a transformation T^{ε} which depends on the parameter ε, we have $\bar{\zeta}\to\tilde{\zeta}(\bar{\zeta},\Phi,\varepsilon),\Phi\to\tilde{\Phi}(\bar{\zeta},\Phi,\varepsilon)$, where $\tilde{\zeta}\, and\, \tilde{\Phi}$ are assumed to be differentiable with respect to ε. When $\varepsilon=0$, the transformation reduces to the identity. For infinitesimally small ε, we have $\tilde{\zeta}=\bar{\zeta}+\delta\varepsilon,\tilde{\Phi}=\Phi+\delta\Phi$. At the same time, $T^{\varepsilon},\Phi(\bar{\zeta})\to\tilde{\Phi}(\tilde{\zeta})$ by the transformation T^{ε}, and the domain of integration D is transformed into $\tilde{D}$,

$$S\{\phi\}\to\tilde{S}\{\tilde{\phi}\} = \int_D\int_{x^1}^{\infty} L'(\tilde{\Phi},\tilde{\partial}\tilde{\Phi})\,d\tilde{\zeta}$$

where $\tilde{\partial}$ denotes differentiation with respect to $\tilde{\zeta}$. The change $\delta S = \tilde{S}\{\tilde{\phi}\} - S\{\phi\}$ in the limit of ε under the above transformation can be expressed as

$$\delta S = \int_D\int_{x^1}^{\infty}\left[L'(\tilde{\Phi},\tilde{\partial}\tilde{\Phi}) - L'(\tilde{\Phi},\partial\tilde{\Phi})\right]d\bar{\xi} + \int_D\int_{x^1}^{\infty} L'(\Phi,\partial\Phi)\sum_{\upsilon=0}^{d}\frac{\partial\delta\xi_{\upsilon}}{\partial\xi_{\upsilon}}\,d\bar{\xi} \tag{116}$$

where we used the Jacobian expansion $\frac{\partial\left(\bar{\xi}_0,\ldots,\bar{\xi}_d\right)}{\partial\left(\xi_0,\ldots,\xi_d\right)}=1+\sum_{v=0}^{d}\frac{\partial\delta\xi_\upsilon}{\partial\xi_\upsilon}$, and $L'\left(\tilde{\Phi},\tilde{\partial}\tilde{\Phi}\right)$, in the second term on the right-hand side has been replaced by the leading term $L'(\Phi,\partial\Phi)$ in the expansion. Now define

$$\delta\tilde{\Phi}_i=\tilde{\Phi}_i\left(\bar{\xi}\right)-\tilde{\Phi}_i\left(\bar{\xi}\right)=\partial_\upsilon\Phi_i\delta\xi_\upsilon+\delta\Phi_i\left(\xi\right)$$

$$\tilde{\partial}_\upsilon\tilde{\Phi}_i\left(\bar{\xi}\right)-\partial_\upsilon\Phi_i\left(\xi\right)=\left(\tilde{\partial}_\upsilon-\partial_\upsilon\right)\tilde{\Phi}_i\left(\bar{\xi}\right)+\partial_\upsilon\left[\tilde{\Phi}_i\left(\bar{\xi}\right)-\Phi_i\left(\xi\right)\right] \tag{117}$$

with.

$$\partial_\upsilon=\frac{\partial\bar{\xi}_\mu}{\partial\xi_\upsilon}\tilde{\partial}_\mu=\left(\delta_{\upsilon\mu}+\frac{\partial\delta\xi_\mu}{\partial\xi_\upsilon}\right)\tilde{\partial}_\mu=\tilde{\partial}_\upsilon+\frac{\partial\delta\xi_\mu}{\partial\xi_\upsilon}\tilde{\partial}_\mu$$

We then have

$$L'\left(\tilde{\Phi},\tilde{\partial}\tilde{\Phi}\right)-L'(\Phi,\partial\Phi)=\frac{\partial L'}{\partial\Phi_i}\left[\tilde{\Phi}_i\left(\bar{\xi}\right)-\Phi_i\left(\xi\right)\right]+\frac{\partial L'}{\partial\left(\partial_\upsilon\Phi_i\right)}\left[\tilde{\partial}_\upsilon\tilde{\Phi}_i\left(\bar{\xi}\right)-\partial_\mu\Phi_i\left(\xi\right)\right]$$

$$=\frac{\partial L'}{\partial\Phi_i}\partial\Phi_i+\partial_\mu\left(L'\delta\xi_\upsilon\right)-L'\frac{\partial\delta\xi_\upsilon}{\partial\xi_\upsilon}+\partial_\upsilon\left[\frac{\partial L'}{\partial\left(\partial_\upsilon\Phi_i\right)}\right]\delta\Phi_i-\partial_\mu\left[\frac{\partial L'}{\partial\left(\partial_\upsilon\Phi_i\right)}\right]\delta\Phi_i$$

Eq. (116) can now be replaced by

$$\delta S=\int_D\int_{x'}^{\infty}\left\{\frac{\partial L'}{\partial\Phi_i}-\frac{\partial}{\partial\xi_\upsilon}\left[\frac{\partial L'}{\partial\left(\partial_\upsilon\Phi_i\right)}\right]\right\}\delta\Phi_i\,\mathrm{d}\,\bar{\xi}+\int_D\int_{x'}^{\infty}\frac{\partial}{\partial\xi_\upsilon}\left[L'\delta\xi_\upsilon+\frac{\partial L'}{\partial\left(\partial_\upsilon\Phi_i\right)}\delta\Phi_i\right]\mathrm{d}\,\bar{\xi}$$

where we have used

$$\frac{\partial}{\partial\xi_\upsilon}\left(L'\delta\xi_\upsilon\right)=L'\frac{\partial\delta\xi_\upsilon}{\partial\xi_\upsilon}+\frac{\partial L'}{\partial\Phi_i}\partial_\upsilon\Phi_i\delta\xi_\upsilon+\frac{\partial^2L'}{\partial\left(\partial_\mu\Phi_i\right)}\partial^2{}_{\upsilon\mu}\Phi_i\delta\xi_\upsilon,$$

$$\frac{\partial L'}{\partial\left(\partial_\upsilon\Phi_i\right)}\partial_\upsilon\int_{x'}^{\infty}\delta\Phi_i\frac{\partial}{\partial\xi_\upsilon}\left[\frac{\partial L'}{\partial\left(\partial_\upsilon\Phi_i\right)}\delta\Phi_i\right]-\frac{\partial}{\partial\xi_\upsilon}\left[\frac{\partial L'}{\partial\left(\partial_\upsilon\Phi_i\right)}\delta\Phi_i\right]\delta\Phi_i$$

Using the Euler-Lagrange equation, the first term on the right-hand side in the equation of δS vanishes. We can get the Noether theorem[42], *i.e.,* (A) if the action Eq. (115) is invariant under the infinitesimal transformation of the dependent and independent variables $\phi\to\phi+\delta\phi,\bar{\xi}\to\bar{\xi}+\delta\bar{\xi}$ where $\bar{\xi}=\left(t,x_1\ldots x_d\right)$, the following conservation law holds[28-29]

$$\frac{\partial}{\partial\xi_\upsilon}\left[L'\delta\xi_\upsilon-\frac{\partial L'}{\partial\left(\partial_\upsilon\Phi_i\right)}\delta\Phi_i\right]=0,\text{or},\frac{\partial}{\partial\xi_\upsilon}\left[L'\delta\xi_\upsilon+\frac{\partial L'}{\partial\left(\partial_\upsilon\Phi_i\right)}\left(\delta\Phi_i-\frac{\partial\Phi_i}{\partial\zeta_\mu}\delta\xi_\mu\right)\right]=0 \tag{118}$$

in terms of $\delta\hat{\Phi}_i$ defined above, where L'= *L*.

If the action is invariant under the infinitesimal transformation

$$t\to\bar{t}=t+\delta t\left(x,t,\phi\right),x\to\bar{x}=x+\delta x\left(x,t,\phi\right),$$

$$\phi(x,t) \to \bar{\phi}(\bar{t},\bar{x}) = \phi(t,x) + \delta\phi(t,x),$$

then

$$\int\left[\frac{\partial L'}{\partial \phi_t}\left(\partial_t \phi \partial_t + \nabla\phi\cdot\delta\vec{x} - \delta\phi\right) + \frac{\partial L'}{\partial \phi_t^*}\left(\partial_t \phi^* \partial_t + \nabla\phi^*\cdot\delta\vec{x} - \delta\phi^*\right) - L\delta t\right] dx$$

is a conserved quantity.

For the nonlinear *SchrÖdinger* equation (20) we have

$$\frac{\partial L'}{\partial \phi_t} = \frac{i}{2}\phi^*, \text{ and } \frac{\partial L'}{\partial \phi_t^*} = -\frac{i}{2}\phi$$

where L' = $\mathcal{L}$ is given in Eq.(70). Several conservation laws and invariance can be obtained from the Noether theorem.

(a) Invariance under time translation and energy conservation law

The action, Eq.(115), is invariant under the infinitesimal time translation $t \to t + \delta t$ with $\delta x = \delta\phi = \delta\phi^* = 0$, then equation (118) becomes

$$\partial_t\left[\nabla\phi\cdot\nabla\phi^* - \frac{b}{2}\left(\phi\phi^*\right)^2 + V(x,t)\phi^*\phi\right] - \nabla\cdot\left(\phi_t\nabla\phi^* + \phi_t^*\nabla\phi\right) = 0$$

This results in the conservation of energy

$$E = \int\left(\nabla\phi\cdot\nabla\phi^* - \frac{b}{2}\left(\phi^*\phi\right)^2 + V(x,t)\phi^*\phi\right)dx = constant \quad (119)$$

(b) Invariance of the phase shift or gauge invariance and mass conservation law

It is very clear that the action related to the nonlinear *Schrödinger* equation is invariant under the phase shift $\bar{\phi} = e^{i\theta}\phi$, which for infinitesimal θ gives $\delta\phi = i\theta\phi$, with $\delta t = \delta x = 0$. In this case, equation (118) becomes

$$\partial_t|\phi|^2 + \nabla\left\{i\left(\phi\nabla\phi^* - \phi^*\nabla\phi\right)\right\} = 0 \quad (120)$$

This results in the conservation of mass or number of particles.

$$N = \int|\phi|^2 dx = \text{constant}$$

and the continuum equation

$$\frac{\partial N}{\partial t} = \nabla\cdot\vec{j},$$

where $\vec{j}$ is the mass current density

$$\vec{j} = -i\left(\phi\nabla\phi^* - \phi^*\nabla\phi\right)$$

(c) Invariance of space translation and momentum conservation law

If the action is invariant under an infinitesimal space translation $x \to x + \delta x$ with $\delta t = \delta\phi = \delta\phi^* = 0$, then Eq.(118) becomes

$$\partial_t\left[i\left(\phi\nabla\phi^* - \phi^*\nabla\phi\right) + \nabla\cdot\left\{2\left(\nabla\phi^*\times\nabla\phi + \nabla\phi\times\nabla\phi^* + \mathcal{L}\right)\right\}\right] = 0$$

This leads to the conservation of momentum

$$\vec{P} = i\int\left(\phi\nabla\phi^* - \phi^*\nabla\phi\right)dx = \text{constant.} \tag{121}$$

Note that the center of mass of the microscopic particles is defined by

$$\langle x\rangle = \frac{1}{N}\int x|\phi|^2\,dx,$$

We then have

$$N\frac{d\langle x\rangle}{dt} = \int x\partial_t|\phi|^2\,dx = -\int x\nabla\left[i\left(\phi\nabla\phi^* - \phi^*\nabla\phi\right)\right]dx$$

$$= \int i\left(\phi\nabla\phi^* - \phi^*\nabla\phi\right)dx = \vec{P} = -\vec{J} = -\int\vec{j}dx \tag{122}$$

This is the definition of momentum in classical mechanics. It shows clearly that the microscopic particles described by the nonlinear *Schrödinger* equation have the feature of classical particles.

(d) Invariance under space rotation and angular momentum conservation law

If the action, Eq. (115), is invariant under a rotation of angle $\delta\theta$ around an axis $\vec{I}$ such that $\delta t = \delta\phi = \delta\phi^* = 0$ and $\delta\vec{x} = \delta\theta\vec{I}\times\vec{x}$, this leads to the conservation of the angular momentum

$$\vec{M} = i\int\vec{x}\times\left(\phi^*\nabla\phi - \phi\nabla\phi^*\right)dx$$

Besides the above, Sulem also derived another invariance of the nonlinear *Schrödinger* equation the from the Noether theorem for nonlinear SchrÖdinger equation.

(e) Galilean Invariance

If the action is invariant under the Galilean transformation:

$$x \to x'' = x - \upsilon t, t \to t'' = t,$$

$$\phi(x,t) \to \phi''(x'',t'') = exp\{-i\left[\frac{1}{2}\upsilon x + \frac{1}{2}\vec{\upsilon}\cdot\vec{\upsilon}t\right]\}\phi(x,t),$$

which can also retain the nonlinear *Schrödinger* equation invariance. For an infinitesimal velocity $\upsilon, \delta\vec{x} = -\upsilon t, \delta t = 0$ and $\delta\hat{\phi} = \phi''(x'',t'') - \phi(x,t) = -(i/2)\upsilon x\phi(x,t)$. After integration over the space variables, equation (118) leads to the conservation law Eq. (122) which implies that the velocity of the center of mass of the microscopic particles is a constant. It is also the same, even though the particle is in motion. This exhibits clearly that the microscopic particles have the particulate nature.

f) Classical natures of collision of microscopic particles

i. The features of collision of the microscopic particle at b>0 in Eq.(20)

As is known, the most obvious feature of macroscopic particles is meeting the collision law or conservation law of momentum. Therefore, we often also use the law to determine the particulate feature of macroscopic particles. As a matter of fact, Zakharov *et al.*[25-26] used the inverse scattering method to find out the following solution of Eq.(26) at b=1>0. It now is denoted by

$$\phi_s(x',t') = 2\sqrt{2}\eta\,\mathrm{sec}\,h\{2\eta(x'-x_0') - 8\eta\xi t'\}\exp\{2i\xi x' - i4(\xi^2-\eta^2)t' + i\theta\} \tag{123}$$

where, $2\sqrt{2}\eta$ is the amplitude, $2\sqrt{2}\xi$ denotes the velocity, θ is its phase. At the same time, they studied further the collision feature of two microscopic particles based on the solution (123). From this study they obtain that the translations of mass centre $x_0'^{+}$ and phase θ^{+} of each particles after collision can, respectively, represent by

$$x_{0m}'^{+} - x_{0m}' = \frac{1}{\eta_m}\prod_{p=m+1}^{N}\left|\frac{\varsigma_m - \varsigma_p}{\varsigma_m - \varsigma_p^*}\right| < 0, \text{ and } \theta_m^{+} - \theta_m = -2\prod_{p=m+1}^{N}\arg\left(\frac{\varsigma_m - \varsigma_p}{\varsigma_m - \varsigma_p^*}\right)$$

where η_m and ς_m are some constants related to the amplitude and velocity of m^th particles. The equations show that shift of position of mass centre of the particles and their variation of phase are a constants after collision. The collision process of two particles with different velocities and amplitudes can be described as follows. In the case of $t' \to -\infty$ the slowest soliton is in the front while the fastest at the rear, they collide with each other at t'=0, after the collision and $t' \to \infty$, they are just reversed. Thus Zakharov *et al.*[25-26] obtained that as the time *t* varies from $-\infty$ to ∞, the relative change of mass centre of two particles, $\Delta x'_{0m}$, and the relative change of their phases can, respectively, denoted by

$$\Delta x'_{0m} = x'^{+}_{0m} - x'^{-}_{0m} = \frac{1}{\eta_m}\left(\sum_{k=m+1}^{N} \ln\left|\frac{\varsigma_m - \varsigma_p}{\varsigma_m - \varsigma_p^*}\right| - \sum_{k=1}^{N-1}\ln\left|\frac{\varsigma_m - \varsigma_p}{\varsigma_m - \varsigma_p^*}\right|\right) \tag{124}$$

and

$$\Delta\theta_m = \theta_m^+ - \theta_m = 2\prod_{k=1}^{m-1} \arg\left(\frac{\varsigma_m - \varsigma_p}{\varsigma_m - \varsigma_p^*}\right) - 2\prod_{k=m+1}^{N} \arg\left(\frac{\varsigma_m - \varsigma_p}{\varsigma_m - \varsigma_p^*}\right) \tag{125}$$

Equation (124) can be interpreted by assuming that the microscopic particles collide pairwise and every microscopic particle collides with others. In each paired collision, the faster microscopic particle moves forward by an amount of $\eta_m^{-1}\ln\left|\left(\varsigma_m - \varsigma_k^*\right)/\varsigma_m - \varsigma_k\right|$, $\varsigma_m > \varsigma_k$, and the slower one shifts backwards by an amount of $\eta_k^{-1}\ln\left|\left(\varsigma_m - \varsigma_k^*\right)/\varsigma_m - \varsigma_k\right|$. The total shift is equal to the algebraic sum of their shifts during the paired collisions. So that there is no effect of multi-particle collisions at all. In other word, in the collision processin each time the faster particle moves forward by an amount of phase shift, and the slower one shifts backwards by an amount of phase. The total shift of the particles is equal to the algebraic sum of those of the pair during the paired collisions. The situation is the same with the phases. This rule of collision of the microscopic particles described by the nonlinear SchrÖdinger equation is the same as that of classical particles, or speaking, meet also the collision law of macroscopic particles, i.e., during the collision these microscopic particles interact and exchange their positions in the space-time trajectory as if they had passed through each other. After the collision, the two microscopic particles may appear to be instantly translated in space and/or time but otherwise unaffected by their interaction. The translation is called a phase shift as mentioned above. In one dimension, this process results from two microscopic particles colliding head-on from opposite directions, or in one direction between two particles with different amplitudes. This is possible because the velocity of a particle depends on the amplitude. The two microscopic particles surviving a collision completely unscathed demonstrates clearly the corpuscle feature of the microscopic particles. This property separates the microscopic particles (solitons) described by nonlinear SchrÖdinger equation from the particles in the quantum mechanical regime. Thus this demonstrates the classical feature of the microscopic particles.

Using the above features of collision of two particles and following the approach of Zakharov and Shabat[25-26], Desem and Chu[43-44] obtained a solution corresponding to two discrete eigenvalues $\varsigma_{1,2}$ for the interacting two microscopic particles in the process of collision, which is represented by

$$\phi(x',t') = \frac{|\alpha_1|\cosh(a_1 + i\theta_1)e^{i\theta'_2} + |\alpha_2|\cosh(a_2 + i\theta_2)e^{i\theta'_1}}{\alpha_3\cosh(a_1)\cosh(a_2) - \alpha_4\left[\cosh(a_1 + a_2) - \cos(A')\right]} \tag{126}$$

where $\theta'_{1,2} = 2\left[2\left(\eta_{1,2}^2 - \xi_{,2}^2\right)t' - x'\xi_{1,2}\right] + \left(\theta'_0\right)_{1,2}$, $A' = \theta'_2 - \theta'_1 + (\theta_2 - \theta_1)$,

$$\alpha_{1,2} = 2\eta_{1,2}\left(x' + 4t'\xi_{1,2}\right) + (a_0)_{1,2}, \; |\alpha_{1,2}|e^{i\theta_{1,2}} = \pm\left\{\left[\frac{1}{2\eta_{1,2}} - \frac{\eta}{\left(\Delta\xi^2 + \eta^2\right)}\right] \pm i\frac{\Delta\xi}{\left(\Delta\xi^2 + \eta^2\right)}\right\}$$

$$\alpha_3 = \frac{1}{4\eta_1\eta_2}, \alpha_4 = \frac{1}{2\left(\eta^2 + \Delta\xi^2\right)}, \; \varsigma_{1,2} = \xi_{1,2} + i\eta_{1,2}, \Delta\xi = \xi_2 - \xi_1, \eta = \eta_1 + \eta_2,$$

here η and ξ are the same as those in Eq. (123), and represent the velocities and amplitudes of the microscopic particle, $(a_0)_{1,2}$ the position, and $(\theta_0^{'})_{1,2}$ the phase. They are all determined by the initial conditions.

Of particular interest here is an initial pulse waveform,

$$\phi(0,x')=\sec h\left(x'-x_0^{'}\right)+\sec h\left(x'+x_0^{'}\right)e^{i\theta} \tag{127}$$

which represents the motion of two microscopic particles into the system. Equation (127) will evolve into two particles described by Eq.(126) The interaction between the two microscopic particles given in Eq.(127) can therefore be analyzed through the two-particle function in Eq.(126). Given the initial separation $x_0^{'}$, phase difference θ between the two microscopic particles, the eigenvalues $\varsigma_{1,2}$,a_0 and θ'_0 can be evaluated by solving the Zakharov and Shabat equation (194), using Eq.(128) as the initial condition. Substituting the eigenvalues obtained into Eq.(126), we then obtain the description of the interaction between the two microscopic particles.

The two microscopic particles described by Eq.(127) interact through a periodic potential in t', through the $\cos A'$ term. The period is given by $\pi/\left(\eta_2^2-\eta_1^2\right)$. The propagation of two microscopic particles with the initial conditions $\theta=0$, $\xi_1=\xi_2=0$, $(\theta_0^{'})_1=(\theta_0^{'})_2=0$, obtained by Desem and Chu[43-44] is shown in Fig.3. The two microscopic particles with initially separated by $x_0^{'}$ coalesce into one microscopic particle at $A'=\pi$. Then they separate and revert to the initial state with separation $x_0^{'}$ at $A'=\pi$, and so on. An approximate expression for the separation between the microscopic particles as a function of the distance along the system can be obtained provided the two microscopic particles are well resolved. Assuming that the separation between the particles is sufficiently large, one can obtain the separation Δx as $\Delta x=\ln\left[\frac{2}{a}\left|\cos(at')\right|\right], a=2e^{-x_0^{'}}$. Thus the period of oscillations is approximately given by $t_p^{'}=(\pi/2)e^{x_0^{'}}$.

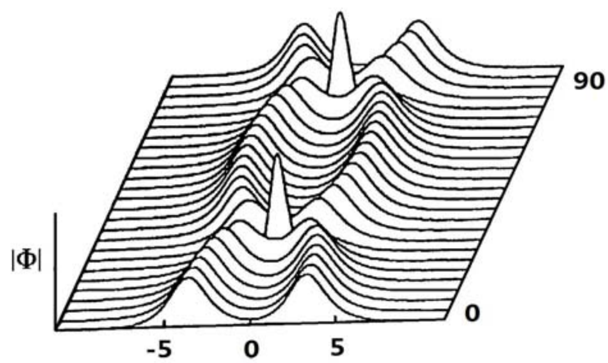


Fig. 3: Interaction with two equal amplitude microscopic particles. Initial microscopic particles separation=3.5 pulse width (pw)

The above collision features of the microscopic particle are obtained by using the inverse scattering method. However, the properties of collisions of microscopic particles can obtained by numerically solving Eq.(20). Numerical simulation can reveal more detailed feature of collision between two microscopic particles. For this purpose we begin by dividing Eq.(20) with V=constant into the following two-equations[45]

$$i\frac{\partial\phi'}{\partial t'}+\frac{\partial^2\phi'}{\partial x'^2}=\phi' u,\ \frac{\partial^2 u}{\partial t'^2}-\frac{\partial^2 u}{\partial x'^2}=\frac{\partial^2}{\partial x'^2}\left(|\phi'|^2\right). \tag{128}$$

Obviously, if $\xi_0=x'-vt'$ is assumed, we can get the nonlinear constant $b=1/\left(1-v^2\right)$ in Eq.(20) at $\lim_{|x'|\to\infty}\phi_{x'}^{'}=0$,where ϕ' represents the state of a microscopic particle, then u denotes a background field or other particles, b is related to the velocity of particle v. The soliton solution of (128) can now be written as

$$\phi'=\sqrt{2\left(1-v^2\right)}\eta\sec h\left[\eta\left(x'-x_0^{'}-vt'\right)\right]\exp\left[\frac{i}{2}vx'-i\left(\frac{v^2}{4}-\eta^2\right)t'+i\theta\right]$$

$$u=-2\eta^2\sec h^2\left[\eta\left(x'-x_0^{'}-vt'\right)\right].$$

The properties of the soliton depend on three parameters: η, v and θ, where η and v determine the amplitude and width of the particle, θ is the phase of the sinusoidal factor of ϕ' at $t'=0$. Tan et al.[45] carried out numerical simulation for the collision process between two particles using the Fourier pseudo-spectral method with 256 basis functions for the spatial discretization together with the fourth-order Runge-Kutta method for time-evolution. The system given in Eq.(128) has two exact integrals of motion, $N_s = \int_{-\infty}^{\infty} |\phi'|^2 dx'$ and $E_1 = \int_{-\infty}^{\infty} u dx'$, which can be used to check the accuracy of the numerical solutions.

For the collision experiments, the initial state is two solitary waves separated by distance x_0',

$$\phi' = \sqrt{2\left(1-v_1^2\right)}\eta_1 \sec h[\eta_1 x']\exp\left[\frac{i}{2}v_1 x' + i\theta_1\right] +$$

$$\sqrt{2\left(1-v_2^2\right)}\eta_2 \sec h\left[\eta_2\left(x'+x_0'\right)\right]\exp\left[-\frac{v^2}{2}\left(x_2'+x_0'\right)+i\theta_2\right],$$

$$u = -2\eta_1^2 \sec h^2\left(\eta_1 x'\right) - 2\eta_2^2 \sec h^2\left[\eta_2\left(x'+x_0'\right)\right].$$

where the first term in each expression represents one particle (1) while the second term represents the other particle(2). It can be shown that the post-collision state of the particles is strongly dependent on both the initial phases and the initial velocities of the particles. Since ϕ' can be multiplied by an arbitrary phase factor, $\exp\left(i\theta\%\right)$, where $\theta\%$ is an arbitrary constant, and still remains a solution (which u unchanged), one of the phases is arbitrary, and only the difference of the two initial phases is significant. Thus we can set $\theta_1 = 0$ for the convenience of discussion.

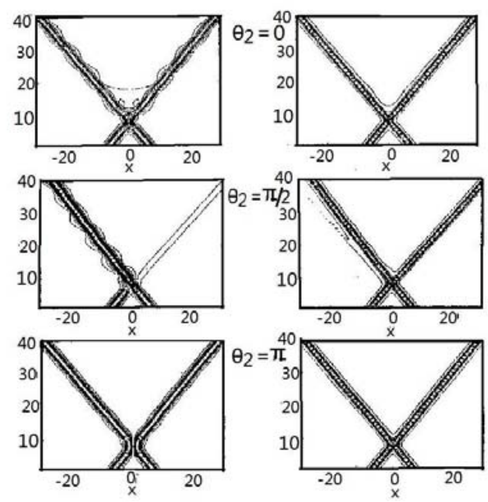


Fig. 4: Fast collisions of two microscopic particles. The initial ratio of velocities of the fast and slow particles to be1.8

Fig.4 shows the fast collisions obtained by Tan et al[45]., in which the initial ratio of velocities of the fast and slow particles is fixed to be 1.8. The absolute value of the ϕ' are shown using contours on the left in each pair of plots, with x' being the horizontal coordinate and t' increasing upward. The right panel shows the absolute value of u. The relative phase increases from 0 (top) to $\pi/2$ (middle) to π (bottom). All cases are identical except that θ_2 is increased by $\pi/2$ in each case, beginning with $\theta_2 = 0$ at the top. Before the collision, each of the initial particle contributes 0.7600 to N_s in all three cases ($\theta_2 = 0$, $\pi/2$ and π). When the relative phase is zero (top), the particles penetrate each other freely and then emerge with their shapes and velocity unchanged. When $\theta_2 = \pi/2$ (middle graphs), ϕ emerges from the collision asymmetrically, and a large particle which contributes 1.4272, moving to the left, at the same velocity as the initial speed of particle 2. Another small pulse, contributing 0.0928, travels to the right at the speed which is the same as the initial speed of particle 1. The post-collision energies are the same as those of pre-collision for ϕ' when $\theta_1 = 0$ and $\theta_2 = \pi$. For all values of θ_2, there is little change in the contributions of the particles in their u –field to energy E_1, and they are not shown here. When $\theta_2 = \pi$, as shown in the bottom panel of Fig.4, the u–components penetrate freely, but the ϕ'–components bounce off each other and change their directions, without interpenetration. The fourth case, $\theta_2 = 3\pi/2$, is not shown here because it is just the mirror image of the middle figure. That is

$$\phi'\left(x',t',\theta_2=\frac{3\pi}{2}\right)=\phi'\left(-x',t',\theta_2=\frac{\pi}{2}\right), \text{and } u\left(x',t',\theta_2=\frac{3\pi}{2}\right)=u\left(-x',t',\theta_2=\frac{\pi}{2}\right).$$

The same is true for intermediate and slow collisions processes. However, the reflection principle cannot be generalized to all solutions which are different in their initial phases by π because the cases of $\theta_2=0$ and $\theta_2=\pi$ are quite different in the general case.

Pang et al[46-48]. further simulated numerically the collision behaviors of two particles described nonlinear Schrodiger equation (20) at V(x)=constant using the fourth-order Runge_Kutta method. This result is shown in Fig.5. From figures 4-5, we see clearly that the two particles can go through each other while retaining their form after the collision, which is the same with that of the classical particles. Therefore, the microscopic particles depicted by the nonlinear SchrÖdinger equation (20) have an obvious corpuscle feature, their collision show the featuresof collision of classical particles. Thus we can conform that microscopic particles described by nonlinear SchrÖdinger equation.(20) has the corpuscle property.

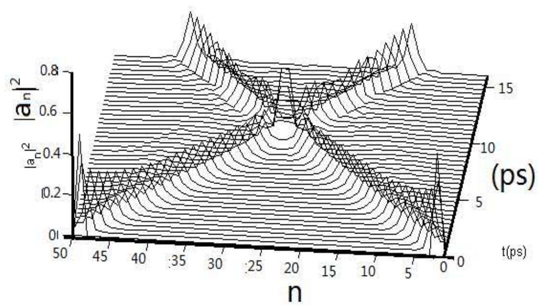


Fig. 5: The features of collision of microscopic particles

ii. *The rules of collision of microscopic particle at b<0 in Eq.(20)*

As known, in the case of $b<0$ the equation (20) has still soliton solution, when $\lim_{|x'|\to\infty}\left|\phi\left(x',t'\right)\right|^2 \to$ constant, and $\lim_{|x'|\to\infty}\phi_{x'}=0$. The solutions are dark (hole) solitons, in contrast to the bright soliton when $b>0$. The bright soliton was observed experimentally in focusing fibers with negative dispersion, and the hole soliton solution was observed in defocusing fibers with normal dispersion effect by Emplit *et al*. and Krokel. In practice, it is an empty state without matter in microscopic world. Therefore $b>0$ corresponds to attractive between Bose particles, and $b<0$ corresponds to repulsive interaction between them. Thus, reversing the sign of *b* not only leads to changes in the physical picture of the phenomenon described by the nonlinear SchrÖdinger equation (20), but also requires considerable restructuring of the mathematical formalism for its solution. Solution of the nonlinear SchrÖdinger equation must be again analyzed and the collision rules of the microscopic particles in the case of $b<0$ must be studied separately using the inverse scattering method. Zakharov and Shabat[25-26] studied these problems. The soliton solution in such a case can be represented by

$$\frac{b}{2}|\phi(x',t')|^2 = 1-\frac{\nu^2}{\cosh^2[\nu(x'-x_0'-2\lambda t')]}$$

The parameter λ characterizes the amplitude ans velocity of the microscopic particles, and x_0' the position of its centre at t'=0, where $d(\ln\mu)/dt'=2\lambda\nu$ or $\ln\mu=2\nu(x_0'+2\lambda t')$.

They studied further the features of collision described by the above formula. The displacements of the two microscopic particles after the collision were found to be

$$\delta x_1' = \frac{1}{2v_1}\ln\left(\frac{b_1^+}{b_1^-}\right)=\frac{1}{2v_1}\ln\left(\frac{1}{\left|a_2\left(\lambda_1,iv_1\right)\right|^2}\right)=\frac{Y}{2v_1},$$

$$\delta x_2' = \frac{1}{2v_1}\ln\left(\frac{b_2^+}{b_2^-}\right)=\frac{1}{2v_1}\ln\left(\left|a_1\left(\lambda_2,iv_2\right)\right|^2\right)=-\frac{Y}{2v_2}, \qquad (129)$$

where $Y = \ln\left[\frac{(\lambda_1-\lambda_2)^2+(v_1+v_2)^2}{(\lambda_1-\lambda_2)^2+(v_1-v_2)^2}\right]$.

Thus, the microscopic particle which has the greater velocity acquires a positive shift, and the other has only a negative shift. The microscopic particles behave like repelling each other of classical particles. From (129) we get[25-26]

$$v_1\delta x_1' + v_2\delta x_2' = 0.$$

This relation was also obtained by Tsuzuki directly from Eq.(20) for $b<0$ by analyzing the motion of the center of mass of a Bose gas. It can be interpreted as the conservation of mass centre of the microscopic particles during the collision. This shows sufficiently the classical feature of microscopic particles described by Eq.(20).

The collision of many particles can be studied similarly. The result obtained shows that in the case of $t'\to-\infty$ the slowest soliton is in the front while the fastest at the rear, faster microscopic particle tracks the slower microscopic particle, they collide with each other at t'=0, after the collision and $t'\to\infty$, they are just reversed. So that each particle collides with each other particle. Going through the same analysis given above, we can verify that the total displacement of a particle, regardless of the details of the collisions, is equal to the sum of the displacements in individual collisions[25-26], i.e., $\delta_j = x_j'^{+} - x_j'^{-} = \sum_{i=1}\delta_{ij}$

where $\delta_{ij} = sign(\lambda_i-\lambda_j)\frac{1}{2v_i}\ln\left[\frac{(\lambda_i-\lambda_j)^2+(v_i+v_j)^2}{(\lambda_i-\lambda_j)^2+(v_i-v_j)^2}\right]$.

From the above studies we see that collisions of many microscopic particles described by the nonlinear SchrÖdinger equation (20), with both $b>0$ or $b<0$, satisfy rules of classical physics. This shows sufficiently the corpuscle feature of microscopic particles described by nonlinear SchrÖdinger equation.

iii. *The mechanism and properties of collision of microscopic particles at b<0*

In the following, we describe a series of laboratory and numerical experiments dedicated to investigate the detailed structure, mechanism and rules of collision between the microscopic particles described by the nonlinear Schrödinger equation (20) at b<0 . The properties and rules of such collision between two microscopic particles have been first studied by Aossey *et al*.[49]. Both the phase shift of the microscopic particles after their interaction and the range of the interaction are functions of the relative amplitude of the two colliding microscopic particles. The microscopic particles preserve the shape after the collision.

In accordance with Asossey et al's[49] representation the hole-particle or dark spatial soliton of Eq.(26) in the case of $b<0$ [26-27] is now given by

$$\phi(x',t') = \phi_0\sqrt{1-B^2\operatorname{sech}^2(\xi')}\,e^{\pm i\Theta\xi'} \tag{130}$$

where

$$\Theta(\xi') = \sin^{-1}\left[\frac{B\tanh(\xi')}{\sqrt{1-B^2\operatorname{sech}^2(\xi')}}\right], \xi' = \mu(x'-\upsilon_t t')$$

Here, B is a measure of the amplitude ("blackness") of the solitary wave (hole or dark soliton) and can take a value between -1 and 1, υ_t is the dimensionless transverse velocity of the particle center, and μ is the shape factor of the particle. The intensity (I_d) of the solitary wave (or the depth of the irradiance minimum of the dark soliton) is given by $B^2\phi_0^2$. Aossey *et al.* showed that the shape factor μ and the transverse velocity υ_t are related to the amplitude of the particles, which can be obtained from the nonlinear *Schrödinger* equation in the optical fiber to be

$$\mu^2 = n_0|n_2|\mu_0^2B^2\phi_0^2, \upsilon_t \approx \pm\sqrt{(1-B^2)\frac{|n_2|\phi_0^2}{n_0}}$$

where n_0 and n_2 are the linear and nonlinear indices of refraction for the optical fiber material. We have assumed $|n_2|\phi_0^2 \ll n_0$. When two microscopic particles described by Eq.(26) collide, their individual phase shifts are given by

$$\delta x_j = \sqrt{\frac{n_0}{|n_2|\phi_0^2}}\frac{1}{2\mu_0 n_0 B_j}\ln\left[\frac{\left(\sqrt{1-B_1^2}+\sqrt{1-B_2^2}\right)^2+\left(B_1+B_2\right)^2}{\left(\sqrt{1-B_1^2}+\sqrt{1-B_2^2}\right)^2+\left(B_1-B_2\right)^2}\right] \tag{131}$$

The interaction of microscopic particles can be easily investigated numerically by using a split- step propagation algorithm, which was found, by Thusrston *et al.* [50], to closely predict experimental results. The results of a simulated collision between two equi-amplitude microscopic particles are shown in Fig.6 (a), which are similar to that of general microscopic particles (bright solitons) as shown in Fig.5. We note that the two particles interpenetrate each other, retain their shape, energy and momentum, but experience a phase shift at the point of collision. In addition, there is also a well- defined interaction length in z along the axis of time t that depends on the relative amplitude of two colliding microscopic particles. This case occurs also in the collision of two KdV solitons[51-52]. Cooney *et al*.[51] studied the overtaking collision, to verify the KdV soliton nature of an observed signal in the plasma experiment. In the following, we discuss a fairly simple model which was used to simulate and to interpret the experimental results on the microscopic particles described by nonlinear SchrÖdinger equation (26) at b<0 and KdV solitons.

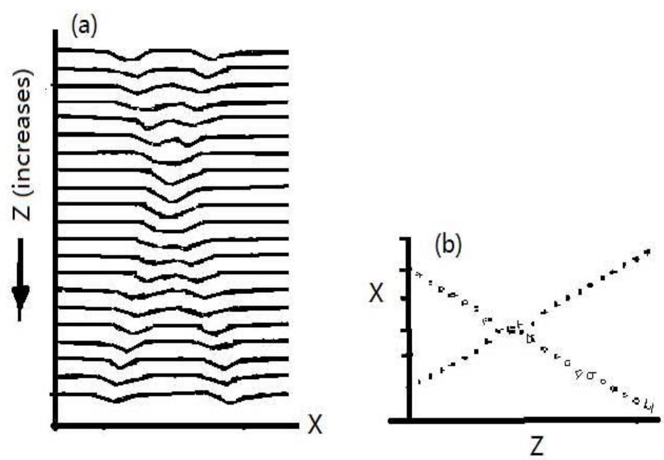


Fig. 6: Numerical simulation of an overtaking collision of equi-amplitude dark particles. (a) Sequence of the waves at equal intervals in the longitudinal position z. (b) Time-of-flight diagrams of the signal

The model is based on the fundamental property of solitons that two microscopic particles can interact and collide, but survive the collision and remain unchanged. Rather than using the exact functional form of $\mathrm{sech}\,\xi$ for microscopic particles described by Eq.(26), the microscopic particles are represented by rectangular pulses with an amplitude A_j and a width W_j where the subscript j denotes the jth microscopic particles. An evolution of the collision of two microscopic particles is shown in Fig.7(a). In this case, Aossey *et al.* [49] considered two microscopic particles with different amplitudes. The details of what occurs during the collision need not concern us here other than to note that the microscopic particles with the larger-amplitude has completely passed through the one with the smaller amplitude. In regions which can be considered external to the collision, the microscopic particles do not overlap as there is no longer an interaction between them. The microscopic particles are separated by a distance, $D = D_1 + D_2$, after the interaction. This manifests itself in a phase shift in the trajectories depicted in Fig. 7(b). This was noted in the experimental and numerical results. The minimum distance is given by the half-widths of the two.

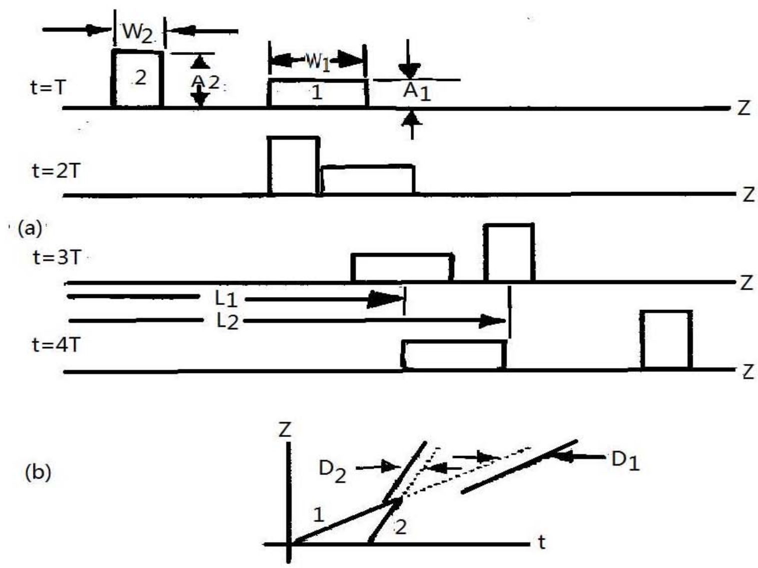


Fig. 7: Overtaking collision of two microscopic particles. (a) Model of the interaction just prior to the collision and just after the collision. After the collision, the two microscopic particles are shifted in phase. (b) Time-of-light diagram of the signals. The phase shifts are indicated

microscopic particles, $D \geq W_1/2 + W_2/2$. Therefore,

$$D_1 \geq \frac{W_1}{2} \text{ and } D_2 \geq \frac{W_2}{2} \tag{132}$$

Another property of the microscopic particles is that their amplitude and width are related. For the microscopic particles described by the nonlinear *Schrödinger* equation with $b < 0$ in Eq. (26) ($W \approx 1/\mu$), we have

$$B_j W_j = \text{constant}=K_1 \tag{133}$$

Using the minimum values in Eq.(132), we find that the ratio of the repulsive shifts for the microscopic particles described by the nonlinear *Schrödinger* equation (26) is given by

$$\frac{D_1}{D_2} = \frac{B_2}{B_1} \tag{134}$$

Results obtained from simulation of the kind of microscopic particle are presented in Fig. 6(a). The solid line in the figure corresponds to Eq.(134).

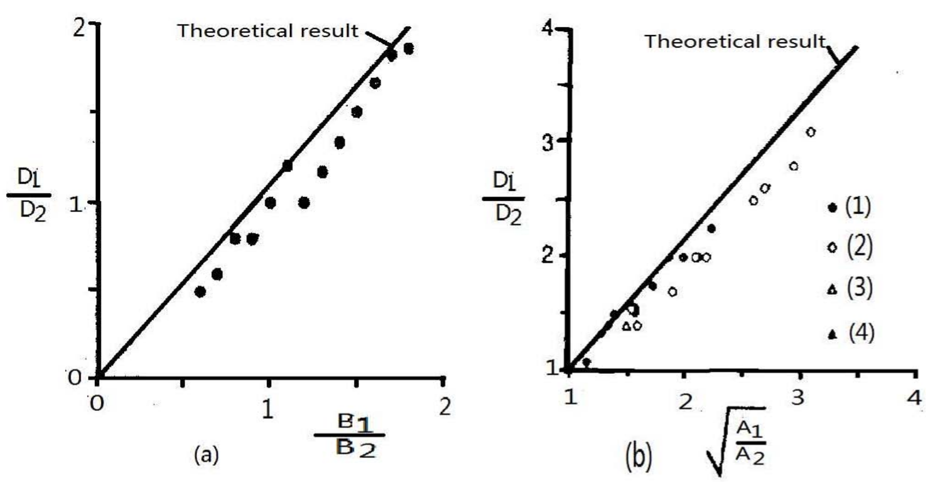


Fig. 8: Summary of the ratio of the measured phase shifts as a function of the ratio of amplitudes. (a) The particle in Eq.(26) at b<0, the solid line corresponds to Eq.(131). (b) KdV solitons, the data are from (1) this experiment, (2) Zabusky et al. [52], (3) Lamb's[41] and (4) Ikezi et al.'s [54] results. The solid line corresponds to Eq.(138)

In addition to predicting the phase shift that results from the collision of two microscopic particles, the model also allows us to estimate the size of the collision region or duration of the collision. Each microscopic particles depicted in Fig.6 travels with its own amplitude-dependent velocity υ_j. For the two microscopic particles to interchange their positions during a time ΔT, they must travel a distance L_1 and L_2,

$$L_1 = \upsilon_1 \Delta T \text{ and } L_2 = \upsilon_2 \Delta T \tag{135}$$

The interaction length must then satisfy the relation

$$L = L_2 - L_1 = \left(\upsilon_2 - \upsilon_1\right) \Delta T \approx W_1 + W_2 \tag{136}$$

Equation (135) can be written in terms of the amplitudes of the two microscopic particles. For the particle in Eq.(26) at b<0, combining Eqs. (132) and (136), Aossay *et al.* obtained

$$L \geq K_1 \left[\frac{1}{B_1} + \frac{1}{B_2} \right] \tag{137}$$

In Fig. 8(a), the results for the microscopic particles in Eq.(26) at b<0 are presented. The dashed line corresponds to Eq. (137) with $B_2 = 1$ and $K_1 = 6$. The interaction time (solid line) is the sum of the widths of the two microscopic particles, minus their repulsive phase shifts, and multiplied by the transverse velocity of microscopic particles 1. Since the longitudinal velocity is a constant, this scales as the interaction length. From the figure, we see that the theoretical result obtained using the simple collision model is in good agreement with that of the numerical simulation.

The discussion presented above and the corresponding formulae reveal the mechanism and rule of the collision between microscopic particles depicted by nonlinear SchrÖdinger equation (26) at b<0.

To verify the validity of this simple collision model, Aossey *et al.* studied the collision of the solitons using the exact form of $sec\,h^2\xi$ for the KdV equation, $u_t + uu_x + d'u_{xxx} = 0$, and the collision model shown in Fig.6. For the KdV soliton they found that

$$A_j \left(W_j\right)^2 = \text{cons}\tan t = K_2 \text{ and } \frac{D_1}{D_2} = \frac{W_1/2}{W_2/2} = \sqrt{\frac{A_2}{A_1}} \tag{138}$$

where A_j and W_j are the amplitude and width of the jth KdV soliton, respectively. Corresponding to the above, Aossey *et al.* obtained

$$L \geq K_2 \left(\frac{1}{\sqrt{A_1}} + \frac{1}{\sqrt{A_2}} \right) = \frac{K_2}{\sqrt{A_1}} \left(1 + \sqrt{\frac{A_1}{A_2}} \right) \tag{139}$$

for the interaction length.

Aossey *et al.*[49]compared their results for the ratio of the phase shifts as a function of the ratio of the amplitudes for the KdV solitons, with those obtained in the experiments of Ikezi, Taylor, and Baker[53], and those obtained from numerical work of Zabusky and Kruskal[52] and Lamb[54], as shown in Fig.7(b). The solid line in Fig. 7(b) corresponds to Eq. (138). Results obtained by Aossey *et al.* for the interaction length are shown in Fig. 8(b) as a function of amplitudes of the colliding KdV solitons. Numerical results (which were scaled) from Zabusky and Kruskal are also shown for comparison. The dashed line in Fig. 8(b) corresponds to Eq. (139), with $A_1 = l$ and $K_2 = l$.

Since the theoretical results obtained by the collision model based on macroscopic bodies in Fig.6 are consistent with experimental data for the KdV soliton, shown in Figs. 7(b) and 8(b), it is reasonable to believe the validity of the above theoretic results of model of collision presented above , and results shown in Figs.7(a) and 8(a) for the microscopic particles described in the nonlinear Schrödinger equation (26) which are obtained using the same model as that shown in Fig 6. Thus, the above colliding mechanism for the microscopic particles shows clearly the corpuscle feature of the microscopic particles is described by nonlinear SchrÖdinger equation.

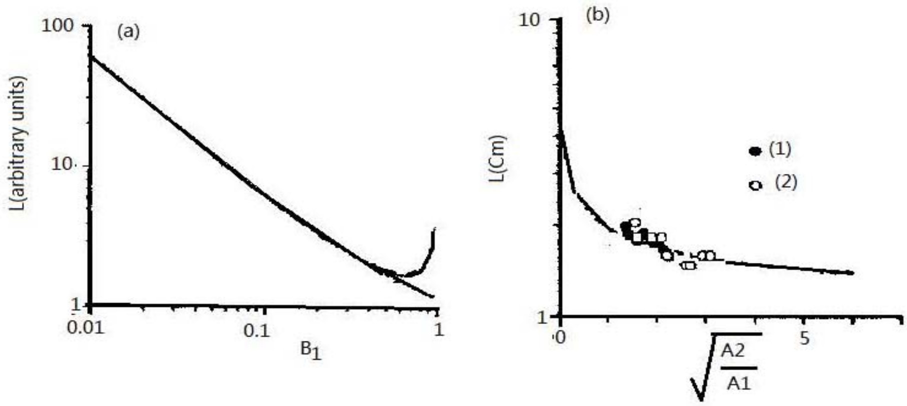


Fig. 9: Summary of the measured interaction length as a function of the amplitudes. **(a)** The particles described by Eq.(26) at b<0, the dashed line corresponds to Eq. (134) with $B_2 = 1$ and $K_1 = 6$. **(b)** KdV solitons, the symbols represent (1) experiment results of Ikezi et al., and (2) numerical results of Zabusky *et al.* [31]. The dashed line corresponds to Eq. (136) with $K_2 = A_1 = 1$

g) The uncertainty relationship obeyed for microscopic particles

i. Correct form of uncertainty relation in the quantum mechanics

As known, in quantum mechanics the microscopic particle has not a determinant position, disperses always in total space, the probability occurring at each points in the space is represented by square of the wave function. Thus the position and momentum of the particles cannot be simultaneously determined. This means that there is an uncertainty relationship between the position and momentum, then the values of mechanical quantities of the particles are only denoted by some statistical average values of the wave function, etc.. These concepts are considerably inconsistent with conventional knowledge to particles and result in a long-term controversies of one century on its essences and explanations in physics, which have not an unitary conclusion up to now. Therefore, we feel especially perplexity to the uncertainty relationship, which is a persistent ailment in quantum physics we may say. Whether is the uncertainty relationship an intrinsic feature of microscopic particles or caused by the quantum measurement? This problem is not clear as yet[8-12]. Therefore, to clarify the essence of uncertainty relationship is a most challenging problem in physics. Obviously, it is closely related to elementary features of microscopic particles.

As known, the uncertainty relation in the quantum mechanics can be obtained from [1-6]

$$I(\xi) = \int \left| \left(\xi \Delta \hat{A} + i \Delta \hat{B} \right) \psi(\vec{r},t) \right|^2 d\vec{r} \geq 0 \tag{140}$$

or

$$\bar{\hat{F}}(\xi) = \int \psi^*(\vec{r},t) \hat{F}\left[\hat{A}(\vec{r},t), \hat{B}(\vec{r},t) \right] \psi(\vec{r},t) d\vec{r}$$

In the coordinate representation, $\vec{A}$ and $\vec{B}$ are operators of two physical quantities, for example, position and momentum, or energy and time, and satisfy the commutation relation $\left[\hat{A}, \hat{B} \right] = i\hat{C}$, $\psi(x,t)$ and $\psi^*(x,t)$ are wave functions of the microscopic particle satisfying the linear Schro- dinger equation(7) and its conjugate equation, respectively, $\hat{F} = \left(\Delta A \xi + \Delta B \right)^2$, ($\Delta\hat{A} = \hat{A} - \bar{A}$, $\Delta\hat{B} = \hat{B} - \bar{B}$, $\bar{A}$ and $\bar{B}$ are the average values of the physical quantities in the state denoted by $\psi(x,t)$), is an operator of physical quantity related to $\bar{A}$ and $\bar{B}$, ξ is a real parameter.

After some simplifications, we can get

$$I = \bar{F} = \overline{\Delta\hat{A}^2}\xi^2 + 2\overline{\Delta A \Delta \hat{B}}\xi + \overline{\Delta B^2} \geq 0$$

or

$$\overline{\Delta\hat{A}^2}\xi^2 + \bar{C}\xi + \overline{\Delta\hat{B}^2} \geq 0 \tag{141}$$

Using mathematical identities, this can be written as

$$\overline{\Delta\hat{A}^2}\,\overline{\Delta\hat{B}^2} \geq \frac{\bar{\hat{C}}^2}{4} \tag{142}$$

This is the uncertainty relation in the quantum mechanics. From the above derivation we see that the uncertainty relation was obtained based on the fundamental hypotheses of linear quantum mechanics, including properties of operators of the mechanical quantities, the state of particle represented by the wave function, which satisfies the linear Schrödinger equation (7), the concept of average values of mechanical quantities and the commutation relations and eigenequation of operators. Therefore, we can conclude that the uncertainty relation Eq. (142) is a necessary result of the quantum mechanics. Since the quantum mechanics only describes the wave nature of microscopic particles, the uncertainty relation is a result of the wave feature of microscopic particles, and it inherits the wave nature of microscopic particles. This is why its coordinate and momentum cannot be determined simultaneously. This is an essential interpretation for the uncertainty relation Eq. (142) in quantum mechanics. It is not related to measurement, but closely related to the quantum mechanics. In other words, if quantum mechanics could correctly describe the states of microscopic particles, then the uncertainty relation should also reflect the peculiarities of microscopic particles.

Equation (141) can be written in the following form:

$$\hat{\hat{F}}=\overline{\Delta\hat{A}^2}\left(\xi+\frac{\overline{\Delta\hat{A}\Delta\hat{B}}}{\overline{\Delta\hat{\hat{A}}^2}}\right)^2+\overline{\Delta B^2}-\frac{\left(\overline{\Delta\hat{A}\Delta\hat{B}}\right)^2}{\overline{\overline{\Delta A^2}}}\geq 0$$

or

$$\overline{\Delta\hat{A}^2}\left(\xi+\frac{\bar{\hat{C}}}{4\overline{\overline{\Delta\hat{\hat{A}}^2}}}\right)^2+\overline{\Delta\hat{B}^2}-\frac{\left(\bar{\hat{C}}\right)^2}{4\overline{\overline{\Delta A^2}}}\geq 0 \tag{143}$$

This shows that $\overline{\Delta\hat{A}^2}\neq 0$, if $\left(\overline{\Delta\hat{A}\Delta\hat{B}}\right)^2$ or $\bar{\hat{C}}^2/4$ is not zero, else, we cannot obtain Eq.(142) and $\overline{\Delta\hat{A}^2}\,\overline{\Delta\hat{B}^2} > \left(\overline{\Delta A\Delta B}\right)^2$ because when $\overline{\Delta\hat{A}^2}=0$, Eq. (143) does not hold. Therefore, $\overline{\left(\Delta\hat{A}^2\right)}\neq 0$ is a necessary condition for the uncertainty relation Eq. (142), $\overline{\Delta\hat{A}^2}$ can approach zero, but cannot be equal to zero. Therefore, in the quantum mechanics, the right uncertainty relation should take the form [18]:

$$\overline{\Delta\hat{A}^2\Delta\hat{B}^2} > \frac{\left(\bar{\hat{C}}^2\right)^2}{4} \tag{144}$$

ii. *The new uncertainty relation of microscopic particles described by nonlinear SchrÖdinger equation*

We now return to study the uncertainty relation of microscopic particles described nonlinear SchrÖdinger equation (20). In such a case the microscopic particles is a soliton and has a wave- corpuscle duality. Thus we have the reasons to believe that the uncertainty relation in this case should be different from that in the quantum theory given above.

We now derive this relation for position and momentum of a microscopic particle depicted by the nonlinear SchrÖdinger Equation (26) with a solution, ϕ_s, as given in Eq.(34), which is now represented by[25-26]

$$\phi_s(x',t') = 2\sqrt{2}\eta\,\mathrm{sech}\{2\eta(x'-x_0')-8\eta\xi t'\}\exp\{2i\xi x'-i4(\xi^2-\eta^2)t'+i\theta\} \tag{145}$$

where $x'=x\sqrt{2m}/\hbar, t'=t/\hbar$, $2\sqrt{2}\eta$ is the amplitude, $2\sqrt{2}\xi$ denotes the velocity, θ is a constant. The function $\phi_s\left(x',t'\right)$ is a square integral function localized at $x_0'=0$ in the coordinate space. If the microscopic particle is localized at $x_0'\neq 0$. The Fourier transform of this function is

$$\phi_s\left(p,t'\right)=\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty}\phi_s\left(x',t'\right)e^{-ipx'} \tag{146}$$

It shows that $\phi_s\left(p,t^{'}\right)$ is localized at p in momentum space. For Eq.(146), the Fourier transform is explicitly given by

$$\phi_s\left(p,t^{'}\right)=\sqrt{\frac{\pi}{2}}\operatorname{sech}\left[\frac{\pi}{4\sqrt{2\eta}}\left(p-2\sqrt{2}\xi\right)\right]\exp\{i4(\eta^2+\xi^2-p\xi/2\sqrt{2})t^{'}-i\left(p-2\sqrt{2}\xi\right)x_0^{'}+i\theta\} \quad (147)$$

The results in Eqs. (146) and (147) show that the microscopic particle is localized not only in position space in the shape of soliton, but also in the momentum space in a soliton. For convenience, we introduce the normalization coefficient B_0 in Eqs. (145) and (147), then obviously $B_o^2=\frac{1}{4\sqrt{2}}\eta$, the position of the certain of mass of the microscopic particle, $\left\langle x^{'}\right\rangle$, and its square, $\left\langle x'^2\right\rangle, at \quad t'=0$ are given by

$$\left\langle x'\right\rangle=\int_{-\infty}^{\infty}dx'\left|\phi_s\left(x'\right)\right|^2, \quad \left\langle x'^2\right\rangle=\int_{-\infty}^{\infty}dx'x'^2\left|\phi_s\left(x'\right)\right|^2. \quad (148)$$

We can thus find that

$$\left\langle x'\right\rangle=4\sqrt{2}\eta A_0^2x_0^{'}, \quad \left\langle x'^2\right\rangle=\frac{A_0^2\pi^2}{12\sqrt{2}\eta}+4\sqrt{2}A_0^2\eta x_0^{'2} \quad (149)$$

respectively. Similarly, the momentum of the center of mass of the microscopic particle, $\left\langle p\right\rangle$, and its square , $\left\langle p^2\right\rangle$, are given by

$$\left\langle p\right\rangle=\int_{-\infty}^{\infty}p\left|\hat{\phi}_s\left(p\right)\right|^2dp, \quad \left\langle p^2\right\rangle=\int_{-\infty}^{\infty}p^2\left|\hat{\phi}_s\left(p\right)\right|^2dp \quad (150)$$

which yield

$$\left\langle p\right\rangle=16A_0^2\eta\xi, \quad \left\langle p^2\right\rangle=\frac{32\sqrt{2}}{3}A_0^2\eta^3+32\sqrt{2}A_0^2\eta\xi^3 \quad (151)$$

The standard deviations of position $\Delta x'=\sqrt{\left\langle x'^2\right\rangle-\left\langle x'\right\rangle^2}$ and momentum $\Delta p=\sqrt{\left\langle p^2\right\rangle-\left\langle p\right\rangle^2}$ are given by

$$\left(\Delta x'\right)^2=A_0^2\left[\frac{\pi^2}{12\eta}+4\eta x_0^{'2}\left(1-4\sqrt{2}\eta A_0^2\right)\right]=\frac{\pi^2}{96\eta^2},$$
$$\left(\Delta p\right)^2=32\sqrt{2}A_0^2\left[\frac{1}{3}\eta^3+\eta\xi^3\left(1-4\sqrt{2}\eta A_0^2\right)\right]=\frac{8}{3}\eta^2, \quad (152)$$

respectively. Thus we obtain the uncertainty relation between position and momentum for the microscopic particle depicted by nonlinear SchrÖdinger equation in Eq.(26)

$$\Delta x'\Delta p=\frac{\pi}{6} \quad (153)$$

This result is not related to the features of the microscopic particle (soliton) depicted by the nonlinear SchrÖdinger equation because Eq. (153) has nothing to do with characteristic parameters of the nonlinear SchrÖdinger equation. π in Eq. (153) comes from of the integral coefficient $1/\sqrt{2\pi}$. For a quantized microscopic particle, π in Eq. (153) should be replaced by $\pi\hbar$, because Eq. (147) is replaced by

$$\phi_s\left(p,t'\right)=\frac{1}{\sqrt{2\pi\hbar}}\int_{-\infty}^{\infty}dx'\phi_s\left(x',t'\right)e^{-ipx'/\hbar}. \quad (154)$$

The corresponding uncertainty relation of the quantum microscopic particle is given by

$$\Delta x \Delta p = \frac{\pi \hbar}{6} = \frac{h}{12} \tag{155}$$

The uncertainty relation in Eq.(155) or Eq.(153) differ from the $\Delta x \Delta p > h/2$ in the quantum mechanics Eq.(144). However, the minimum value $\Delta x \Delta p = h/2$ has not been both obtained from the solutions of linear SchrÖdinger equation and observed in practical quantum mechanical systems up to now except for the coherent and squeezed states of microscopic particles.

Therefore we can draw a conclusion that the minimum uncertainty relationship is a nonlinear effect, instead of linear effect, and a result of wave-corpuscle duality. From this result we see that when the motion of the particles satisfies $\Delta x \Delta p > h/2 \ or \ \pi/6$, the particles obey laws of motion in quantum mechanics, and the particles are some waves. When the motion of the particles satisfies $\Delta x \Delta p = h/12 \ or \ \pi/6$, the particles should be described by nonlinear SchrÖdinger equation, and have wave-corpuscle duality. If the position and momentum of the particles satisfies $\Delta x \Delta p = 0$, then this is the feature of classical particles with only a corpuscle feature. Therefore, the theory established by nonlinear SchrÖdinger equation bridges the gap between the classical and linear quantum mechanics. Therefore to study the properties of microscopic particles described by nonlinear SchrÖdinger equation has important significances in physics.

iii. *The uncertainty relations of the coherent states*

As a matter of fact, we can represent one-quantum coherent state of harmonic oscillator by [18-19]

$$\left|\alpha\right\rangle = \exp\left(\alpha \hat{b}^{+} - \alpha^{*}\hat{b}\right)\left|0\right\rangle = e^{-\alpha^{2}/2}\sum_{n=0}^{\infty}\frac{\alpha^{n}}{\sqrt{n-1}}\hat{b}^{+n}\left|0\right\rangle,$$

in the number picture, which is a coherent superposition of a large number of microscopic particles (quanta). Thus

$$\left\langle\alpha\left|\hat{x}\right|\alpha\right\rangle = \sqrt{\frac{\hbar}{2\omega m}}\left(\alpha+\alpha^{*}\right), \quad \left\langle\alpha\left|\hat{p}\right|\alpha\right\rangle = i\sqrt{\hbar m\omega}\left(\alpha-\alpha^{*}\right)$$

and

$$\left\langle\alpha\left|\hat{x}^{2}\right|\alpha\right\rangle = \frac{\hbar}{2\omega m}\left(\alpha^{*2}+\alpha^{2}+2\alpha\alpha^{*}+1\right), \quad \left\langle\alpha\left|\hat{p}^{2}\right|\alpha\right\rangle = \frac{\hbar\omega m}{2}\left(\alpha^{*2}+\alpha^{2}-2\alpha\alpha^{*}-1\right),$$

where

$$\hat{x} = \sqrt{\frac{\hbar}{2\omega m}}\left(\hat{b}+\hat{b}^{+}\right), \quad \hat{p} = i\sqrt{\frac{\hbar\omega m}{2}}\left(\hat{b}^{+}-\hat{b}\right),$$

and $\hat{b}^{+}\left(\hat{b}\right)$ is the creation (annihilation) operator of microscopic particle (quantum), α and α^{*} are some unknown functions, ω is the frequency of the particle, m is its mass. Thus we can get

$$\left(\Delta x\right)^{2} = \frac{\hbar}{2\omega m}, \quad \left(\Delta p\right)^{2} = \frac{\hbar\omega m}{2}, \quad \left\langle\Delta x\right\rangle^{2}\left\langle\Delta p\right\rangle^{2} = \frac{h^{2}}{4} \tag{156}$$

$$\frac{\Delta x}{\Delta p} = \frac{1}{\omega m}, \text{ or } \Delta p = \left(\omega m\right)\Delta x$$

For the squeezed state of the microscopic particle: $\left|\beta\right\rangle = \exp\left[\beta\left(b^{+2}-b^{2}\right)\right]\left|0\right\rangle$, which is a two quanta coherent state, we can find that

$$\left\langle\beta\left|\Delta x^{2}\right|\beta\right\rangle = \frac{\hbar}{2m\omega}e^{4\beta}, \left\langle\beta\left|\Delta p^{2}\right|\beta\right\rangle = \frac{\hbar m\omega}{2}e^{-4\beta},$$

using a similar approach as the above . Here β is the squeezed coefficient and $\left|\beta\right| < 1$. Thus,

$$\Delta x \Delta p = \frac{h}{2}, \quad \frac{\Delta x}{\Delta p} = \frac{1}{m\omega}e^{8\beta}, \text{ or } \Delta p = \Delta x\left(\omega m\right)e^{-8\beta} \tag{157}$$

This shows that the momentum of the microscopic particle (quantum) is squeezed in the two-quanta coherent state compared to that in the one-quantum coherent state.

From the above results, we see that both one-quantum and two-quanta coherent states satisfy the minimal uncertainty principle. This is the same with the above result of the microscopic particle described by nonlinear SchrÖdinger equation (20). We can conclude that a coherent state is a kind of nonlinear quantum effect, at the same time, the coherence of quanta is a nonlinear phenomenon, instead of a linear effect.

As is known, the coherent state satisfies the classical equation of motion, in which the fluctuation in the number of particles approaches zero, which is a classically steady wave. In fact, according to quantum theory, the coherent state of a harmonic oscillator at time t can be represented by

$$|\alpha,t\rangle = e^{-i\hat{H}t}|\alpha\rangle = e^{-i\hbar\omega(\hat{b}^{+}\hat{b}+1/2)t}|\alpha\rangle = e^{-i\hbar\omega t/2-|\alpha|^2/2}\sum_{n=0}^{\infty}\frac{\alpha^n e^{-i\hbar n\omega t}}{\sqrt{n!}}|n\rangle$$

$$= e^{-i\hbar\omega t/2}\left|\alpha e^{-i\hbar\omega t}\right\rangle, \quad \left(|n\rangle = (b^{+})^{n}|0\rangle\right)$$

This shows that the shape of a coherent state can be retained during its motion. This is the same as that of a microscopic particle (soliton). The mean position of the particle in the time-dependent coherent state is

$$\langle\alpha,t|x|\alpha,t\rangle = \langle\alpha|e^{iHt/\hbar}xe^{-iHt/\hbar}|\alpha\rangle = \left\langle\alpha\left|x-\frac{it}{h}[x,H]+\frac{(-it)^2}{2!\hbar^2}[[x,H],H]+\cdots\right|\alpha\right\rangle$$

$$= \left\langle\alpha\left|x+\frac{pt}{m}-\frac{1}{2!}t^2\omega^2x+\cdots\right|\alpha\right\rangle = \left\langle\alpha\left|x\cos\omega t+\frac{p}{m\omega}\sin\omega t\right|\alpha\right\rangle = \sqrt{\frac{2\hbar}{m\omega}}|\alpha|\cos(\omega t+\theta) \qquad (158)$$

where $\theta = \tan^{-1}\left(\frac{y}{x}\right)$, $x+iy=\alpha$, $[x,H]=\frac{i\hbar p}{m}$, $\quad [p,H] = -i\hbar m\omega^2 x.$

Comparing (95) with the solution of a classical harmonic oscillator

$$x=\sqrt{\frac{2E}{m\omega^2}}\cos(\omega t+\theta), \qquad E=\frac{p^2}{2m}+\frac{1}{2}m\omega^2x^2$$

we find that they are similar with

$$E = \hbar\omega\alpha^2 = \langle\alpha|H|\alpha\rangle - \langle 0|H|0\rangle, \quad H=\hbar\omega\left(b^{+}b+\frac{1}{2}\right).$$

Thus, we can say that the mass center of the coherent state-packet indeed obeys the classical law of motion, which is the same as the law of motion of microscopic particles described by nonlinear SchrÖdinger equation discussed in Eqs. (111).

We can similarly obtain

$$\langle\alpha,t|p|\alpha,t\rangle = -\sqrt{2m\hbar\omega}|\alpha|\sin(\omega t+\theta), \langle\alpha,t|x^2|\alpha,t\rangle = \frac{2\hbar}{\omega m}\left[|\alpha|^2\cos^2(\omega t+\theta)+\frac{1}{4}\right],$$

$$\langle\alpha,t|p^2|\alpha,t\rangle = 2m\hbar\omega\left[|\alpha|^2\sin^2(\omega t+\theta)+\frac{1}{4}\right]$$

and

$$[\Delta x(t)]^2 = \frac{\hbar}{2\omega m}, \quad [\Delta p(t)]^2 = \frac{1}{2}m\omega\hbar, \Delta x(t)\Delta p(t) = \frac{h}{2} \qquad (159)$$

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This is the same with Eq. (155). It shows that the minimal uncertainty principle for the coherent state is retained at all times, *i.e.*, the uncertainty relation does not change with time t.

The mean number of quanta in the coherent state is given by

$$\bar{n}=\langle\alpha|\hat{N}|\alpha\rangle=\langle\alpha|\hat{b}^{+}b|\alpha\rangle=\alpha^{2},\quad \langle\alpha|N^{2}|\alpha\rangle=|\alpha|^{4}+|\alpha|^{2}$$

Therefore, the fluctuation of the quantum in the coherent state is

$$\Delta n=\sqrt{\langle\alpha|\hat{N}^{2}|\alpha\rangle-\left(\langle\alpha|N^{2}|\alpha\rangle\right)^{2}}=|\alpha|.$$

which leads to

$$\frac{\Delta n}{n}=\frac{1}{|\alpha|}\ll 1.$$

It is thus obvious that the fluctuation of the quantum in the coherent state is very small. The coherent state is quite close to the feature of soliton and solitary wave.

These properties of coherent states are also similar to those of microscopic particles described by the nonlinear Schrodinger equation (20). In practice, the state of a microscopic particle described by nonlinear SchrÖdinger equation can always be represented by a coherent state, for example, the Davydov's wave functions, both $\mathrm{ID}_1>$ and $\mathrm{ID}_2>$, [55] and Pang's wavefunction of exciton-solitons in protein molecules and the wave function in acetanilide[56-61]; the wave function of proton transfer in hydrogen-bonded systems [37-41] and the BCS's wave function in superconductors[62], etc. Hence, the coherence of particles is a kind of nonlinear phenomenon that occurs only in nonlinear quantum systems. Thus it does not belong to systems described by linear quantum mechanics, because the coherent state cannot be obtained by superposition of linear waves, such as plane wave, de Broglie wave, or Bloch wave, which are solutions of the linear SchrÖdinger equation in the quantum mechanics. Therefore, the minimal uncertainty relation Eq. (155), as well as Eqs. (157) and (159), are only applicable to microscopic particles described by nonlinear SchrÖdinger equation. In other words, only microscopic particles described by nonlinear SchrÖdinger equation satisfy the minimal uncertainty principle. It reflects the wave-corpuscle duality of microscopic particles because it holds only if the duality exists.

This uncertainty principle also suggests that the position and momentum of the microscopic particle can be simultaneously determined in a certain degree. A rough estimate for the size of the uncertainty can be given. If it is required that $\phi_s(x,t)$ in Eq.(145) or $\phi_s(p,t)$ in Eq. (147) satisfies the admissibility condition *i.e.*, $\phi_s(0)\approx 0$, we choose $\xi=140,\ \eta=\sqrt{300/0.253}/2\sqrt{2}$ and $\vec{x}_0=0$ in Eq.(145) (In fact, in such a case we can get $\phi_s(0)\approx 10^{-6}$, thus the admissibility condition can be satisfied). We then get $\Delta x\approx 0.02624$ and $\Delta p\approx 19.893$, according to (154) and (155). These results show that the position and momentum of microscopic particles described by nonlinear SchrÖdinger equation can be simultaneously determined within a certain approximation.

Pang *et al*. [55-61] also calculated the uncertainty relation and quantum fluctuations and studied their properties in nonlinearly coupled electron-phonon systems based on the Holstein model by a new ansatz in Pang's new model including the correlations among one-phonon coherent and two-phonon squeezing states and polaron state. Many interesting results were obtained. The minimum uncertainty relation takes different forms in different systems which are related to the properties of the microscopic particles. Nevertheless, the minimum uncertainty relation in Eq. (155) holds for both the one-quantum coherent state and two-quanta squeezed state. These works enhanced our understanding of the significance and nature of the minimum uncertainty relation.

iv. *Quantum fluctuation effects of particles described by quantized nonlinear SchrÖdinger equation*

Finally, we determine the quantum fluctuation effect arising from the uncertainty of position and momentum of the microscopic particle described by quantized nonlinear SchrÖdinger equation. The features of quantized nonlinear SchrÖdinger equation were discussed by Lai and Haus et. al[63]. A superposition of a subclass of bound state $|n,P\rangle$, characterized by number of the boson (such as, photon or phonon), n , and the momentum of the center of the mass P, can reproduce the expectation values of the microscopic particle (soliton) in the limit where the average number of the bosons are larger; we refer to these states formed by the superposition of $|n,P\rangle$ as a fundamental soliton states. In quantum theory, the quantized dynamic equation in the second quantized picture is given by

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$$i\hbar\frac{\partial}{\partial t}\hat{\phi}(x,t)=-\frac{\hbar^2}{2m}\frac{\partial^2}{\partial u^2}\hat{\phi}(x,t)+2b\hat{\phi}^+(x,t)\hat{\phi}(x,t)\hat{\phi}(x,t) \tag{160}$$

The operators $\hat{\phi}(x,t)$ and $\hat{\phi}^+(x,t)$ are the annihilation and creation operators of microscopic particles at a "point " x and "time " t, they satisfy the commutation relation:

$$[\hat{\phi}(x'',t),\hat{\phi}^+(x,t)]=\delta(x-x''),[\hat{\phi}(x'',t),\hat{\phi}(x,t)]=[\hat{\phi}^+(x'',t),\hat{\phi}^+(x,t)]=0 \tag{161}$$

The corresponding quantum Hamiltonian is given by

$$\hat{H}=\frac{\hbar^2}{2m}\int \hat{\phi}_x^+(x,t)\hat{\phi}_x(x,t)dx+b\int\hat{\phi}^+(x,t)\hat{\phi}^+(x,t)\hat{\phi}(x,t)\hat{\phi}(x,t)dx \tag{162}$$

In the Schrodinger picture, the time evolution of the system is described by

$$i\hbar\frac{d}{dt}|\Phi\rangle=\hat{H}_s|\Phi\rangle \tag{163}$$

with the commutation relation:

$$[\hat{\phi}(x''),\hat{\phi}^+(x)]=\delta(x-x''),[\hat{\phi}(x''),\hat{\phi}(x)]=[\hat{\phi}^+(x''),\hat{\phi}^+(x)]=0 \tag{164}$$

where $\hat{\phi}(x)$ and $\hat{\phi}^+(x)$ are the field operators in the SchrÖdinger representation. The corresponding quantum Hamiltonian is given by

$$\hat{H}_s=\frac{\hbar^2}{2m}\int \hat{\phi}_x^+(x)\hat{\phi}_x(x)dx+b\int\hat{\phi}^+(x)\hat{\phi}^+(x)\hat{\phi}(x)\hat{\phi}(x)dx \tag{165}$$

The many-particle state $|\Phi\rangle$ can be built up from the n-quantum states given by

$$|\Phi\rangle=\sum_n a_n\int\frac{1}{\sqrt{n!}}f_n(x_1...,x_n,t)\hat{\phi}^+(x_1)...\hat{\phi}^+(x_n)dx_1...dx_n|0\rangle \tag{166}$$

The quantum theory based on Eq.(166) describes an ensemble of bosons interacting via a $\delta-$potential. Note that $\hat{H}$ preserves both the particle number.

$$\hat{N}=\int\hat{\phi}^+(x)\hat{\phi}(x)dx \tag{167}$$

and the total momentum

$$\hat{P}=i\frac{\hbar}{2}\int\left[\frac{\partial}{\partial x}\hat{\phi}^+(x)\hat{\phi}(x)-\hat{\phi}^+(x)\frac{\partial}{\partial x}\hat{\phi}(x)\right]d \tag{168}$$

Lai *et al*.[55] proved that the boson number and momentum operator commute, so that common eigenstates of $\hat{H}$, $\hat{P}$ and $\hat{N}$ exist in such a case. In the case of a negative b, the interaction between the bosons is attractive and Hamiltonian Eq. (160) has bound states. A subset of these bound states is characterized solely by the eigenvalues of $\hat{N}$ and $\hat{P}$:

$$f_{n,p}=N_{n,}\exp\left(ip\sum_{j=1}^{\infty}x_j+\frac{b}{2}\sum_{1\le i,j<n}^{\infty}|x_i-x_j|\right), \tag{169}$$

where $$N_n = \sqrt{\frac{(n-1)!|b|^{n-1}}{2\pi}}.$$

Thus

$$f_n(x_1,\cdots,x_n,t) = \int dp g_n(p) f_n p(x_1,\cdots,x_n,t) e^{-iE(n,p)t}, \tag{170}$$

where $$g_n = \sqrt{g(p)} e^{-inpx_0}, \text{ and } g(p) = \frac{e\phi\left\{-(p-p_0)^2 \big/ \left|2(\Delta p)^2\right|\right\}}{\sqrt{2\pi(\Delta p)^2}}$$

Using $f_{n,p}$ given in Eq. (169), we find that $|n,P\rangle$ decays exponentially with separation between an arbitrary pair of bosons. It describes an soliton moving with n-quantum, momentum $P = \hbar np$ and energy $E(n,p) = np^2 - |b|^2(n^2-1)n/12$. By construction, the quantum number p in this wave function is related to the momentum of the center of mass of the n interacting bosons, which is now defined as

$$\hat{X} = \lim_{\varepsilon\to 0}\int x\hat{\phi}^+(x)\hat{\phi}(x)\,dx\left(\varepsilon+\hat{N}\right)^{-1} \tag{171}$$

with $$\left[\hat{X},\hat{P}\right] = i\hbar$$

The limit of $\varepsilon \to 0$ is introduced to regularize the position operator for the vacuum state.

We are interested in the quantum fluctuations of Eqs. (167), (168) and (169) for a state $|\Phi(t)\rangle$ with a large average Boson number and a well-defined mean field. Kartner and Boiven[64] decomposed these operators in its mean values and a remainder which is responsible for the quantum fluctuations.

$$\hat{\phi}(x) = \left\langle \psi'(0)\middle|\hat{\phi}^+(x)\middle|\psi(0)\right\rangle + \hat{\phi}_1(x), \left[\hat{\phi}_1(x),\hat{\phi}_1^+(x')\right] = \delta(x-x'), \left[\hat{\phi}_1(x),\hat{\phi}_1^+(x')\right] = 0 \tag{172}$$

Since the field operator $\hat{\phi}$ is time independent in the Schrodinger representation, we can then choose $t=0$ for definiteness. Inserting Eq.(172) into Eqs.(167), (168) and (171) and neglecting terms of second and higher order in the noise operator, Kartner et al[64]. obtained that

$$\hat{N} = n_0 + \Delta\hat{n}, n_0 = \int dx\left(\left\langle\hat{\phi}^+(x)\right\rangle\left\langle\hat{\phi}(x)\right\rangle\right), \Delta\hat{n} = \int dx\left(\left\langle\hat{\phi}^+(x)\right\rangle\hat{\phi}_1(x)\right) + c.c.,$$

$$\hat{P} = \hbar n_0 P_0 + \hbar n_0 \Delta P, P_0 = \frac{i}{n_0}\int dx\left\langle\hat{\phi}_x^+(x)\right\rangle\left\langle\hat{\phi}(x)\right\rangle, \Delta P = \frac{i}{n_0}\int dx\left\langle\hat{\phi}_x^+(x)\right\rangle\hat{\phi}_1(x) + c.c.,$$

$$\hat{X} = x_0\left(1-\frac{\Delta\hat{n}}{n_0}\right) + \Delta\hat{x}, x_0 = \frac{1}{n_0}\int dxx\left\langle\hat{\phi}^+(x)\right\rangle\left\langle\hat{\phi}(x)\right\rangle, \Delta\hat{x} = \frac{1}{n_0}\int dxx\left\langle\hat{\phi}^+(x)\right\rangle\hat{\phi}(x) + c.c.$$

where $\Delta\hat{x}$ is the deviation from the mean value of the position operator, $\Delta\hat{n},\Delta\hat{p},$ and $\Delta\hat{x}$ are linear in the noise operator. Because the third- and fourth-order correlators of $\hat{\phi}_1$ and $\hat{\phi}_1^+$ are very small, they can be neglected in the limit of large n_0. Note that $\Delta\hat{n},\Delta\hat{p},$ and $\Delta\hat{x}$ are all quadratures of the noise operator with $\Delta\hat{p}$ and $\Delta\hat{x}$ being conjugate variables. To complete this set, we introduce a quadrature variable conjugate to $\Delta\hat{n}$,

$$\Delta\hat{\theta} = \frac{1}{n_0}\int dx\left\{i\left[\hat{\phi}^+(x) + x\left\langle\hat{\phi}_x^+(x)\right\rangle\right] - p_0 x\left\langle\hat{\phi}_x^+(x)\right\rangle\right\}\hat{\phi}_1(x) + c.c.$$

As is known, if the propagation distance is not too large, the mean value of the particle is given to the first order by the classical soliton solution

$$\left\langle \hat{\phi}(x) \right\rangle = \phi_{0,n_0}(x,t)\left[1 + O\left(\frac{1}{n_0}\right)\right]$$

with

$$\phi_{0,n_0}(x,t) = \frac{n_0\sqrt{|b|}}{2}\exp\left[i\Omega_{nl} - ip_0^2 t + ip_0(x - x_0) + i\theta_0\right]\times \text{sech}\left[\frac{n_0|b|}{2}(x - x_0 - 2p_0 t)\right], \quad (173)$$

and the nonlinear phase shift $\Omega_{nl} = n_0^2|b|^2 t/4$. If $p_0 = x_0 = \theta_0 = 0$, we obtain the following for the fluctuation operators in the Heisenberg picture,

$$\Delta\hat{n}(t) = \int dx\left[f_{-n}(x)^* F'_{nl} + c.c\right], \Delta\hat{\theta}(t) = \int dx\left[f_{-\theta}(x)^* F'_{nl} + c.c\right],$$

$$\Delta\hat{p}(t) = \int dx\left[f_{-p}(x)^* F'_{nl} + c.c\right], \Delta x(t) = \int dx\left[f_{-x}(x)^* F'_{nl} + c.c\right],$$

with $$F'_{nl} = e^{i\Omega_{nl}}\hat{\phi}_1(x,t),$$

and the set of adjoint functions

$$f_{-n}(x) = \frac{n_0\sqrt{|b|}}{2}\operatorname{sec}h(x_{n_0}),\ f_{-\theta}(x) = \frac{i\sqrt{|b|}}{2}\left[\operatorname{sec}h(x_{n_0}) + x_{n_0}\frac{d}{dx_{n_0}}\operatorname{sec}h(x_{n_0})\right],$$

$$f_{-p}(x) = -\frac{in_0\sqrt{|b|^3}}{4}\frac{d}{dx_{n_0}}\operatorname{sec}h(x_{n_0}),\ f_{-x}(x) = \frac{1}{n_0\sqrt{|b|}}x_{n_0}\operatorname{sec}h(x_{n_0}),$$

where $x_{n_0} = \frac{1}{2}n_0|b|x$

For a coherent state defined by

$$\hat{\phi}(x)\left|\Phi_{0,n_0}\right\rangle = \phi_{0,n_0}(x)\left|\Phi_{0,n_0}\right\rangle,\ \ \hat{\phi}_1(x)\left|\phi_{0,n_0}\right\rangle = 0$$

where

$$\left|\Phi_{0,n_0}\right\rangle = \exp\left\{\int d\ \left[\phi_{0,n_0}x(x)\hat{\phi}^+(x) - \phi^*{}_{0,n_0}(x)\hat{\phi}^+(x)\right]\right\}|0\rangle$$

ϕ_{0,n_0} has been given by Eq. (173). Kartner *et. al.* further obtained that

$$\left\langle\Delta\hat{n}_0^2\right\rangle = n_0,\ \left\langle\Delta\hat{\theta}_0^2\right\rangle = \frac{0.6075}{n_0},\ \left\langle\Delta\hat{p}_0^2\right\rangle = \frac{1}{3n_0\tau_0^2},\ \ \left\langle\Delta\hat{x}_0^2\right\rangle = \frac{1.645\tau_0^2}{2n_0},$$

where $\tau_0^2 = 2/n_0|b|$ is the width of the microscopic particle. The uncertainty products of Boson number and phase, momentum and position are, respectively,

$$\left\langle\Delta\hat{n}_0^2\right\rangle\left\langle\Delta\hat{\theta}_0^2\right\rangle = 0.6075 \geq 0.25, n_0^2\left\langle\Delta\hat{p}_0^2\right\rangle\left\langle\Delta\hat{x}_0^2\right\rangle = 0.27 \geq 0.25,$$

Here the quantum fluctuation of the coherent state is white, i.e.,

$$\left\langle\hat{\phi}_1(x)\hat{\phi}_1(y)\right\rangle = \left\langle\hat{\phi}_1^+(x)\hat{\phi}_1(y)\right\rangle = 0$$

However, the quantum fluctuation of the particle cannot be written because the particle interaction results in correlations between them. Thus, Kätner and Boivin[64] assumed a fundamental soliton state with a Poissonian distribution for the boson number $p=\frac{\mathrm{n}_0^{\mathrm{n}}}{\mathrm{n}!}e^{-n_0}$ and a Gaussian distribution for the momentum Eq.(170) with a width $\langle \Delta p_0^2\rangle = n_0|b|^2/4\mu$, where μ is a parameter of the order of unity compared to n_0. They finally obtained the minimum uncertainty values:

$$\langle \Delta\hat{\theta}_0^2\rangle = \frac{0.25}{\langle \Delta\hat{n}^2\rangle} = \frac{0.25}{n_0}\left[1+O\left(\frac{1}{n_0}\right)\right], \text{and } \langle \Delta\hat{x}_0^2\rangle = \frac{0.25}{\langle n_0^2\rangle} = \frac{0.25\mu\tau_0^2}{n_0}\left[1+O\left(\frac{1}{n_0}\right)\right]$$

up to order $1/n_0$ for the corresponding initial fluctuations in microscopic particle phase and timing. Thus, at t=0 the fundamental soliton with the given Boson number and momentum distributions is a minimum uncertainty state in the four collective variables, the Boson number, phase, momentum and position, up to the terms of O($1/n_0$), which are of the form [57,26-27]

$$\langle \Delta\hat{n}_0{}^2\rangle\langle \Delta\hat{\theta}_0^2\rangle = 0.25\left[1+O\left(\frac{1}{n_0}\right)\right], \text{ and } n_0^2\langle \Delta p_0^2\rangle\langle \Delta\hat{x}_0^2\rangle = 0.25\left[1+O\left(\frac{1}{n_0}\right)\right] \quad (174)$$

These are the uncertainty relations arising from the quantum fluctuations of microscopic particles described by quantized nonlinear quantum SchrÖdinger equation. They are the same as Eqs.(155)-(157). This means that the uncertainty relation of the particles takes the minimum values in such a case.

Finally, we conclude that the uncertainty relation of the microscopic particles described by the nonlinear quantum SchrÖdinger equation regardless whether a state is coherent or squeezed, a system is classical or quantum.

h) The features of reflection and transmission of microscopic particles at interfaces and its wave behavior

As mentioned above, microscopic particles described nonlinear SchrÖdinger equation (20) have also the wave property, in addition to the corpuscle property. This wave feature can be conjectured from the following reasons.

(1) Eqs. (20)－(23) are wave equations and their solutions, Eqs.(34) and (50)- (59) are solitary waves having the features of traveling waves. A solitary wave consists of a carrier wave and an envelope wave, has certain amplitude, width, velocity, frequency, wavevector, and so on, and satisfies the principles of superposition of waves, although the latter are different when compared with classical waves or the de Broglie waves in the quantum mechanics.

(2) The solitary waves have reflection, transmission, scattering, diffraction and tunneling effects, just as that of classical waves or the de Broglie waves in the quantum mechanics. At present, we study the reflection and transmission of the microscopic particles at an interface.

The propagation of microscopic particles (solitons) in a nonlinear nonuniform media is different from that in uniform media. The nonuniformity can be due to a physical confining structure or two nonlinear materials being juxtaposed. One could expect that a portion of microscopic particles that was incident upon such an interface from one side would be reflected and a portion would be transmitted to the other side due to its wave feature. Lonngren *et al.* [65-66] observed the reflection and transmission of microscopic particles (solitons) in a plasma consisting of a positive ion and a negative ion interface, and numerically simulated the phenomena at the interface of two nonlinear materials. To illustrate the rules of reflection and transmission of microscopic particles, we discuss here the work of Lonngren *et al.* [65-66]

Lonngren *et al.* [65] simulated numerically the behaviors of microscopic particles described by nonlinear SchrÖdinger equation (20). They found that the signal had the property of a soliton. These results are in agreement with numerical investigations of similar problems by Aceves et al [67]. A sequence of pictures obtained by Lonngren *et al.* [65] at uniform temporal increments of the spatial evolution of the signal are shown in Fig. 9. From this figure, we note that the incident microscopic particles propagating toward the interface between the two nonlinear media splits into a reflected and transmitted soliton at the interface. From the numerical values used in producing the figure, the relative amplitudes of the incident, the reflected and the transmitted solitons can be deduced.

They assumed that the energy that is carried by the incident microscopic particle is all transfer- red to either the transmitted or reflected microscopic particle and none is lost through radiation. Thus

$$E_{\mathrm{inc}} = E_{\mathrm{ref}} + E_{\mathrm{trans}} \quad (175)$$

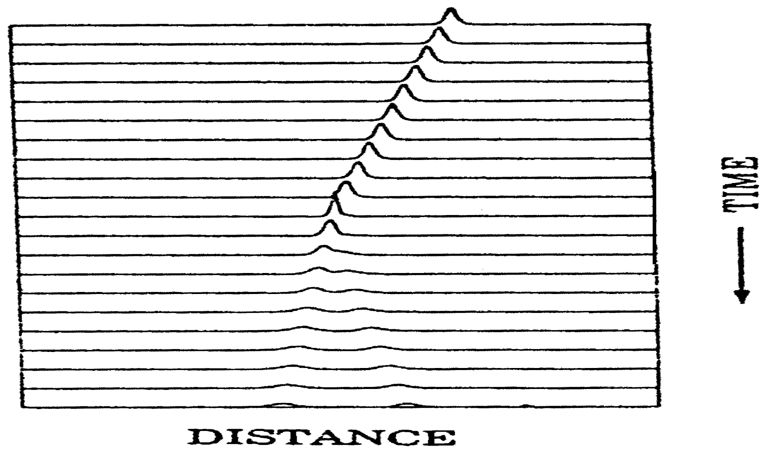

Fig. 10: Simulation results showing the collision and scattering of an incident microscopic particles described by Eq.(20) (top) onto an interface. The peak nonlinear refractive index change is 0.67% of the linear refractive index for the incident microscopic particles and the linear offset between the two regions is also 0.67%.

Lonngren *et al.* gave approximately the energy of the microscopic particle by

$$E_j = \frac{A_j^2}{Z_c} W_j ,$$

where the subscript j refers to the incident, reflected or transmitted microscopic particles. The amplitude of the microscopic particle is A_j and its width is W_j. The characteristic impedance of a particle is given by Z_c. Hence, Eq. (176) can be written as

$$\frac{A_{\text{inc}}^2}{Z_{\text{cI}}} W_{\text{inc}} = \frac{A_{\text{ref}}^2}{Z_{\text{cI}}} W_{\text{ref}} + \frac{A_{\text{trans}}^2}{Z_{\text{cII}}} W_{\text{trans}} \tag{176}$$

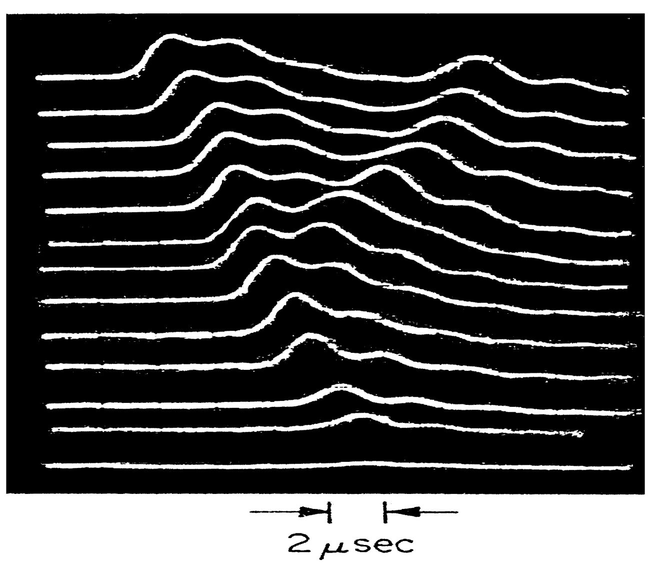

Fig. 11: Sequence of the signals detected as the probe is moved in 2 mm increments from 30 to 6 mm in front of the reflector. The incident and reflected KdV solitons coalesce at the point of reflection, which is approximately 16 mm in front of the reflector. A transmitted soliton is observed closer to the disc. The amplitude scale at 8 and 6 mm is increased by 2 from the previous traces

Since $A_j W_j = \text{constant}$ for the microscopic particle described nonlinear SchrÖdinger equation (26) (see Eq. (130)-(131) in which B_j is replaced by A_j), we obtain the following relation between the reflection coefficient R=A_{ref}/A_{inc} and the transmission coefficient $T = A_{\text{trans}} / A_{\text{inc}}$

$$1 = R + \frac{Z_{cI}}{Z_{cII}} T \tag{177}$$

for the microscopic particle described by nonlinear SchrÖdinger equation (26).

To verify further this idea, Lonngrel *et al.*[44] conducted experiments with KdV soliton. They found that the detected signal had the characteristics of a KdV soliton. Lonngrel *et al.*[68] showed a sequence of pictures taken using a small probe at equal spatial increments starting initially in a homogeneous plasma sheath adjacent to a perturbing biased object, as shown in Fig.10. From this figure, we see that the probe first detects the incident soliton and some time later the reflected soliton. The signals are observed, as expected, to coalesce together as the probe passed through the point where the soliton was actually reflected. Beyond this point which was at the location where the density started to decrease in the steady-state sheath, a transmitted soliton was observed. From Fig.10, the relative amplitudes of incident, the reflected and the transmitted solitons can be deduced, which was done by the author.

For the KdV solitons, there is also $A_j W_j^2 = \text{constant}$ (see Eq.(138)) . Thus, for the KdVsoliton, we have

$$1 = R^{3/2} + \frac{Z_{eI}}{Z_{eII}} T^{3/2}$$

The relations between the reflection and the transmission coefficients for the microscopic particle described by nonlinear Scrodinger equation (26) and KdV soliton are shown in Fig.11, with the ratio of characteristic impedances set to one. The experimental results on KdV solitons and results of the numerical simulation of microscopic particle described by nonlinear Scrodinger equation (26) are also given in this figure. The computed data are shown using triangles. Good agreement between the analytic results and simulation results can be seen. The oscillatory deviation from the analytic result is due to the presence of radiation modes in addition to the soliton modes. The interference between these two types of modes results in the oscillation in the

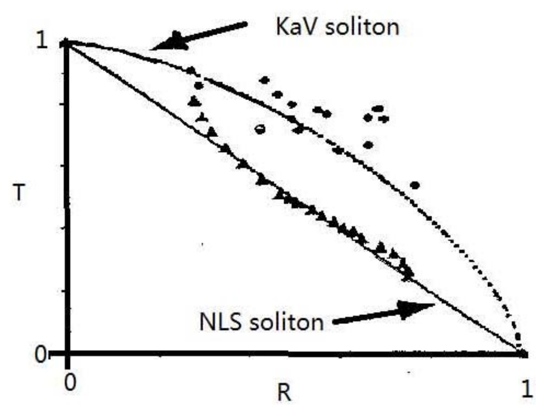

Fig. 12: The relationship between the reflection and transmission coefficients of a microscopic particle (soliton)given in Eq.(178). The solid circles are results from the laboratory experiment on KdV solitons and the hollow circle is Y. Nishida's result. The solid triangles are Lonngren *et al.*'s numerical results for the microscopic particle described by nonlinear SchrÖdinger equation (20)

soliton amplitude. In the asymptotic limit, the radiation will spread and damp the oscillation, and result in the reflection –transmission coefficient curve falling on the analytic curve.

The above rule of propagation of the microscopic particles described by nonlinear SchrÖdinger equation is different from that of linear waves in classical physics. Lonngren *et al*.[68] found that a linear wave obeyed the following relation:

$$1 = R^2 + \frac{Z_{eI}}{Z_{eII}} T^2 \tag{178}$$

This can be also derived from Eq.(177), by assuming the linear waves. The width of the incident, reflected and transmitted pulses W_j will be the same. For the linear waves

$$R = \frac{Z_{cII} - Z_{cI}}{Z_{cII} + Z_{cI}} \text{,and } T = \frac{2Z_{cII}}{Z_{cII} + Z_{cI}}$$

Equation (179) is satisfied. Obviously, equation (179) is different from Eq. (178). This shows clearly that the microscopic particles described by the nonlinear SchrÖdinger equation have a wave feature, but it is different from that of linear classical waves and the de Broglie waves in quantum mechanics.

i) The properties of eigenvalue problem of microscopic particles described by nonlinear SchrÖdinger equation

i. *The eigenenergy spectrum of the Hamiltonian of the nonlinear systems*

In the quantum mechanics, because the Hamiltonian of the systems is independent of the state wavefunction of the particle, the eigenenergy spectrum of the Hamiltonian operator of the systems can be easily obtained from its eigenequation, H$\left|\psi\left(x,t\right)\right\rangle$ =E$\left|\psi\left(x,t\right)\right\rangle$, where $\left|\psi\left(x,t\right)\right\rangle$ is its eigenwave-function in coordinate or particle number representation. It also is just a time-independent linear SchrÖdinger equation in the coordinate representation.

However, for nonlinear SchrÖdinger equation (20), which can represent as $i\hbar\frac{\partial\phi}{\partial t}=\hat{H}(\phi)\phi$, where $\hat{H}(\phi)=-\frac{\hbar^2}{2m}\nabla^2-b\left|\phi\right|^2+V(r,t)$ is the Hamiltonian operator of the system,but corresponding eigenequation and eigenvalues can be obtained through inserting Eq.(60) into Eq.(20), it is of the form

$$\hat{H}(\varphi)\varphi=E\varphi \text{ or } E\varphi=-\frac{\hbar^2}{2m}\nabla^2\varphi(r)+V(r)\varphi(r)-b\left|\varphi\right|^2\varphi \qquad (179)$$

where the Hamiltonian operator is now represented by

$$\hat{H}=-\frac{\hbar^2}{2m}\nabla^2+V(r)-b\left|\varphi\right|^2=\hat{H}_0-b\rho(r) \qquad (180)$$

Where $\hat{H}_0=-\frac{\hbar^2}{2m}\nabla^2+V(\vec{r}),\quad \rho=\left|\varphi\right|^2$ or $\left|\phi(\vec{r},t)\right|^2=\rho(\vec{r},t)$, E and $\phi\left(x,t\right)$ are just the eigenvalue and eigenfunction of the Hamiltonian operator, respectively. Its distinction with that in quantum mechanics is that the Hamiltonian operator is dependent on the wave function of the particles, thus the eigenvalues and eigenfunction cannot be obtained in accordance with above same method in the quantum mechanics. If life-multiplying both sides of Eq.(180) by φ^* and integrating it with respect to x we can find the eigenenergy of the Hamiltonian operator, which can denote as

$$E=\int[-\frac{\hbar^2}{2m}\varphi^*\nabla^2\varphi(x)+V(x)\varphi^*\varphi^2-b\left|\varphi\right|^2\varphi^*\varphi]dx$$

$$=\int[\frac{\hbar^2}{2m}\left|\nabla\varphi\right|^2+V(x)\left|\varphi\right|^2-b\left|\varphi\right|^2\left|\varphi\right|^2]dx$$

This is just Eq.(72). Therefore we can determine the eigenfunctions and eigenvalues of the Hamiltonian operator from Eqs.(180) and Eq.(72), respectively. However, the eigenfunctions and eigenvalues found from this way are only ones of a single particle.

In fact, From Eq.(20) we can also the energy spectra of many particles or many model of motion. In such a case we ever translate Eq.(180) or the above Hamiltonian operator into the particle number representation from coordinate representation to find the eigenfunctions and eigenvalues of the Hamiltonian operator of the systems. We often use the latter to find the eigenenergy of the Hamiltonian operator of the systems.

We know that the wave function of a microscopic particle can be quantized by the creation and annihilation operators of the particle in the second quantum representation. Then the Hamiltonian of a system described by the wave function $\phi\left(x,t\right)$ can be quantized by introducing creation and annihilation operators in the particle number representation or second quantization representation. Thus, we can calculate the eigenenergy spectrum by using the eigenequation of the quantum Hamiltonian and corresponding wavevector in number representation. For convenience, we express the nonlinear SchrÖdinger equation (20) in the following discrete form:

$$i\hbar\frac{\partial\phi_j}{\partial t}=-\frac{\hbar}{2mr_0^2}(\phi_{j+1}-2\phi_j+\phi_{j-1})-b\,|\,\phi_j\,|^2\,\phi_j+V(j,t)\phi,(j=1,2,3,...,J) \qquad (181)$$

in a lattice field, where r_0 is a spacing between two neighboring lattice points, j labels the discrete lattice points, J is total number of lattice points in the lattice field in the system. The vector form of the above equation in the lattice field is

$$[i\hbar\frac{\partial}{\partial t}-\frac{\hbar^2}{mr_0^2}-V(j,t)]\bar{\phi}=-\varepsilon M\bar{\phi}-bdiag.(|\phi_1|^2,|\phi_2|^2\ldots|\phi_\alpha|^2)\bar{\phi}, \tag{182}$$

where $\bar{\phi}(x,t)$ is the column vector, $\bar{\phi}(x,t)$=Col.(ϕ_1, ϕ_2 ,... ϕ_α), whose complex components, equation (183) is a vector nonlinear SchrÖdinger equation with α modes of motion. In Eq. (183), b is a nonlinear parameter and α is a number of motion modes that exist in the systems. M=[M_{nl}]is an $\alpha\times\alpha$ real symmetric dispersion matrix, $\varepsilon=\hbar^2/2mr_0^2$. Here, n and l are integers denoting the modes of motion. The Hamiltonian and the particle number corresponding to Eq. (183), respectively, are

$$H=\sum_{N=1}^{\alpha}\left(\hbar\omega_0|\phi_n|^2-\frac{1}{2}b|\phi_n|^4\right)-\varepsilon\sum_{n\neq l}^{\alpha}M_{nl}\phi_n\phi_l\text{, and }N=\sum_{N=L}^{\alpha}|\phi_n|^2 \tag{183}$$

where $\hbar\omega_0=\hbar^2/2mr_0^2+V(j,t)$.

We have assumed that $V(j,t)$ are independent of j and t. In the canonical second quantization theory, the complex amplitude (ϕ_n^* and ϕ_n) become boson creation and annihilation operators ($\hat{B}_n^+$ and $\hat{B}_n$) in the number representation. If $|m_n>$ is an eigenfunction of a particular mode, then

$$\hat{B}_n^+|m_n\rangle=\sqrt{m_n+1}\,|m_n+1>,\hat{B}_n\,|m_n>=\sqrt{m_n}\,|m_n-1>\text{and }\hat{B}_n\,|0>=0.$$

Since no particular ordering is specified in Eq.(184) thus we use the averages:

$$|\phi|^2\to\frac{1}{2}(\hat{B}_n^+\hat{B}_n+\hat{B}_n\hat{B}_n^+)$$

and

$$|\phi_n|^4\to\frac{1}{6}(\hat{B}_n^+\hat{B}_n^+\hat{B}_n\hat{B}_n+\hat{B}_n^+\hat{B}_n\hat{B}_n^+\hat{B}_n+\hat{B}_n^+\hat{B}_n\hat{B}_n\hat{B}_n^++\hat{B}_n\hat{B}_n^+\hat{B}_n\hat{B}_n^++\hat{B}_n\hat{B}_n\hat{B}_n^+\hat{B}_n^++\hat{B}_n\hat{B}_n^+\hat{B}_n^+\hat{B}_n)$$

with the Boson commutation rule $\hat{B}_n\hat{B}_n^+-\hat{B}_n^+\hat{B}_n=1$, the Eq. (184) then becomes

$$\hat{H}=\sum_{n=1}^{\alpha}[(\hbar\omega_0-\frac{1}{2}b)(\hat{B}_n^+\hat{B}_n+\frac{1}{2})-\frac{1}{2}\,b\hat{B}_n^+\hat{B}_n\hat{B}_n^+\hat{B}_n]-\varepsilon\sum_{n\neq l}^{\alpha}M_{nl}\,\hat{B}_n^+\hat{B}_l \tag{184}$$

$$\hat{N}=\sum_{n=1}^{\alpha}(\hat{B}_n^+\hat{B}_n^++\frac{1}{2}) \tag{185}$$

From now on, we will use the notation [m_1, m_2,... m_α] to denote the products of number states| m_1 >| m_2 >...| m_α >. Thus, stationary states of the vector nonlinear SchrÖdinger equation (114) must be eigenfunctions of both $\hat{N}$ and $\hat{H}$. Consider an m-quantum state (i.e., the nth excited level, m= $m_1+m_2+\ldots m_j$), with m< α . An eigenfunction of $\hat{N}$ can be established as

$$|\phi_m\rangle=C_1\,[\text{m,0,0,…,0}]+\ldots+C_2\,[\text{0,m,0,0,…,0}]+\ldots+C_i\,[\text{0,0,0,…, m ,}]+\ldots+C_{i+1}\,[\text{m-1,m,0,0,…,0}]+\ldots+C_p[\text{0,0,0,…,0,1,1…,1}]. \tag{186}$$

The number of terms in Eq.(117) is equal to the number of ways that m quanta can be placed on α sites, which is given by P=$\frac{(m+\alpha-1)}{m!(\alpha-1)!}$. The wave function | ϕ_m > in Eq.(187) is an eigenfunction of $\hat{N}$ for any values of the $C_\alpha^{'}$. Thus, we are free to choose these coefficients so that

$$\hat{H}\,|\phi_m>=\mathrm{E}|\phi_m>. \qquad (187)$$

Equation (188) requires that the column vector C=Col.($C_1, C_2, \ldots C_p$) satisfies the matrix equation:

$$|\,\mathrm{H}-\mathrm{IE}\,|\mathrm{C}=0 \qquad (188)$$

where H is a $p\times p$ symmetric matrix with real elements. I is a $p\times p$ identity matrix, E is just the eigenenergy. Eq. (188) is an eigenvalue equation of quantum Hamiltonian operator (185) of the systems. We can find the eigenenergy spectra E_m of the systems from Eq. (189) for given parameters, ε, ω_0 , and b. Scott *et al*. [69-71] and Pang *et al*. [72-79] used this method to calculate the energy-spectra of vibrational excitations (quanta) in many nonlinear systems, for example, small molecules or organic molecular crystals and biomolecules. These results can be compared with the experimental data.

ii. *The eigenvalue problem of the nonlinear SchrÖdinger equation and its properties*

In the quantum mechanics we know that the time-independent linear SchrÖdinger equation is an eigenequation of the Hamiltonian operator in the coordinate representation. However, we do not know the meaning of the eigenvalue problem of the nonlinear SchrÖdinger equation, which is therefore a new problem. This problem comes from the Lax method. According to this method, for any nonlinear equation, $\frac{\partial}{\partial t}\phi(\vec{r},t)=$ K($\phi(\vec{r},t)$), where K($\phi(\vec{r},t)$) is a nonlinear operator. If K($\phi(\vec{r},t)$) is related to two linear operators $\hat{L}$ and $\hat{B}$, which depend on ϕ and satisfy the Lax operator equation:

$$i\hat{L}_{t'}=\hat{B}\hat{L}-\hat{L}\hat{B}=[\hat{B},\hat{L}] \qquad (189)$$

where $t'=t/\hbar$, then the eigenvalue E, which does not vary with time, and eigenfunction ψ of the nonlinear equation is determined by the eigenequation of operator $\hat{L}$ as follows

$$\hat{L}\psi=\lambda\psi\,; \qquad i\psi_{t'}=\hat{B}\psi \qquad (190)$$

where E= λ. Thus, the eigenvector and eigenvalue of nonlinear systems are determined by the eigenvector and eigenvalue of the above linear operators. In general, concerning any types of nonlinear equation, the corresponding linear eigenequation and time-independent eigenvalue can always be found from the Lax equation. For the nonlinear SchrÖdinger equation (26), the two linear operators $\hat{L}$ and $\hat{B}$ are determined by[25-26]

$$\hat{L}=\begin{pmatrix}1+s & 0\\ 0 & 1-s\end{pmatrix}\frac{\partial}{\partial x'}+\begin{pmatrix}0 & \phi^*\\ \phi & 0\end{pmatrix},$$

$$\hat{B}=-\begin{pmatrix}1 & 0\\ 0 & 1\end{pmatrix}\frac{\partial^2}{\partial x'^2}+\begin{pmatrix}|\phi|^2/(1+s) & i\phi_{x'}\\ -i\phi_{x'} & -|\phi|^2/(1-s)\end{pmatrix} \qquad (191)$$

where $s^2=1-2/b$, $x'=x\sqrt{2m/\hbar^2}$. Thus the eigenvalue of Eq.(26) is determined by

$$\hat{L}\psi=\lambda\psi\,, \qquad \psi=\begin{pmatrix}\psi_1\\ \psi_2\end{pmatrix}, \qquad (192)$$

Its corresponding solution can be found by use of inverse-scattering or another method.

According to this way the eigenequation corresponding to the nonlinear SchrÖdinger equation (26) and the Galilei invariance are represented by the linear Zakharov-Shabat equation [25-26]]:

$$\mathrm{i}\,\psi_{x'}+\Phi\,\psi=\lambda\sigma_3\psi \qquad (193)$$

This is an eigenequation of eigenfunction ψ with an eigenvalue λ and potential Φ , where,

$$\sigma_3 = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}, \Phi = \begin{pmatrix} 0 & \phi \\ \phi^* & 0 \end{pmatrix} \quad (194)$$

where ϕ satisfies Eq.(26). It evolves with time according to Eq. (191). However, what are the properties of the eigenvalue problems determined by these equations? This deserves further discussion.

As is known, the eigenequation is invariant under the Galilei transformation. As a matter of fact, if we substitute the following Galilei transformation:

$$\phi'(\tilde{x},\tilde{t}) = e^{ivx'-iv^2/2}\phi(x',t'), \tilde{x} = x' - vt', \tilde{t} = t' \quad (195)$$

into Eq. (125), then Φ is transformed into

$$\Phi'(\tilde{x}) = \begin{pmatrix} e^{i\theta/2} & 0 \\ 0 & e^{-i\theta/2} \end{pmatrix} \Phi(x') \begin{pmatrix} e^{-i\theta/2} & 0 \\ 0 & e^{i\theta/2} \end{pmatrix} \quad (196)$$

where $\theta = vx' - \frac{1}{2}v^2t' + \theta_0$, here θ_0 is an arbitrary constant. If the eigenfunction $\psi(x')$ is transformed as

$$\psi'(\tilde{x}) = \begin{pmatrix} e^{i\theta/2} & 0 \\ 0 & e^{-i\theta/2} \end{pmatrix} \psi(x') \quad (197)$$

then Eq. (194) becomes

$$i\psi'_{x'} + \Phi'\psi' = (\lambda - \frac{v}{2})\sigma_3\psi' \quad (198)$$

It is clear that in the reference frame that is moving with the velocity v, the eigenvalue is reduced to v/2 compared with that in the rest frame. It shows that the velocity of the microscopic particle is given by $2\Re(\lambda_k)$. When θ is constant, i.e., $\theta = \theta_0$, the eigenvalue is unchanged because v=0. This implies that the nonlinear SchrÖdinger equation (26) is invariant under the gauge transformation, $\phi' = e^{i\theta_0}\phi(x')$.

Satsuma and Yajima [80] studied the eigenfunction of Eq. (194) and its properties, where the eigenfunction satisfied the boundary condition, $\psi = 0$ at $|x| \to \infty$. The eigenvalues and the corresponding eigenfunctions were denoted by $\lambda_1, \lambda_2, ..., \lambda_N \, and \, \psi_1, \psi_2, ..., \psi_N$. respectively. For a given eigenfunction , $\psi_n(x')$, equation (194) reads

$$i\frac{d\psi_n(x')}{dx'} + \Phi(x')\psi_n(x') = \lambda_n\sigma_3\psi_n(x'), n = 1, 2, ..., N \quad (199)$$

$\psi(x')$ was expressed in terms of Pauli's spin matrices σ_1 and σ_2 ,

$$\psi(x') = \Re[\psi(x')]\sigma_1 - \Im[\psi(x')]\sigma_2 \quad (200)$$

Multiplying Eq. (200) by σ_2 from the left and taking the transpose of the resulting equation, we get

$$-i\frac{d\psi_m^T}{dx'}\sigma_2 - \psi_m^T\Phi^*\sigma_2 = i\lambda_m\psi_m^T\sigma_1 \quad (201)$$

where the superscript T denotes transpose. Multiplying the above equation by ψ_n from right and Eq. (199) by $\psi_m^T\sigma_2$ from the left and subtracting one from the other, Satsuma and Yajima[80] obtained the following equation

$$(\lambda_n - \lambda_m)\int_{-\infty}^{\infty} \psi_m^T\sigma_1\psi_n dx' = 0$$

The boundary conditions, $\psi_n, \psi_m \to 0$ as $|x'| \to \infty$, were used in obtaining the above equation. The following orthonormal condition was then derived:

$$\int_{-\infty}^{\infty} \psi_m^T \sigma_1 \psi_n dx' = \delta_{nm} \tag{202}$$

Satsuma and Yajima further demonstrated that Eq. (200) has the following symmetry properties.

(1) If $\phi(x')$ satisfies $\phi(-x') = \phi^*(x')$, then replacing x' by - x' in Eq. (200) and multiplying it by σ_2 from left , we can get

$$i\frac{d}{dx'}[\sigma_2\psi_n(-x')] + \Phi(x')[\sigma_2\psi_n(-x')] = \lambda_n\sigma_3[\sigma_2\psi_n(-x')]$$

Since $\sigma_2\psi_n(-x')$ is also an eigenfunction associated with λ_n, its behavior resembles that of $\psi_n(x')$ in the asymptotic region, i.e., $\sigma_2\psi_n(-x') \to 0$ as $|x'| \to \infty$, thus ψ_n has the following symmetry

$$\sigma_2\psi_n(-x') = \delta\ \psi_n(x') \text{ ,or } \psi_n(-x') = \delta\ \sigma_2\psi_n(-x') \text{ ,(} \delta = \pm 1)$$

Therefore, if $\phi(-x') = \phi^*(x')$, then $\psi(x')$ satisfies the symmetry property $\psi_n(-x') = \delta\ \sigma_1\psi_n(-x')$ with $\delta = \pm 1$. This can easily be verified by replacing σ_1 with σ_2 in the above derivations.

(2) If $\phi(x')$ is a symmetric (or antisymmetric) function of x', i.e., $\phi(-x') = \pm\phi(x')$, then $\psi_n^{(s)}(x') = \sigma_1\psi * (-x')$ is the eigenfunction belonging to the eigenvalue $-\lambda_n^*$, and $\psi'^{(a)}_n(x') = \sigma_2\psi * (-x')$ is the eigenfunction belonging to the eigenvalue λ_n^*. The suffix s (or a) to the eigenfunction ψ'_n indicates that ϕ is symmetric (or antisymmetric). Since $\phi(-x') = \phi\ (x')$, replacing x' with - x' in Eq. (130) and taking complex conjugate, we get

$$i\frac{d}{dx'}[\sigma_1\psi * (-x')] + \psi(x')[\sigma_1\psi * (-x')] = -\lambda_n\sigma_3[\sigma_1\psi^*{}_n(-x')]$$

Compared with Eq. (200), the above equation implies that $-\lambda_n^*$ is also an eigenvalue and the associated eigenfunction $\psi_n^s(x')$ is just $\sigma_1\psi^*{}_n(-x')$, with the arbitrary constant. For $\phi(-x') = -\phi\ (x')$, the same conclusion is obtained by replacing σ_1 with σ_2 in the above derivations.

These symmetry properties are useful in providing a general view of the solution of Eq. (26) with V(x,t)= A(ϕ)=0 . As is known, the real part of the eigenvalue, ξ_n, corresponds to the velocity of a soliton and the imaginary part, η_n, the amplitude. Then, if $\phi(x', t' = 0)$, whose initial value has the symmetry $\phi(x', t' = 0), = \pm\phi(-x', t' = 0)$, breaks into the series of solutions, the decay is bisymmetric, corresponding to the eigenvalues $-\lambda_n^*$. If $\phi(x')$ is real, the above symmetry property yields

$$\psi'^{(s)}_n(-x') = \sigma_1[-\delta\sigma_2\psi_n^*(-x')] = \delta\sigma_2\psi'^{(s)}_n(x')$$

$$\psi'^{(a)}_n(-x') = \sigma_2[-\delta\sigma_1\psi_n^*(-x')] = \delta\sigma_1\psi'^{(a)}_n(x')$$

i.e., $\psi'^{(s)}_n(x')$ has the same parity as $\psi_n(x')$, while $\psi'^{(a)}_n(x')$ has the opposite one. When $\phi(-x') = -\phi\ (x')$ and λ_n is pure imaginary ($\lambda_n = -\lambda_n^*$), the eigenvalues corresponding to the positive and negative parity eigenfunctions degenerate.

(3) If $\phi(x')$ is real, but not antisymmetric, then the eigenvalue λ_n is pure imaginary, i.e., $\Re(\lambda_n)$=0. From Eq. (200) and its Hermitian conjugate, Satsuma et.al[68] found that

$$\Re(\lambda_n)\langle n|\sigma_2|n\rangle = \langle n|\Im[\phi(x')]\sigma_3|n\rangle \tag{203}$$

with

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$$<\mathrm{m}|\,\sigma_2\,|\mathrm{n}>=\int_{-\infty}^{\infty}\psi_m^+\sigma_2\psi_n dx' \tag{204}$$

where $[\Phi,\sigma_1]=2i\Im(\phi)\sigma_3$ was used. We see from Eq. (204) that $\Re(\lambda_n)$ vanishes if ϕ is real and $<\mathrm{m}|\,\sigma_2\,|\mathrm{n}>\neq 0$. When ϕ is a real and an antisymmetric function of x', the symmetry property (I) gives

$$<\mathrm{m}|\,\sigma_2\,|\mathrm{n}>=\delta^2\int_{-\infty}^{\infty}\psi_m^+(-x')\sigma_1\sigma_2\sigma_1\psi_n(-x')dx'=-<|\,\sigma_2\,|>$$

Thus $<\mathrm{n}|\,\sigma_2\,|\mathrm{n}>=0$.

(4) If the initial value takes the form of $\phi=e^{ivx'}R(x')$, where $R(x')$ is a real, but not antisymmetric function of x', then all the eigenvalues have the common real part, -v/2. This can be easily shown by the Galilei transformation. In fact, when $\phi(x',t'=0)=e^{ivx'}R(x')$, the solution does not decay to the series of solitons moving with the different velocities, but form a bound state. In this case, the real parts are common to all the eigenvalues, i.e., the relative velocities of the solitons vanish.

(5) If ϕ is a real non-antisymmertric function of x', it can be shown that

$$\psi_n^*(x')=i\delta\sigma_3\psi_n(x') \tag{205}$$

where $\delta=\pm 1$. Because $\Re(\lambda_n)=0$, from the complex conjugate of Eq. (200), one can get $\psi_n^*(x')\propto\sigma_3\psi$. Substituting Eq. (194) into the normalization condition Eq. (202), one then has $\delta=\pm 1$. If the eigenvalue of Eq. (124) is real, i.e., $\lambda=\xi$ is real, then

$$i\frac{d\psi}{dx'}+\Phi\,\psi=\xi\sigma_3\psi \tag{206}$$

and the adjoint function of $\psi,\overline{\psi}=i\sigma_2\psi^*$, is also a solution of Eq. (207), i.e.,

$$i\frac{d\overline{\psi}}{dx'}+\Phi\overline{\psi}=\xi\sigma_3\overline{\psi}$$

From this and Eq. (207), Satsuma and Yajima obtained the following

$$\frac{d}{dx'}(\psi^+\psi)=\frac{d}{dx'}(\overline{\psi}^+\psi)=\frac{d}{dx'}(\psi^+\overline{\psi})=\frac{d}{dx'}(\overline{\psi}^+\overline{\psi})=0 \tag{207}$$

Using the above boundary conditions, they found that the solutions of Eq.(194) $\psi_1(x',\xi),\psi_2(x',\xi),$ and $\overline{\psi}_2(x',\xi)$ satisfy the following relations.

$$\psi_1^+\psi_1=\psi_2^+\psi_2=\overline{\psi}_2^+\overline{\psi}_2=1,\overline{\psi}_2^+\psi_2=\psi_2^+\overline{\psi}_2=0$$

From $\psi_1=a(\xi)\overline{\psi}_2+b(\xi)\psi_2$, we get a= $\overline{\psi}_2^+\psi_1$ and b= $\overline{\psi}_2^+\psi_1$, where $\psi_1=(x',\xi)=\begin{pmatrix}1\\0\end{pmatrix}e^{-i\xi x'}$, as $x'=-\infty$ and $\psi_2=(x',\xi)=\begin{pmatrix}0\\1\end{pmatrix}e^{+i\xi x'}$, $\overline{\psi}_2(x',\xi)=\begin{pmatrix}1\\0\end{pmatrix}e^{-i\xi x'}$ as $x'=\infty$. As pointed out earlier, if a real (not antisymmetric) initial value is considered, the microscopic particle does not decay into moving solitons, but forms a bound states of solitons pulsating with the proper frequency. Satauma and Yajima developed a perturbation approach to investigate the conditions for the solutions to evolve and decay into moving solitons.

If the wave function ϕ in Eq. (124) undergoes a small change, i.e., $\phi\to\phi'=\phi+\Delta\phi$, the corresponding change in Φ is given by

$$\Delta\Phi=\begin{pmatrix}0 & \Delta\phi\\ \Delta\phi^* & 0\end{pmatrix}.$$

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Then, λ_n and ψ_n changes as $\lambda_n + \Delta\lambda_n$ and $\psi_n + \Delta\psi_n$, respectively. To the first order in the variation, Eq.(194) becomes

$$[i\frac{d}{dx'} + (\Phi - \lambda_n\sigma_3)]\Delta\psi_n + (\Delta\Phi - \Delta\lambda_n\sigma_3)\psi_n = 0$$

Multiplying the above equation by $\psi_n^T\sigma_2$ from the left and integrating with respect to x' over $(-\infty,\infty)$, we get

$$\Delta\lambda_n = -i\int_{-\infty}^{\infty}\psi_n^T\sigma_2\Delta\Phi\psi_n dx' = -\int_{-\infty}^{\infty}\psi_n^T\Re(\Delta\phi)\sigma_3\psi_n dx' + i\int_{-\infty}^{\infty}\psi_n^T\Im(\Delta\phi)\psi_n dx'$$

If ϕ is a real and non-antisymmetric function of x', Eq.(207) holds and

$$\Delta\lambda_n = \delta < n|\Im(\Delta\phi)\sigma_3|n> + i\delta < n|\Re(\Delta\phi)|n> \qquad (208)$$

Equation (209) indicates that if $<n|\Im(\Delta\phi)\sigma_3|n> \neq 0$, the perturbation $\Delta\phi$ makes the real part of the eigenvalue finite. That is, for the initial value, $\phi(x') + \Delta\phi(x')$, the solution of Eq.(26) breaks up into moving solitons with velocity $2\Re(\Delta\lambda_n)$. If ϕ is real and is either a symmetric or an antisymmetric function of x', the above symmetry properties of eigenvalues of the nonlinear Schrodiger equation (26) lead to

$$< n|\Im(\Delta\phi(x'))\sigma_3|n> = - < n|\Im(\Delta\phi(-x))\sigma_3|n>$$

Therefore, if $\Im(\Delta\phi)$ is a symmetric function, then $<n|\Im(\Delta\phi)\sigma_3|n>$ vanishes, i.e., $\Re(\Delta\lambda_n) = 0$, and the soliton bound state does not resolve into moving solitons even in the presence of the perturbation $\Delta\phi$.

Satsuma and Yajima[80] also obtained the shifts of the eigenvalues of Eq.(194) under the double-humped initial values, $\phi(x', t'=0) = \phi_0(x' - x_0') + e^{i\theta_0}\phi(x' + x_0')$, where ϕ_0 is a real and symmetric function of x', x_0' and ϕ_0 are real. The shifts of the eigenvalues were finally written as

$$\Delta\lambda_n^{\pm} = \delta[\sin\ \theta < n|\sigma_3\phi_0(x' + 2x_0')|n> \mp \sin(\frac{\theta_0}{2}) < n|\sigma_3\phi_0(x')e^{2x_0'(d/dx')}|n>] +$$

$$i\delta[\cos\theta_0 < n|\phi_0(x' + 2x_0')|n> \pm \cos(\frac{\theta_0}{2}) < n|\phi_0(x')e^{2x_0'(d/dx')})|n>]$$

where

$$-\delta\cos(\frac{\theta_0}{2}) < n|\phi_0(x')e^{2x_0'(d/dx')})|n> - i\delta\sin(\frac{\theta_0}{2}) < n|\sigma_3\phi_0(x')e^{2x_0'(d/dx')}|n>$$

$$= \int_{-\infty}^{\infty}\psi_2^{''(n)T}\sigma_2\Phi\psi_1^{''(n)}dx' = \int_{-\infty}^{\infty}\psi_1^{''(n)T}\sigma_2\Phi\psi_2^{''(n)}dx'$$

$$-\delta\cos(\theta_0) < n|\phi_0(x' + 2x_0'')|n> - i\delta\sin(\theta) < n|\sigma_3\phi_0(x' + 2x_0')|n>$$

$$= \int_{-\infty}^{\infty}\psi_1^{''(n)T}\sigma_2\Phi_2\psi_1^{''(n)}dx' = \int_{-\infty}^{\infty}\psi_2^{''(n)T}\sigma_2\Phi_1\psi_2^{''(n)}dx',$$

here

$$\Phi(x') = \Phi_1(x') + \Phi_2(x'), \Phi_1(x') = \sigma_1\phi_0(x' - x_0')$$

$$\Phi_2(x') = [(\cos(\theta_0)\sigma_1 - \sin(\theta)\sigma_2]\phi_0(x' + x_0')$$

The corresponding eigenvalue equation is given by

$$i\frac{d}{dx'}\psi_n'' + \Phi(x')\psi_n'' = \lambda_n\sigma_3\psi_n''(x')$$

The eigenfunction $\psi_n''(x')$ satisfies the following symmetry and orthogonality requirements:

$$\psi''_{n\pm}(-x') = \pm\delta[\cos(\frac{\theta_0}{2})\sigma_2 + \sin(\frac{\theta_0}{2})\sigma_1]\psi''_{n\pm}(x'), \delta \pm 1$$

$$\int_{-\infty}^{\infty} \psi_{n+}^{''T}(x')\sigma_1\psi''_{n-}(x')dx' = 0$$

When $\theta_0 = 0, \phi(x')$ is real and symmetric, $\Delta\lambda_n^{(\pm)}$ is pure imaginary, when $\theta_0 = \pi$, $\phi(x')$ is real and antisymmetric, $\Delta\lambda_n^{(\pm)}$ is real,

$$\Re[\Delta\lambda_n^{(\pm)}(\theta_0 = \pi)] = \mp\delta < n | \sigma_3\phi_0(x')e^{2x_0' (d/dx')} | n >$$

$$\Im[\Delta\lambda_n^{(\pm)}(\theta_0 = \pi)] = -\delta < n | \sigma_3\phi_0(x' + 2x_0') | n > \quad (210)$$

Thus, the solution of the nonlinear SchrÖdinger equation (26) decays into paired solitons and each pair consists of solitons with equal amplitude and moving in the opposite directions with the same speed. For arbitrary θ_0', we can see from Eq. (210) that the solution of Eq. (26) breaks up into an even number of moving solitons with different speeds and amplitudes.

From the above investigations we know that the eigenvalues and eigenequations of nonlinear Schrodiger equation are a very complicated and different properties.

III. The Nonlinear Schrödinger Equation is a Correct and Universal Dynamic Equation of the Microscopic Particles in all Physical Systems

a) *The results brought by the using the nonlinear SchrÖdinger equation*

As known, the states and properties of microscopic particles were described by the linear Schrodiner equation (7) in the quantum mechanics, but the microscopic particles have only the wave feature, not corpuscle nature in such a case. This feature is contradictory with the traditional concept of particles. At the same time, position and momentum of the particles meet also the uncertainty relation, the occurrence of particles at a point in time-space is represented by a probability, the mechanical quantities of the particles are denoted by some average values, and so on. These uncertain descriptions to the properties of the microscopic particles bring us plenty of difficulties and troubles to understand their natures and essences. At the same time, these properties of microscopic particles also correspond not with the experimental results of electronic diffraction on double seam by Davisson and Germer in 1927[8-12] and de Broglie's relation of wave-corpuscle duality[8-9]. Thus there are considerable, intense and durative controversies in physics, which elongate and continue a century. Very surprisingly, these difficulties, contradictions and controversies have not been solved up to now.

In such a case we have broken through the hypothesis of independence of Hamiltonian operator of the systems on states of microscopic particles, forsaken the traditional quantum mechanical method of average field approximation to replace real and complicated interactions among the particles or between the particle and background field and introduced further the nonlinear interaction between them into the dynamic equation of particles to build the nonlinear SchrÖdinger equation. And we used it to replace the linear SchrÖdinger equation in quantum mechanics and to study further the nature and states of microscopic particles. From this investigation we find that the states and properties of microscopic particles are considerably and essentially changed relative to those in quantum mechanics, a lot of interesting and important results are obtained from this investigation. These considerable changes are described as follows.

(1) An outstanding and obvious change is that the microscopic particles have a wave- corpuscle duality and is embedded by organic combination of envelope and carrier wave. The particle has not only wave features of certain amplitude, velocity, frequency, and wavevector, but also corpuscle natures of a determinant mass centre, size, mass, momentum and energy. This is first time to shed light theoretically on the wave-corpuscle duality of microscopic particles in quantum theory. At the same time, we proved that the wave-corpuscle duality of microscopic particles is quite stable, even though they are in an externally applied potential field.

(2) The motion of the particles satisfy the classical Newtonian law, Lagrangian equation and Hamilton equation, which exhibit the classical properties of microscopic particles.

(3) The microscopic particles have determinant mass, momentum and energy, and obey the universal conservation laws of mass, momentum, energy and angular momentum.

(4) The microscopic particles meet also the classical collision rule when they collide with each other. Although these particles are deformed in collision process, they can still retain themselves form and amplitude to move towards after collision, where a phase shift may occur.
(5) The position and momentum of the mass centre of microscopic particles are determinant, but their coordinate and momentum obey still a minimum uncertainty relation, which differs from those in quantum mechanics. This property of the particle displays its wave-corpuscle duality.
(6) We can determine that the microscopic particles possess a wave feature from its features of reflection and transmission features on the interface , but this wave feature are different from that of both linear wave and KdV solitary wave.
(7) We know from the investigations of eigenvalue problem of nonlinear SchrÖdinger equation that the eigenvalue states of microscopic particles described by the nonlinear SchrÖdinger equation have a lot of unusual features which are completely different from that in quantum mechanics, the eigenenergy spectra of Hamiltonian operator of the microscopic particles can be obtained in second quantum representation or number representation. This suggests that the natures of microscopic particles described by the nonlinear SchrÖdinger equation are in essence different from those in quantum mechanics.

The above new properties of the microscopic particles exhibit and display clearly both corpuscle and wave features which are consistent with the concepts of traditional particle and wave, respectively. Therefore the natures of microscopic particles described by the nonlinear SchrÖdinger equation (20) differ in essence from those described by the linear SchrÖdinger equation (7) and relate directly to these difficult and disputed problems as mentioned above, thus this investigation pounds considerably the quantum mechanics, its influences on quantum mechanics are crucial and considerable. Thus this research idea and results could overcome and solve the century difficulties and disputations existed in the quantum mechanics. To sum up, the influences of such a investigation on the quantum mechanics can be described as follows.

b) The essences of quantum mechanics

First influence is that we see clearly the essences of the quantum mechanics. As far as the quantum mechanics is concerned, we should confirm that its birth is a revolution of physics or science, it is the foundation of modern science, its applications acquire the great successes, especially when it was applied in hydrogen atom and molecule as well as helium atom and molecule, the theoretical results obtained are consistent with experimental data. However, it nevertheless encountered some problems and difficulties, which are embodied in not only the elementary hypothesizes of quantum mechanics but also its applications. In its hypothesizes the difficulties and controversies are the occurrence of particles at a point in time-space to be represented by a probability, the mechanical quantities of the particles to be denoted by some average values and the hypothesis of independence of Hamiltonian operator of the systems on states of microscopic particles. In the applications the difficulties come from its applications in the systems of many particles and many bodies. When the quantum mechanics is used to study the properties of motion of microscopic particles in these complicated systems, we have to utilize ever many simple and approximate method unassociated with the states of particles in virtue of different approximate methods, such as, the signal and free electronic approximations, compact -binding approximation and average field approximation, and so on, to replace some complicated and real nonlinear interaction among these particles, or between the particle and backgrounds, which could determine the essences and natures of particles, in the systems in calculation.Thus we obtained only some approximation, but not real, complete and correct, solutions in which the effects and results arising from these complicated effects and nonlinear interactions are ignored completely. Then the states and properties of particles determined by the average potential as well as the studied method are not real and correct. Therefore, we can conclude that the linear SchrÖdinger equation is a linearity of dynamic equation, can only describe the properties and states of a single microscopic particle in vacuum or the system of less body without nonlinear interaction, then the quantum mechanics is correct, but has some limitations and is only a simple, approximate and linear theory and cannot represent in truth the properties and states of motion of the microscopic particles in general and complicated systems. These are just the essence of the quantum mechanics. Therefore the quantum mechanics must develop toward.

c) The roots of localization of microscopic particle and the necessity developing nonlinear quantum mechanics

Second influence on the quantum mechanics is that we know clearly the basic root of no localization of microscopic particles, in other word, these difficulties and disputations in quantum mechanics, which are just that the Hamiltonian operator of the systems is too simple, composed only of kinetic and externally applied potential energy operators and depends not with wave function of states of the particles. Concretely speaking, plenty of complicated and nonlinear interactions among the particles or the particle and background field related to the states of the particles have been completely forsaken in the Hamiltonian operator of the system. Thus its dynamic equation is linear. If these nonlinear interactions are introduced into the dynamic equation of particles, then the linear SchrÖdinger equation (7) in the quantum mechanics is replaced by the nonlinear SchrÖdinger equation (20). In the latter the nonlinear interaction related to the states of particle can balance and suppress the dispersion effect of the kinetic term in the dynamic equation (7), then the effective potential of the system becomes a double-well potential from a signal well's, thus wave feature of the particle is suppressed, the shape of wave becomes the form of sech(x-vt), its mass, energy, and momentum are gathered and maintained, thus the microscopic particle is localized at x_0 and become eventually as a soliton with wave-corpuscle duality. Thus the natures of the microscopic particle are thoroughly changed in such a case. The results obtained from use of nonlinear SchrÖdinger equation (20) also verify that the natures of microscopic particles described by the nonlinear SchrÖdinger equation (20) differ in essence from those described by the linear SchrÖdinger equation (7). Thus, the basic root of localization of the microscopic particles described by nonlinear SchrÖdinger equation is just this nonlinear interactions, which suppress and cancel the dispersive effect of kinetic energy in the dynamic equation.

The third influence is that the quantum mechanics seeks the development direction, namely, it is necessary to establish and develop nonlinear quantum mechanics based on the nonlinear SchrÖdinger equation. In such a case the Hamiltonian operator of the systems must be related to the wave function of state of the microscopic particles and is nonlinear function of states of the particles. Based on these ideas and the properties of wave functions of the particles in the nonlinear SchrÖdinger equation we could establish the nonlinear quantum mechanics. To develop nonlinear quantum mechanics can promote the development of physics and can enhance and raise the knowledge and recognition to the essences of microscopic matter. This just is the most great influence on quantum mechanics [22-25].

In fact, all realistic physics systems are always composed of many particles and many bodies, hydrogen atom is a most simple system and composed also of two particles, thus the system composed only of one particle does not exist in nature. In such a case, the nonlinear interactions exist always in any realistic physics systems including the hydrogen atom[10-15]. Therefore, when the states and properties of microscopic particles in a realistic physics systems are studied by using quantum theory, we should use the nonlinear SchrÖdinger equation (20) or nonlinear quantum mechanics[22-25], instead of the linear SchrÖdinger equation (7) in quantum mechanics. Only if the coupling interaction among the particles, or between the particle and background field equal to zero or exists not, then equation(20) can degenerate to the linear SchrÖdinger equation (7). This indicates again that the linear SchrÖdinger equation in quantum mechanics is only an especial and approximate case of nonlinear SchrÖdinger equation, and can only describe the states and properties of a single particle without the nonlinear interaction.

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Metaphysics of Classical Space and Time

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Abstract- In the article suggests the conclusion of classical space-time of the real physical laws discovered by Johannes Kepler in the analysis of long-term astronomical observations of Tycho Brahe. Rather than lay a priori given space-time at all the theoretical constructs are invited to rely on the real physical picture of the world, as set out in Metaphysics I. Kepler and will be further developed in the works of Isaac Newton, Albert Einstein and Arthur Eddington. The article argues that the agenda set by modern fundamental theoretical physics problem of withdrawal of the classical space-time representations of the concepts and laws of physics of the microscopic physics, first tried to constructively implement A. Eddington in his latest work Fundamental theory. The article deals with the boundary conditions for Einstein's general theory of relativity. Einstein's equations are invariant and are applicable only to describe the reversible processes in equilibrium systems. The fundamental error in Einstein's general relativity is to deny the existence of the interaction and the exchange of energy between the system and the environment (ether) and, consequently, a violation of the law of conservation of energy.

Keywords: fiber space, the base layer, imaginary time (cyclic, invariant), cosmological time (evolutionary probabilistic), the time horizon, the inertial mass, gravitational mass, vector potential, magnetic field vector, scalar magnetic field, bias currents.

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Strictly as per the compliance and regulations of :

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Keywords: fiber space, the base layer, imaginary time (cyclic, invariant), cosmological time (evolutionary probabilistic), the time horizon, the inertial mass, gravitational mass, vector potential, magnetic field vector, scalar magnetic field, bias currents.

I. Introduction

The problem of deriving classical space-time from the laws of microscopic physics now is one of the urgent problems of theoretical physics. It is closely connected with the physical essence of the cosmic medium (ether), which determines the properties and the geometry of space-time. It would be wrong to assert that the appeal to metaphysics as the first philosophy (ἡ πρώτη φιλοσοφία) takes as its subject the unknowable essence of the cosmic medium. On the contrary, the experimental cosmological discoveries of recent years, including the presence of thermal background radiation of the universe of 2.7 K, its anisotropic distribution in space, the cosmological expansion of the universe to the acceleration and the rapid development of the theory of continuous superfluid medium allows to describe the universe, as the world is physically installed and clear interactions. In view of the above I would like to explain the concept of physically substantiated classical space - time, built on the basis of the laws of celestial mechanics and models of the space environment, fundamentally different from the standard cosmological model ΛCDM (Λ- Cold Dark Matter).

Professor of Moscow State University Yu. S. Vladimirov in his article [1] considered three directions of finding a solution to this problem: Penrose's twistor program, A. P. Yefremov's quaternionic program and Yu. S. Vladimirov's binary geometrophysics. But there is a fourth direction to solve this problem - it is Arthur Eddington's Fundamental theory [2]. The essence of this direction is described in the article Five-dimensional world of Kepler – Newton - Eddington, published in the book "Cosmic Medium" [3]. It A. Eddington in his latest work Fundamental theory first tried to constructively implement the idea of derivation of the classical concepts of space-time from the laws of microscopic physics. Eddington's five- dimensional world (Uranoid) contains three spatial dimensions and two - time and consists entirely of charged particles (electrons and positrons). This, with great difficulty presents the results have been amazing for Eddington himself, because considered hypothetical system was completely out of real experience. However, relying on high-precision astronomical data in recent years, obtained by the probe Wilkinson (satellite WMAP), and Planck space telescopes HST, BTA (Big Telescope azimuth) et al., Eddington's Fundamental theory can be extended to the real universe. The experimental results of the Military Engineering Space Academy with the clock and magnetometer installed on the artificial earth satellites, clearly confirm the reality of heterogeneous polarized dipole space environment, which has electric and magnetic perception, analog superfluid ^{3}He-B. [4,5]. The fundamental theory allows us to give a response to said Yu.S. Vladimirov complex problems of difficulty in solving the problem [1]. Here are the problems:

1. First of all it is a theoretical justification of space having fiber bundle Xm (Xn) when geometrisation of dynamical systems. The basis of it is n-dimensional differentiable manifold Xn (a base-coordinate space), and layer - m-dimensional manifold (a layer - momentum space);

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2. Yu. S. Vladimirov asks "Why describe the physics of the microscopic physics uses complex numbers, whereas the conventional geometry and classical physics are set out on the basis of the set of real numbers?";
3. Yu. S. Vladimirov considers it necessary "to justify theoretically quadratic definition of measure in the coordinate and momentum-space, that is, to prove the existence of the Pythagorean theorem and its generalization in the form of a quadratic metric in general relativity $ds^2 = g_{\alpha\beta}\, dx^\alpha\, dx^\beta$?»;
4. As a way geometrical properties of space and time associated with physical interactions? After all, even Kant linked the three-dimensional space with the law of decreasing strength is inversely proportional to the square of the distance. Visually, the three-dimensional space is represented and described by Euclidean geometry in Cartesian coordinates. Descartes imagined space as something absolutely unchangeable, like an empty box, inside of which occur physical processes. Kant's idea to introduce space, based on the specific physical laws. He wrote: "The three-dimensionality possible on what substances act on each other in such a way that the force of action is inversely proportional to the square of the distance.". Obviously, the geometric representation of this law is a sphere. The observer, placed in the center of the sphere, the visual space will be presented three-dimensional. The relativity of space means that it depends on the attitude and the mechanical interaction of bodies among themselves. According to Kant, and three-dimensional Euclidean space, because the forces of interaction between material bodies (the law Cavendish) and electric charge (Coulomb's law) are inversely proportional to the square of the distance. If the particles interact and charges is directly proportional to the law of F = k • x (Gauss's law), the space would become Kant in straight lines radiating from the observer to infinity. This space is no longer would have the continuity, and was to be discrete.

In his article Yu.S.Vladimirov calls and a number of other important issues, which form a part of the solution of the problem of the withdrawal of the classical space-time concepts and laws of physics of the microscopic physics [1]. However, in this paper, we confine ourselves to the above listed four questions, the answers to which can be found in the three laws of J. Kepler formulated it as a result of long-term analysis of astronomical observations of Tycho Brahe in 1609 – 1619y. These laws are:

1. All planets move in elliptical orbits in one of the foci is the Sun;
2. Area of space described by the radius vector of the planet is proportional to the time;
3. The ratio of period squares of any two planets is a ratio of cubes of their large semi-axes of elliptical orbits, along which they rotate around a central body. This implies that the ratio of the cube of the orbit radius to the square of the orbit time of the planet is constant [6].

II. Metaphysics J. Kepler

From Kepler's third law it implies that the five-dimensional world of the universe includes two-dimensional and three-dimensional space time associated constant K:

$$K = \frac{R^3}{T^2} \qquad (1)$$

where

R is a distance from the centre of the planet to the centre of the Sun,

T is complex time, $T = (t + i\tau)$,

t is time of planet movement around the Sun,

τ is the continuous cyclic time equal to the period of rotation of the planet around its own axis, K is Kepler's constant.

Kepler calculated K values for all planets known to him in the Solar System:

$$K = (3.33 – 3.35)10^{24}\ km^3{\cdot}year^{-2}$$

At the same time, the complex time - a time during which the system makes a complete loop in its orbit, and it returns to the initial state in full accord with the first law of Kepler. It returns to the initial state is decisive in the formation of the concept of the "base" and allows you to describe the state of the system (classical and quantum oscillators) symmetric invariant equations, while the system is in a steady state of the integrable. This system corresponds to the concept of the time horizon within which we can predict the state of the system, its development path, and then the initial state of the system cannot serve as a basis for prediction. Transition system to a new level, in which the system to become non-integrable, it is dominated by irreversible processes and loses time invariance property and its state is probabilistic, vector character corresponds to the concept of "layer". The database to describe the state of the system (classical and quantum oscillators) can be used symmetrical, invariant equations, but in the layer to describe irreversible processes require a different mathematical apparatus, that is, they describe different laws that have individual character.

Contemporary physics traditionally assumes that a structure function of particles can be presented either as a time function (time representation), or as a function of an amplitude of frequencies harmonic components (spectral representation).

However, these representations are only equivalent to symmetric invariant processes, while the

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time is definitely connected with the cyclic motion. There will be an error to use the time representation to describe non-invariant, irreversible processes going beyond the time horizon and connected to the probability of systems restructuring, their birth or disappearance. In this case, the adequate description of processes can be only achieved with the spectral representation. Professor at the Moscow State Automobile and Road Technical University, L.G. Sapogin, used the spectral representation of the electron structure function to describe processes of birth and disappearance of particles in his Unitary Quantum Theory (UQT) [16].

One reason for the use of complex numbers in the microcosm and the macrocosm is in the presence of two time dimensions: the real-time evolution of non-invariant systems (t) and imaginary cyclic invariant time (τ). In 1955, M.Bunge introduced the complex time into the theory of electron:

$$T = (t + i\tau)$$

where

t is the time of an electron live in an atom;

τ is the continuous cyclic time, equal to an electron spin period ($\tau = \frac{h}{4\pi mc^2}$ $\tau = 10^{-21}$s.)

Similarly, you can enter the description of the Earth's rotation around the sun complex time Te = (t + íτ), where t- time of a complete revolution of the Earth around the center of gravity of the solar planetary system, and τ- turnover time of the Earth around its own axis.

Regarding the understanding of the dual nature of the time S.Hawking wrote: “There is such a need to understand what is imaginary time – just it is different from the time that we call reality.”[19]

According to Kepler's second law to each point in time is proportional to the area described by the radius vector of the system, and not the path. Toroidal vortex and the nature of micro-movements as well as macroscopic objects in the Universe determined a quadratic definition of measure. This condition is the Heisenberg uncertainty microscopic physics defines the requirement formulated by Max Bohr and consisting in the fact that the physical meaning has only the square of the absolute value of the wave function: it determines the probability density finding the particle at any point in space. From this perspective, there is no contradiction between the wave functions of the Schrödinger and de Broglie: they describe the same probability density of finding a particle at any point in space.

So, using Kepler's laws, its well-known mathematician, physicist and astronomer transtsindentnoe equation (μ=ε-e sinε) can determine the elliptical orbit of any planet of the solar system, or satellite and all its parameters [13]. Kepler's laws of Metaphysics allow you to associate time and space for the undisturbed planetary motion without attracting and neither Newton's law of universal gravitation, no such dynamic concepts like mass, energy, force, angular momentum, and the like Instead of the mass of the central body Kepler used centric constant, which can be extended to both the macro and micro system. Metaphysics Kepler has been further developed in the works of I. Newton, A. Einstein, A. Eddingtona.

III. Metaphysics Isaac Newton, Albert Einstein, Ilya Prigogine

Half a century after Kepler, Newton introduced forces into the spatial model of the universe [7]. The space of the universe produces gravity and inertia forces acting following quadratic laws of interaction between bodies (laws by Coulomb and Cavendish). Having articulated his laws of dynamics and universal gravitation, Newton got Kepler's third law as consequence of the universal gravitation law and the second law of dynamics as follows:

$$K = GM\frac{m\ gr.}{m\ in.} = \frac{R^3}{T^2}. \qquad (2)$$

where

m gr. is the planet gravitational mass, interacting with the Sun, the M mass, produces a centripetal force of gravity;

m in. is the inertial mass of the planet. It is rotating around a circle of R radius and producing a centrifugal force of repulsion,

G is the gravitational constant.

According to Newton's law of universal gravitation planet moves in a stationary orbit only on condition that the centrifugal and centripetal forces acting on the planet are equal, then the equation of Newton and Kepler's law identical for fixed inertial motion systems. In the equation of Newton appears cosmological time (horizon) within which the need to fulfill two conditions:

1) The presence of a planet's gravitational and inertial mass;
2) The simultaneous impact of gravitational and inertial forces.

The criterion for inertial in real processes is the preservation of the relative energy of the interaction between matter and ether provided compensation body forces of their interaction. This means that the movement of a freely falling body in the gravitational field or motion on a circular orbit of the planet may be viewed as inertial. In case of a non-equilibrium state of the system, a speed of a body increases, its vector is constantly changing, there are vortices appearing behind the body. At the same time, an energy of vortices is actively influencing the system "from the outside" (from a side of the environment). Pressure in a vortex area formed behind the body, will be reduced, so the resultant of pressure forces will be non-zero, determining in its turn any resistance. As a result, frontal resistance consists of frictional resistance and pressure resistance. The ratio between the frictional resistance and the pressure resistance depends on the Reynolds number (Re). The more Re is, the more a role of pressure resistance is. Hence, a transition of the system from a stable state to an unstable one, its non-equilibrium state, would be accompanied with a growth of ether's vortices. The growth would counteract a change to the state of the system, i.e. generating an additional field of inertia, which is stronger, when the greater disturbance influences the environment. Let us pay attention to a difference in a value of the Kepler constant K for terrestrial planets, such as the Venus, the Earth, the Mars, rotating along stable, seldom-perturbed orbits, for which value K = 3.35, and the Mercury, the orbit of which is subject to strong perturbations due its close location to the Sun.

For the Mercury, value K is 3.33, that is 1% less than that for planets with stable orbits. Perhaps, this results from vortex ether-dynamic forces in the space environment responding to its perturbation by the Mercury. At the same time, the inertial field increases and because a value of K depends on the ratio of masses, gravitational to inertial (2), we can conclude about a growth of the inertial mass of the Mercur. The nature of inertia is different from that of gravitation. Gravitation is determined by the charge magnitude of the body, while inertia is determined by the presence of electromagnetic cosmic medium (ε, μ) and its source is the induced electric intensity generating force F preventing the accelerated motion of body [13]. Difference is that the inert acceleration is a vector directed in the line of force F, while gravitational acceleration has radial direction and therefore it is scalar with gradient inversely proportional to the value of squared distance. Since the inertial mass is a factor in the acceleration of Newton's second law, the expression (2) made it possible to establish a connection between gravity and electromagnetism long before all the physical theories of the 20th century.

$$F = -\min \cdot \alpha = qE \qquad \min = -\frac{qE}{a} \tag{3}$$

With the General Relativity Theory (GRT), Einstein proposed a new interpretation for acceleration. The acceleration, explained by Newtonian physics in terms of the gravitational interaction, is considered within the GRT as a result of the curved space-time, whereas the inertial motion meets a case of the "flat" space-time. In Einstein's gravitational theory of the curvature of space - time determines the existence of matter-energy. More specifically, general relativity connects two mathematical objects called tensors: on the one hand, the metric tensor, which describes the curvature of space - time, on the other - stress tensor, which determines the distribution of matter in terms of the density of matter - energy and pressure. His equation of Einstein likened to a building, one wing of which is built of precious marbles, and the other - from cheap wood. Indeed, the mathematical form of the tensor is the result of subtle geometric considerations, whereas the stress tensor that specifies the "source" of the curvature of space-time is described in terms of macroscopic concepts of pressure and energy density. Also, to obtain physical meaning of the stress tensor is necessary to introduce additional boundary condition. This condition requires that in the limit of weak gravitational field of Einstein equation reduces to Newton's equation [20]. Stephen Hawking proposed the introduction of imaginary time τ = íst metric in general relativity. If Euclidean space metric is $ds^2 = dx^2 + dy^2 + dz^2$, in general relativity the metric is $ds^2 = c^2dt^2 - (dx^2 + dy^2 + dz^2)$ and imaginary time c^2dt^2 enters $-d^2\tau$. This eliminates the distinction between time and space in the range ds^2 GRT metrics [19]. In the standard model A.Fridmana universe on a large scale can be considered homogeneous and isotropic. Then the metric takes the simple form:

$$ds^2 = c^2dt^2 - R^2(t)dl^2 \tag{4}$$

where dl^2 is spatial element, which may correspond to the zero curvature, either positive or negative curvature (spherical or hyperboloid);

R (t) is the radius of the universe, corresponding to the limiting distance achievable for astronomical observations.

The standard model establishes the relationship between the radius of the universe R (t) and the curvature of space on the one hand and an average density of mass - energy, which is denoted σ, and the pressure P.

Instead of R (t) is often administered to the Hubble function:

$$H = 1/R\,(dR/dt) \tag{5}$$

The ratio between P and density σ is given by the equation of state.

Therefore, in the standard model there are only two independent variables: density function σ and the Hubble H. To define them, you need two equations, which gives Einstein's theory. One of the equations binds Hubble function H with a density of σ; the second equation expresses the adiabatic space evolution of the universe. Adiabatic means that between the environment and the elementary volume in general relativity Einstein's no heat exchange:

$$dQ = 0 \tag{6}$$

In general relativity, Einstein irreversible processes are absent, the entropy of the universe remains constant. Herewith, the true cosmic time, included into the Newton's Second Law, disappeared from consideration. In the standard cosmological model ΛCDM total energy of the universe is assumed to be zero. It can therefore be assumed that H = 0. Therefore, considering the wave function of the universe, from the Schrodinger equation:

$$H\Psi = ih\frac{d\Psi}{dt} \quad (7)$$

It follows that $d\Psi / dt = 0$; the wave function does not depend on the time (equation $H\Psi = 0$ equation is often called the Wheeler – DeWitt Equation). This is a paradox. The cosmological time is excluded from consideration in the flat Minkowski space. However, if we recall the presence of the fiber bundle, consisting of a base and a layer, it can be assumed that the four-dimensional world of Minkowski - Einstein describes only the "base". This is the second boundary condition, in order to GRT stress tensor have physical meaning, the limits of applicability of Einstein's equations for an adequate description of physical reality is the requirement of a stationary state of the system. This state corresponds to the imaginary part of the complex time - cyclical time. The energy of the electromagnetic field W and inertial mass min are linked Einstein's relation:

$$min = W / c^2 \quad (8)$$

Thus, the inertial mass of electromagnetic field in the "base" and "layer" describes the different ratios. In the layer in the formula (3) includes a time; and based in the formula (8) - a constant c^2. The equality of gravitational and inertial masses, as well as the value of the Reynolds number is an indicator of stability of the stationary state of the system.

To describe the evolution of the system, when the system becomes non-integrable and it is dominated by irreversible processes, that is, "Layer", you must appeal to the five-dimensional Kaluza -Eddingtona system. It Eddington was able to show that in the fifth coordinate (pseudo spatial fourth Kaluza) is the cosmological time corresponding to the real part of the complex time. This time is divided into discrete sections - time horizons. Fifth Dimension Eddington has a special status. It does not allow to enter the universe into the Procrustean bed of symmetric invariant solutions of Einstein's theory. . The discovery of the cosmological expansion of the Universe with acceleration, changes our understanding of the present stage of cosmological evolution, current state of the universe. Previously it was thought that the whole history of the cosmological expansion - is the story of its attenuation after the initial "Big Bang". This was built all the inflationary theory of the anisotropy of the universe, the provisions in the standard cosmological model ΛCDM. Now it turns out that just in our time, the dynamics of expansion of the Universe has moved from the stage of the deceleration to the acceleration stage.

As the field of gravity determines the spherical, continuous geometry of space and inertia field determines the linear and discrete geometry of cosmological time, and ultimately, the geometry of space - time determined by the physical properties and the laws of the space environment. In addition, it is the space environment supports the constancy of cosmological density ρv, synchronizing the processes of accelerated expansion of the Universe and the birth matter.

Prigogine, winner of the Nobel Prize wondered: "Is the Universe a closed system in terms of thermodynamics?" Answering to this question, I. Prigogine came to the conclusion that the postulate of the absence of heat exchange between the environment and the volume element (adiabatic process of cosmological evolution $dQ = 0$) is erroneous [14]. Einstein's universe is a closed universe with constant entropy, since in such a universe there are no irreversible processes. Prigogine writes. "In a stable steady condition, an active influence from the outside on the system is negligible, but it can become of major importance when the system goes into a non-equilibrium condition. Herewith, the system becomes non-integrable, the time loses its invariance and its behaviour is probabilistic in nature."[14]. Active contribution of cosmic medium appears in cosmology in the maintenance of constant energy thickness under the accelerated extension of the Universe. V.Rubakov, a member of the Russian Academy of Sciences, writes in his paper « Energy - it is dark matter»: «There is no law of conservation of energy in cosmology. The universe expands, but energy thickness is constant. Volume increases and the energy in that volume increases, too. Where does it come from? Nowhere, no law of conservation of energy » [15].

For a description of the birth of matter in the Einstein's general relativity is necessary to prevent variations in the density of matter due to the production of particles. This leads to disruption in time symmetry. Prigogine proposed to add the number of variables included in the standard model (the pressure P, the mass-energy density σ and the radius of the universe R (t)) an additional variable n - the density of the particles and an additional equation, which would tie the Hubble function of radius of the universe R (t) and the birth of particles n.

In the case of the universe, consisting of particles of the same type of mass M, when the mass-energy density is simply equal to σ, and the pressure P - vanishes, Prigogine offers a simple equation that takes into account the creation of particles:

$$\alpha H^2 = 1/R^2 \,(dnR^3/dt) \quad (9)$$

where α - kinetic constant equal to zero or positive.

In this equation, the value of α and H are positive since we are talking only about the birth (and not destruction) of the particles. In Minkowski space, where $H = 0$, the production of particles can not be. Furthermore, in the universe, where the total number nR^3 constant irrespective H values, $\alpha = 0$ [14]. Further,

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Prigogine And considering how the birth of the particles leads to a modification of Einstein's equations of general relativity in terms of the first and second laws of thermodynamics. The first expresses the beginning of the conservation of energy. But energy can take many different forms. For example, when we abruptly stop the engine, part of the kinetic energy is converted into heat energy inside. In cosmology, so it is necessary to distinguish between the two types of energy: gravity (it is negative) and "internal" associated with mass energy (it is positive). The internal energy can be created at the expense of gravitational energy. Prigogine writes: "This approach leads to a modification of Einstein's equations. In this equation, the term appears, which we, in comparison with Newtonian physics, we identify with the pressure. By normal pressure P, we add additional pressure Radd., Due to the birth of the particles. Pressure is the sum of two terms, one of which corresponds to the usual thermodynamic equation of state, and the other has no analogue in ordinary physics, as relates to the conversion of gravitational energy into matter. Turning to the second law of thermodynamics, we note that the entropy associated with the internal energy, and not with other forms of energy. Since there is a source of internal energy, and there is a source of entropy. In the standard model entropy is conserved. In our model, we have the production of entropy, proportional to the velocity of particles. "[14].

In 1973, Edward Tryon suggested that our universe could have formed as a result of fluctuations of physical vacuum. In this zero-point energy of the universe is formed as the sum of two equal and non-zero values with opposite signs (energy associated with gravity and the energy associated with the mass of Einstein's famous formula $W = mc^2$).

Recognized by the scientific community of Einstein's general relativity theory of gravitation and related nonlinear Limited, a closed universe. But even 23 years before Einstein's general relativity, Heaviside proposed linear equations of gravitation, like Maxwell's equations. These equations agreed well with a number of laws and principles of physics and associated with unrestricted, open universe. This leads to the fact that in theory the Heaviside, as in Newtonian theory, there is a problem of divergence of the gravitational potential, ie the problem of the gravitational paradox in the infinite space filled with matter. However, this difficulty is only in cases where the alleged existence of the substance only on the positive gravitational mass. If we proceed from the assumption of the equality of positive and negative gravitational inertial mass in the universe, the theory of gravitation Heaviside and Newton immediately removed the objections related to the gravitational paradox. In gravidynamics Heaviside appears fundamental position of equality of positive and negative mass, equivalent to a fundamental position of equality of positive and negative electrical charges in electrodynamics [18].

The relativistic Standard Model fails to describe adequately non-integrable, irreversible processes of birth of elementary particles, stars, galaxies and the universe itself. The resonant nature of the pair of elementary particles under the influence of external radiation is a fundamental process of the universe is formed in the space environment divergent flow or drain and source. Direct experimental determination of the resonance dependence of birth N elementary particle pairs of frequency ν is almost completely silenced by modern physics. Following the deceptive logic of the modern theory, this dependence is drawn as a monotonically increasing curve. The space environment is a global field of oscillators' super-positions with the continuum of frequencies. In contrast to the field, a particle oscillates with the same fixed frequency. In front of us, there is an example of the non-integrable Poincare system. Resonances will occur whenever the frequency of the field and the particles are the same. The evolution of dynamical systems (field-particle) up to the self-organized matter depends on available resonances between degrees of freedom. This was a conclusion by I. Prigogine and I. Stengers in their monograph the "Time, Chaos, Quantum"[14]. They revived an idea by N. Tesla on a theory of global resonance. Nevertheless, if the Tesla's resonance theory of the matter birth in the Aether had been based on an intuition of the ingenious experimenter, then in case of I. Prigogine, this theory acquired rigorous mathematical view. Proved by Poincare non-integrable dynamical systems and the theory of resonant trajectories by Kolmogorov-Arnold-Moser allowed Prigogine to conclude that the mechanism of resonance interaction of particles in large-scale Poincare systems (LPS) was "essentially" probable, i.e. binding. With increasing communication parameters, there is an increase in likelihood of resonance outcomes. It is such LPS dynamic systems, to which systems of particle interaction with the space environment and with each other belong. Consider the features of the phenomenon that is the photoelectric effect destruction process photons structural elements of the space environment and the birth of a pair of oppositely charged microparticles (electrons and positrons). The experimental curves of the relative growth of the flow of electrons and positrons in the space environment, since the photon energy for the beginning photoelectric threshold Wk = 1 MeV energy and ending with cosmic radiation 300GeV. Moreover, it has been experimentally established the presence of two photoelectric threshold and two resonant peaks, which may indicate the presence of near-Earth space of the space environment: dark energy and dark matter.The region of ultra-ray energy and, of course, frequencies (including resonant), generating electrons in

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cosmic medium, (1 MeV - 200GeV) [22], has been extended recently with the energy range of ultra-rays generating positrons in cosmic medium (30 GeV - 300GeV) [23]. Using the ISS AMS detector, it was first found that the share of positrons in cosmic media grows no longer with the energy over 200GeV. Increasing contribution of electrons to total positron-electron flow, starting from 30 GeV, was demonstrated before with the PAMELA, Fermi, and some other detectors.Resonance curves birth of electrons and positrons from the virtual micro-particles forming the dipole vortices are shown in Fig.1[3]. The curves are plotted on the materials presented in [22,23].

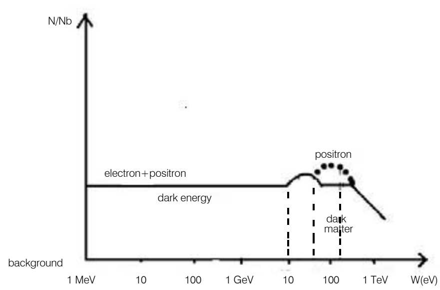

Figure 1: Resonance curves of photoelectric effect in near-Earth medium

Denying the existence of the space environment, modern science is powerless in the face of man-made disasters related to exposure to electromagnetic and gravitational effects arising from the presence of the ethereal sphere of the Earth. Location NPP in areas of tectonic faults, where there is intense electromagnetic and gravitational energy interaction between the liquid magma of the ethereal sphere Earth and to form a toroidal glowing vortex ether size of microparticles to tens of meters (rotator, torsion, yadron), can lead to reversible and irreversible effects up to their complete destruction. According geliemetrii and satellite images most of the nuclear power plant located on tectonic faults which are trace riverbeds [4]. Minor earthquake led to the disastrous consequences of the Chernobyl and Fukushima-1 nuclear power plant, as caused a huge influx of energy from the outside, from the toroidal vortex ether. At the same time plant operation and safety systems have failed because they were designed to incorrect theoretical assumptions that ignore the external electromagnetic and gravitational effects from ethereal sphere Earth. Science for the first time realized the glaring discrepancy between the views of modern physics and traditional real processes taking place in nature, requiring them to account in the design and the greatest caution in NPP. A series of accidents that followed the Chernobyl after the disaster April 26 1986: September 1989. October 1991. February 2000, was accompanied by the formation of luminous disks with a diameter of more than 11 meters (rotator). It should be noted that the risk of another catastrophe at Chernobyl has not disappeared after stopping all the reactors in 2000 because the nuclear fuel in reactors of the station remained. Sarcophagus of the emergency unit and the containers of radioactive waste can be completely destroyed by the gravitational and electromagnetic field ether. A similar pattern is observed in Fokusima-1 nuclear power plant.

Of particular note is a significant interaction of vortices with rotors of electric motors and turbines at the coincidence of their axes of rotation. Experimentally established that, sometimes spontaneously turbine is accelerated and rises along the vertical axis of rotation. This is observed in crustal fault zones. A similar accident occurred August 17, 2009 at the Sayano-Shushenskaya HPP. The turbines of the second hydraulic unit suddenly began to rotate at hypersonic speeds, leading to rupture of the mounting bolts, the destruction of buildings and the death of 75 people.

The land has an electric charge, which, due to the Coulomb repulsion tends to the spherical surface of the planet. The process of electrification of the near-Earth environment can be described as a state of flow of an incompressible fluid. The energy is transmitted primarily along the curve - the shortest path between the source and the receiver on the Earth's surface. current distribution of "electric fluid" on the Earth's surface can be represented analytically, as the theory of a stationary, two-dimensional ideal incompressible fluid on the Riemann surface.

IV. Metaphysics Arthur Eddington

In the 20th century, many scientists including Albert Einstein undertook repeated unsuccessful efforts to unite gravitation and electromagnetism geometrically in the framework of four dimensions of Minkowski continuum, and only T.Kaluza has managed to do it, but in the five-dimensional formal world of four spatial dimensions and one time dimension. Eddington's statement that «a matter particle understood as a population of events is a system the linear extent of which has a time character» allowed him to pass on to the five-dimensional Kaluza theory. Here absolutely implicit physical meaning of the Kaluza fifth coordinate (hidden dimensions) becomes the real pseudo-spatial x5-coordinate. Eddington five-dimensional world absorbed all the advantages of the Kaluza five-dimensional world over the planar four-dimensional Minkowski continuum, allowed to reveal the connection between macrocosm, including space-time vision, and microcosm with the charge and mass of elementary particles, with presence of cosmic environment (uranoid), with the existence of electromagnetic vector and scalar fields. Eddington’s uranoid includes electrically neutral environment and equality of particles with opposite charges and the left and right polarization [2]. This fifth component of the velocity of the particle has the physical meaning of the ratio of electric charge q to the mass m of the particle, which is included in the dimensional coefficient G - Newton's gravitational constant. The fifth equation of a geodesic is constant ratio q / m for the current state of the planets in the solar system (the current time horizon). Justice is even a statement that the momentum of the particles of the fifth coordinate is meaningful electric charge (up to a dimensional constant c / 2√G) [7].

Spatial and temporal diversity of different dimensions different properties introduced into these discrete transformations P-space conversion, the conversion time T and C charge conjugation. Eddington found equality in Uranoide particle systems with different properties.

The 5-dimensional manifold instead of the square of the 4-dimensional interval $ds^2 = g_{a\beta}\, dx^a dx^\beta$ should take $dl^2 = GAB\, dx^A\, dx^B$, where the indices A and B have the meanings: 0, 1, 2, 3, 5. GAB values are components of the five-dimensional metric tensor. They form a square matrix having a generally 15 independent components:

$$GAB = \begin{matrix} G00 & G01 & G02 & G03 & G05 \\ G10 & G11 & G12 & G13 & G15 \\ G20 & G21 & G22 & G23 & G25 \\ G30 & G31 & G32 & G33 & G35 \\ G50 & G51 & G52 & G53 & G55 \end{matrix} \qquad (10)$$

In the curved Riemannian space-time, operating with the components of five-dimensional metric tensor, one can obtain ten components of metric tensor of the Einstein's general theory of relativity, four components of electromagnetic vector potential **A** of the Maxwell theory, and one component which theoretically can describe any new scalar field [7].

Tomsk physicist G.Nikolaev, using the single-valued magnitude of physical property of vector potential **A** and moving charge **e**, at (v « c) [8]

$$A = ev/cr, \qquad (11)$$

ascertained existence of two types of magnetic fields in the space around it:

$$\text{vector field } H^{\perp} = \text{rot}A \qquad (12)$$

$$\text{scalar field } H\| = \text{- diva} \qquad (13)$$

It is generally accepted that if the magnetic field H is known, there is no need to refer to "formal" vector potential A. However, the mere fact that the Schrödinger wave equation appears only vector potential was obvious since the inception of this equation. Unsuccessful attempts to replace the vector potential A in the equations of quantum mechanics "physical" magnetic field H is said that the wave function of any moving charge in the field of the vector potential A, should reflect the existence of a quite tangible interaction between a moving charge with this field. This interaction can be characterized by the magnitude of potential change and the wave function. Experimental observation of the phenomenon of power interaction effect of moving along the axis of the current toroyda electrons with the field of the vector potential A in the experiments of the Aharonov-Bohm (1956) [9], has been confirmed in later experiments by Japanese scientists (1984) [10]. During the experiments it was found change in the phase of the wave function of a moving charge in the absence and presence in the study area of the field of the vector potential A, in the absence of space in the magnetic field H. The positive results of the experiments corresponded to only single digits of the vector potential A, is compared with the same parameters unambiguous elemental current. Changing the phase of the wave function of the vector potential A is given by:

$$\Delta\varphi = q / \hbar \int A ds, \qquad (14)$$

where the integral is taken along the particle's trajectory.

Experimental discovery of the phenomenon of longitudinal force effect of interaction along the axis of current toroid of electrons with the field of vector potential **A** in the experiments of Aharonov-Bohm make one revise the well-established view about the transverse magnetic Lorentz forces alone and accept the presence of longitudinal forces of magnetic interaction. The presence of scalar magnetic field generates forces acting on the charge in the line of the velocity of its motion. The presented approach to the problem of improving the Maxwell's electrodynamics is used by many authors. For example, the author of [21] proposes to abandon the Lorentz calibration, and replace it with a new expression for the electromagnetic energy flux density:

$$S = \text{- div } A - \lambda\varepsilon 0\mu 0\, d\varphi/dt \qquad (15)$$

Obviously, potentials imposed thus allow great flexibility in the use of Maxwell's equations. In the classical case relies S = 0. When using the calibration (15) at λ = 0 we obtain the Coulomb gauge, and at λ = 1 we have the Lorentz calibration. If S is not equal to zero, then for λ = 0 the scalar field acquires the meaning of a longitudinal magnetic field in Nikolaev theory. Further transformations are carried out in a standard way. As a result, we obtain the following system of equations:

$$\begin{aligned} &dE/dt - \text{rot}H - \text{grad } S = 0, \\ &dH/dt + \text{rot}E = 0, \qquad (16) \\ &\text{div } E - dS/dt = 0, \\ &\text{div } H = 0 \end{aligned}$$

For ease of reference the equations (16), the case of absence of currents and charges and accepted ε0 = μ0 = 1 [21].

Under the new theory of electrodynamics, many phenomena have found their explanations, such as motion of U-shaped conductor, an issue of railgun engine (railgun gun) and results of Aronov-Bohm experiments, for which, going from transverse Lorentz forces, there has been no correct explanation found. Thus, we can conclude that inherent in Maxwell's electrodynamics original idea of a vector magnetic field $H^{\perp}$ = rotA, in the apparent disregard of another scalar magnetic field $H\|$ = - divA erroneous [8]. As for not invariant equations of electrodynamics, it is due not so much the existence of scalar magnetic field as an assumption reality of the environment and taking into account the effects of delayed potentials and deformation of the electric field of moving charges. Full invariance of the equations of electrodynamics is valid only in a completely empty space Einstein's SRT. This leads to the conclusion that in principle not possible to create a fusion reactor based on tokamak. Particles of hot plasma in tokamak trapped rush by the magnetic field lines of arbitrary topology to the walls of the tokamak and destroy it.

In the 21st century, analyzing the anisotropy of the thermal background radiation of the universe, it was found that in addition to the forces of gravity and inertia in the cosmos operates more longitudinal force causes the movement of our solar system to the point of "Apex of the Sun", located in the constellation of Leo [11] or Hercules [12]. Staff at the Pulkovo Observatory AA Shpitalnaya A.A.Efimov and found that the anisotropy of time-dependent processes of flare activity of the Sun, earthquakes with magnitude M> 7, the coordinates perihelions comets with parabolic orbits relative to the "fixed" space around the sun is caused by the three mutually orthogonal forces. On the basis of a large number of observations of phenomena of different nature in the solar space they were able to build a triaxial ellipsoid anisotropy orthogonal forces which are directed respectively in the center of the Galaxy, at the apex of the sun and the axis of rotation of the Sun (this direction is almost perpendicular to the direction of the center of the galaxy). It should be noted that the results are quite reliable. Statistical evaluation of the significance of the results is 8σ, where σ - standard random variable [11]. If the nature of the first two forces due to gravity and inertia of Newton, the nature of the longitudinal force directed along the axis of rotation of the Sun can be explained by the existence of a scalar magnetic field, along with the well-known vector magnetic field. Taking into account all the properties of the magnetic field immediately reveals the existence of another and the longitudinal forces of magnetic interaction, greatly differs from the known Lorentz force. Availability scalar magnetic field generates forces on the charge in the direction of its velocity. [8]

Based on the fact of the real existence of bias currents (jb) in the physical environment around a moving charge jb = $1/4\pi\ \partial E / \partial t$, Nikolaev established a functional relationship of these currents induced by them on the basis of short-range magnetic fields:

$$H^{\perp} = 1/c\ 2jb\| / ro = 1/c\ ev/r^2 \sin\varphi,$$

$$H\| = 1/c\ 2jb^{\perp} / xo = 1/c\ ev/r^2 \cos\varphi, \qquad (17)$$

where: $$jb\| = \int so\ jb\|\ dS,$$

$$jb^{\perp} = \int s\sigma\ jb^{\perp}\ dS, \qquad (18)$$

$$(jb = jb\| + jb^{\perp})$$

The surface SO restrict axial flow of the bias current jb ‖. On its outer surface is determined by the intensity of the magnetic field vector $H^{\perp}$. Surface Sσ restricts radial flux bias current $jb^{\perp}$. On its outer surface is defined by the inner strength of the magnetic field H‖ [8].

Considering that on the surface of the Sun is concentrated electric charge Q ≈1,7•10[2°]Kl. and the outer sphere flowing currents, creating a magnetic field H≈80α / m (stained H≈ 10^5α / m), you can imagine the magnitude of the longitudinal forces, forces to move the sun along with the planets of the solar system to its apex at a speed of 330km / s. The result of the new longitudinal force is a collision of galaxies. This process is accompanied by the absorption of smaller galaxies, large galaxies and the formation of powerful gravitational waves. Instead of fading gravitational waves left in the universe after the mythical "Big Bang", the scientists found quite noticeable gravitational waves, born in the collision of galaxies and black holes. Here I would like to point out that even In 1994, when the July 16, 1994. great nucleus of the comet Shoemaker-Levy collided with Jupiter gas sphere, radial oscillations gave rise to the surface gravity waves, instantly resulted in fluctuations in several geodetic satellite command-measuring complex of Russia. Usually geodetic satellites orbit are located inside the tube of about 1 km in diameter. The collision between the diameter of the path of the tube increased by 5 - 8 times. Speed, formed by the collision of a comet with Jupiter, gravitational waves significantly exceeded the velocity of electromagnetic waves (light from Jupiter to Earth is about 1 hour). Thus, the Russian military ahead of American scientists with the discovery of gravitational waves (LIGO project) for 22 years and were even able to roughly estimate their speed of propagation in space.

V. Results and Discussion

In recent years, many studies are recommended to refuse the Minkowski space as a geometric space-time model. At the same time, it is obvious that the Minkowski space, as well as its attempt to generalize to the case of the accelerated movement - Einstein's general theory of relativity can not be regarded as a basic model for describing the universe. Fifth

Dimensional World A.Eddingtona includes all the advantages of a flat Minkowski four-dimensional continuum. He showed the connection of the macrocosm, including spatiotemporal representations, with the microcosm, with the charge and the mass of elementary particles, the presence of the space environment (ether), the existence of vector and scalar fields. Why Eddington theory did not become a working tool for physicists? The reasons for this are subjective in many ways. The scientific elite does not accept such notions as "space environment" (in the sense of ether) and the "arrow of time" (in the sense of the evolution of systems). Of course, the decisive factor in this was that Eddington has not had time to finish his book and his attempt to display the classical concepts of space-time physics microcosm remained unfinished. But he built a bridge between metaphysics and modern physics. To create a cosmological model of the universe, which adequately reflects the physical reality, science must recognize the existence of the space environment (ether), defining a continuous space of spherical geometry and discrete geometry of complex time.

VI. Conclusion

In conclusion, I should note that condescending, patronizing tone of our scholars to address the heritage of J. Kepler speaks only about how little we appreciate the scientific heritage left to us by the geniuses of the past, and how we relate to surface it. Mathematical abstraction of modern twistor theory and R. Penrose quaternion theory A.Efimova, although it allows to remove a large number of mathematical models that make it possible to build a physical theory based on fundamental relationships, can not replace the physical reality, to comprehend the phenomena of nature and experiments. Metaphysical, mystical relationship of mathematics and physics is manifested in the fact that formally derived mathematical conclusions can find the real proof in the real physical world and it gives researchers a subjective ability to detect new types of interactions. In a relational theory of binary geometrophysics Yu. S. Vladimirov postulated axiom systems of relations, indicating that the a priori theory of incompleteness and physical processes are considered from the position of the observer. The incompleteness of the theory may be the result of it is a subjective approach. This is facilitated by the methodology of physics, based on the postulation of relations between the undefined concept, which is in the words of Academician O. A. Osipov “clearly speculative in nature, setting the level of science.” In the book "Physics Philosophy" M. Bunge stated: “In physics, philosophy operationalism established. It is considered that character as well as the equation has the physical meaning only to the extent that it relates to some possible operations person. This leads to the assertion that physics as a whole – is the science of operations, mainly measuring and computing, not the science of nature. That is to say, physics is related precisely to the subjective experience rather than objective reality”[17]. Relativistic invariance, which has at its core the subjective space -time presentation is not consistent with the quantum-mechanical nonlocality, has an objective character. This reflects a deep internal contradiction of quantum-relativistic field theory, leads to insurmountable difficulties in solving the problems of the quantum theory of gravity unified theories and output space-time representations of the physics of the microscopic physics.

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Relative Time Delay and Absolute Time Delay

By Kexin Yao
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Abstract- This paper has explained that, the motion can be divided into two types, i.e. relative motion between two objects and circular motion unrelated to relative motion (also known as absolute motion). Time delay resulted from relative motion is referred to as relative time delay; time delay caused by circular motion is referred to as absolute time delay. Relative time delay refers to a time delay effect obtained by an observer when observing another reference system being in motion; absolute time delay refers to a real time delay of object being in motion. It is deduced that, the only way for human beings to achieve a real time delay situation is that: An observer can travel around the planet by spacecraft. The analyzed results show that, it is impossible for black hole to exist as a real matter. As a result, the time delay obtained after traveling around fixed star A1 by spacecraft shall be considered as the maximum absolute time delay obtained by human beings.

Keywords: *special relativity, time interval, relative velocity, relative time delay, circular motion, absolute time delay, equivalence principle, black hole, time travel.*

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RELATIVETIMEDELAYANDABSOLUTETIMEDELAY

Strictly as per the compliance and regulations of :

Relative Time Delay and Absolute Time Delay

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Keywords: special relativity, time interval, relative velocity, relative time delay, circular motion, absolute time delay, equivalence principle, black hole, time travel.

I. Introduction

A represents a stationary object; M represents its rest mass; L represents its length; T (T_2-T_1) represents its time interval. Now, according to special relativity, when A is in motion at velocity V, the mass of A will be increased to $M'=M/\sqrt{1-V^2/C^2}$; the length of A will be shortened to $L'=L\sqrt{1-V^2/C^2}$; the time interval of A will be reduced to $T'=T\sqrt{1-V^2/C^2}$. T' shall be less than T, which indicates that, the clock motion velocity is low, i.e. time delay.

In the opinion of an observer being in motion at the same velocity V as A, A is still stationary; the mass of A is still expressed as M; the length of A is still expressed as L; however, the time interval observed by the observer is not expressed as T. For the most obvious example, the particle lifetime can be determined by a synchrocyclotron. This example demonstrates that, in the synchrocyclotron, the real time interval of the particle being in motion at velocity V is expressed as $T'=T\sqrt{1-V^2/C^2}$, that is, when the observer observes that the particle being in relative motion is stationary, the real time interval of the particle observed has been changed from T to $T'=T\sqrt{1-V^2/C^2}$. Based on this fact, most of us may consider that, relative to the object being in motion at velocity V, its real clock time interval is expressed as $T'=T\sqrt{1-V^2/C^2}$. However, if this assumption is correct, the motion velocity of A observed by me will be expressed as V_1; the motion velocity of A observed by a walker will be expressed as V_2; the motion velocity of A observed by a runner will be expressed as V_3, and so forth, then the real time interval of A must be consistent with the different conclusions deduced from everyone, i.e. $T'=T\sqrt{1-V_1^2/C^2}=T\sqrt{1-V_2^2/C^2}=T\sqrt{1-V_3^2/C^2}$ Obviously, it is impossible for such an only T' accepted by everyone to exist. This means that, it is impossible for the real time interval of A being in motion at V to be expressed as $T'=T\sqrt{1-V^2/C^2}$.

Moreover, when observing that A is in motion at V, we may consider that the time interval of A shall be expressed as $T'=T\sqrt{1-V^2/C^2}$; relatively, when A observes that we are in motion at the same velocity V, A may also inevitably considers that our own time interval shall also be expressed as $T'=T\sqrt{1-V^2/C^2}$. This is the well-known twin paradox problem, namely, for twins A and B being in relative motion, when A observes B in motion, A considers that B shall become younger than A; relatively, when B observes A in motion, B also considers that A shall inevitably become younger than B. So far, there is no compelling scientific rigor explanation of this contradictory problem.

The above-mentioned untenable problems show that, we currently yet fail to come up with clear and scientific explanations for the time delay. Therefore, it is quite necessary to further analyze and explore the time delay.

II. Two Types of Motion

In general, the motion of an object is relative. For example, someone falls asleep before the train starts; when he wakes up, the train has already started moving; however, he did not know the train had got under way; then he saw a train moving in the opposite direction; his first response would be that the opposite train was traveling. This situation shows that, A being in motion observes that non-moving B is also in motion, i.e. the motion of an object is relative.

However, another motion - circular motion is not relative. For example, generally, the playground would be equipped with a ferris wheel. All people on the ground can observe that, one person in the ferris wheel cabin is being rotated around the center of the ferris wheel, while the person in the ferris wheel cabin can also observe that he is being rotated around the center of the ferris wheel. Obviously, this is different from the fact that both sides evolved in a relative motion will consider that the opposite side is in motion. The circular motion of the ferris wheel cabin refers to a motion

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acceptable to both the person in the ferris wheel cabin and the center of the ferris wheel (including the stationary ground relative to the center of the ferris wheel) as accepted by both sides. Naturally, it is also recognized that, both the center of the ferris wheel and the ground fail to be in motion accordingly.

The above analyzed results show that, motion can be divided into two types, i.e. relative motion in which both sides consider that the opposite side is in motion; and circular motion in which both sides recognize that only one side is in motion. In the universe, circular motion can be found in such forms as the Earth moves around the Sun; and the Moon moves around the Earth, etc. Such a circular motion shall be referred to as the accepted motion, and defined as absolute motion; the circular motion velocity shall be defined as absolute velocity; naturally, the relative motion velocity shall be defined as relative velocity accordingly.

If the rotational velocity of an object being in circular motion is set as V, and the time interval of the center of rotation is set as T, then according to the special relativity, the time interval of the object being in circular motion shall be inevitably expressed as:

$$T' = T\sqrt{1-V^2/C^2} \tag{1}$$

Obviously, here T' represents the time interval between the object being in circular motion and the center of circle. Such T' is not relative, but absolute. Relative to, T' is reduced. A reduced T' indicates that, the time motion velocity is low, i.e. time delay. Such accepted time delay T' shall be defined as absolute time delay, e.g. time delay of the Earth relative to the Sun, time delay of the Moon relative to the Earth, etc.

Next, when it comes to the time motion condition, we will only use the term time interval; when the time interval is relatively reduced, it shall be referred to as time delay.

There are a variety of circular motions in the universe; each has its own different absolute velocity and absolute time delay. The how to compare with their sizes of motion? First of all, there must be a standard to make comparison. For us, of course, the time interval T of the rotation center of the Earth (i.e. the Earth's south and north poles, say 1 hour) shall prevail.

Relative to T, the time interval T_m of the Moon is reduced, i.e. T_m in relation to T is time delay. Assuming that the Moon moves around the Earth at a velocity of V_m, then the time interval of the Moon shall be expressed as:

$$T_m = T\sqrt{1-V_m^2/C^2} \tag{2}$$

If the Earth moves around the Sun at V, and the time interval of the Sun is expressed as T_0, then it can derived that $T = T_0\sqrt{1-V^2/C^2}$, namely,

$$T_0 = T\Big/\sqrt{1-V^2/C^2} \tag{3}$$

Obviously, T_0 is greater than T, so T_0 can not be referred to as time delay. If a certain planet of the Sun moves around it at V_x, the time interval of x planet shall be expressed as:

$$T_x = T_0\sqrt{1-V_x^2/C^2} = T\sqrt{1-V_x^2/C^2}\Big/\sqrt{1-V^2/C^2} \tag{4}$$

It can be observed that, if $V_x > V$, then $T_x < T$. Relative to T, T_x shall be defined as time delay; on the contrary, the time speeds up.

If a certain satellite moves around the Moon at V_s, then the time delay of the Moon's satellite shall be expressed as:

$$T_s = T_m\sqrt{1-V_s^2/C^2} = T\sqrt{1-V_s^2/C^2}\sqrt{1-V_m{}^2/C^2} \tag{5}$$

The comparison between time intervals of other objects being in circular motion can be analogized according to the above calculation methods.

Not only does each celestial body in the universe have its own different time interval, but also each generally rotates by itself. Relative to the axis of rotation, the celestial body has its different velocity of rotation at different locations; there is also a difference between time intervals. In the case of the Earth, the equatorial radius of the Earth is about 6,378km; it takes 24 hours for the Earth to rotate around its axis once; the velocity of rotation of the Earth's land surface can be calculated as 0.464km/s. Along with an increase in terrestrial latitude, the velocity of rotation of different points on the Earth's land surface will be decreased. If the terrestrial latitude somewhere on the Earth is expressed as θ, then the velocity of rotation of this point relative to the axis here shall be expressed as $V_\theta = 0.464\cos\theta km/s$; the time interval at this point shall be expressed as:

$$T_\theta = T\sqrt{1-0.2153\cos^2\theta/C^2} \tag{6}$$

It is concluded from the above analysis that, any celestial body or its different location has its own fixed time interval. The locations with the same time interval can be divided into equal time interval zones. For example, the Earth's surface with the same latitude can be divided into equal time interval zones. If a certain object is placed at T_1 time zone, the time motion velocity of such object will be operated as per T_1; if such object is placed at T_2 time zone, its time motion velocity will be operated as per T_2, and so on.

III. Experiment Conducted by J•C•Hafele and R•E•Keating

In 1971, J· C· Hafele and R· E· Keating carried out an experiment for a relationship between time delay

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and motion velocity. They placed four caesium atomic clocks on an aircraft stopping near the equator. After the aircraft traveled along the equator from east to west so as to make a complete cycle around the Earth; it was found that, the average reading of the four caesium atomic clocks was 273×10^{-9} seconds faster than that of the caesium atomic clock placed on the ground (surface phenomenon was negative time delay). However, after the aircraft traveled along the equator from west to east so as to make a complete cycle around the Earth; it was found that, the average reading of the four caesium atomic clocks was 59×10^{-9} seconds slower than that of the caesium atomic clock placed on the ground (Reference 1). Why would such a result occur? As previously described, the absolute time delay of an object or any point on the ground relative to the Earth's axis shall depend on its motion velocity relative to the Earth's axis. When both the aircraft and equatorial ground are rotating around the Earth's axis, the velocity of rotation of equatorial ground around the Earth's axis shall be set as V_1; the flight velocity of the aircraft shall be set as V. When the aircraft is flying to the west, the motion direction of the aircraft is opposite to the direction of the Earth's rotation; the actual velocity of rotation of the aircraft around the Earth's axis shall be set as $V_2 = V_1 - V$. When the aircraft is flying to the east, the motion direction of the aircraft is consistent with the direction of the Earth's rotation; the actual velocity of rotation of the aircraft around the Earth's axis shall be set as $V_3 = V_1 + V$. It can thus be seen that, the time interval of equatorial ground relative to the Earth's axis (time interval T) shall be expressed as $T_1 = T\sqrt{1-V_1^2/C^2}$; the time interval of aircraft to the west relative to the Earth's axis shall be expressed as $T_2 = T\sqrt{1-(V_1-V)^2/C^2}$; the time interval of the aircraft to the east relative to the Earth's axis shall be expressed as $T_3 = T\sqrt{1-(V_1+V)^2/C^2}$. Obviously, if $T_2 > T_1$, namely, the time motion velocity of the aircraft to the west is faster; in relation to the Earth's axis, the absolute time delay of the aircraft to the west is less than the absolute time delay of equatorial ground (T_2 is large; time delay is small); if $T_3 < T_1$, the absolute time delay of the aircraft to the east is greater than the absolute time delay of the equatorial ground. J· C· Hafele and R· E· Keating drew the following conclusions by calculations on the basis of such difference: The caesium atomic clock on the aircraft to the west should be 275×10^{-9} faster than the caesium atomic clock on equatorial ground, which is consistent with the measured readings. In addition, they reckoned from $T_3\square T_1$ that the caesium atomic clock on the aircraft to the east should be 40×10^{-9} slower than the caesium atomic clock on the equatorial ground. Outwardly, although there is a major difference between this result and the measured readings (59×10^{-9} seconds), this is only a comparison difference, rather than a calculation error. For example, if the height of a wall is up to 300cm, and the height of a tree is up to 301cm; then the tree is 1cm higher than the wall. However, if the calculated height of the tree is up to 304cm; then the tree is 4cm higher than the wall according to calculations. Obviously, there is a major difference between 4 and 1; however, this difference should be considered as a comparison difference, rather than a calculation error. The calculation error shall be considered as the error between 304 and 301, i.e. the error is less than one percent (1%).

In accordance with our requirements, one hour of the equatorial caesium atomic clock, i.e. 3,600 seconds, shall be set as the standard time interval T. When the equatorial caesium atomic clock has gone forward by 50T (i.e. 1.8×10^5 seconds) after the aircraft completes one circle around the Earth, the measured motion time of the caesium atomic clock on the aircraft to the east should be $50T_3 = 1.8\times10^5\text{s} - 59\times10^{-9}\text{s}$; while the theoretically calculated motion time of the caesium atomic clock was $50T_3' = 1.8\times10^5\text{s} - 40\times10^{-9}\text{s}$. The ratio between the calculated value and the measured value (T_3'/T_3) can be expressed as $(1.8\times10^5 - 40\times10^{-9})/(1.8\times10^5 - 59\times10^{-9})$. Thus it can be seen that, there is a relatively small error between the theoretically calculated value T_3' and the measured value. Therefore, we may consider that, the analysis results are consistent with the experimental results as obtained by J· C· Hafele and R· E· Keating.

The experimental results obtained by J· C· Hafele and R· E· Keating have proved that, the velocity of rotation of the equatorial ground, the aircraft to the west or the aircraft to the east around the Earth's axis should be referred to as absolute velocity; They also demonstrated that the circular motion velocity shall be referred to as absolute velocity; the circular motion time delay as absolute time delay. Moreover, it shows the appropriateness of the method for determining the time interval as per the division of time zones.

IV. Analysis of Time Delay

Suppose that an aircraft's flight velocity reaches up to $\sqrt{3}C/2$, i.e. 260,000 km/s, it seems to the people on the ground that the time interval T' of the aircraft would be consequentially equivalent to $1/2$ of the surface interval time T regardless of the direction in which the aircraft is traveling. This is an incontestable conclusion of special relativity. Therefore, if one of the lights outside the aircraft is on for 1‰ of a millisecond, then the people on the ground will consequentially observe that the light is on for 2‰ of a millisecond, and that the light has trailed a stream of light (260m×2=520m). The similar muon lifetime experiment has proved this conclusion. Since the conclusion on time delay will not be changed as a result of the magnitude of the flight velocity of the aircraft, in the experiments conducted by J· C· Hafele and R· E· Keating, people on the equatorial

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ground are supposed to observe that, the time delay results of the aircraft to the east shall be identical with those of the aircraft to the west. However, the experimental results show that, the time delay results of the aircraft to the east are opposite to those of the aircraft to the west, especially the time of the aircraft to the west, instead of being delayed, speeds up. It is proved beyond doubt that, the relative time delay judged by the people as per the relative velocity is fundamentally different from the real absolute time delay of a moving object. The experimental results obtained by J· C· Hafele and R· E· Keating affirmed the correctness of the method for calculating the absolute time delay as per the circular motion velocity. Moreover, the muon and π meson lifetime experiments have also confirmed that, the relative time delay should be considered as a real observation. How to understand the two seemingly different but truthful judgments?

In connection with any changes in the length of an object, we may understand the above-mentioned two different judgments. As we know, when an object is in motion at a velocity V, the length L of the object along the direction of motion will be shortened as $L'=L\big/\sqrt{1-V^2/C^2}$. We observe that, L' of the object being in motion is real, but the length L of the object is also real without any changes, i.e. both L and L' are real. Observers using different reference systems should obtain such an observation. Changes in time are similar to changes in length. That there is the distinction between relative time delay and absolute time delay with respect to time should also be observed by observers using different reference systems.

Why is there a difference between the observations of the aircraft to the east and the aircraft to the west? The reason is that, the absolute velocity of the aircraft to the west shall be expressed as V_1-V; the absolute velocity of the aircraft to the east shall be expressed as V_1+V.

Changes in length and time are related to the motion velocity observed by the observer. The observer on the equatorial ground being in motion at a velocity V_1 observes that, the relative velocity of the aircraft to the west or the aircraft to the east relative to him cab both be expressed as V; both the length contraction and time delay of the two aircraft are naturally identical. However, an observer not standing on the equatorial ground will not observe that, the relative velocity of the aircraft to the west is identical with the relative velocity of the aircraft to the east relative to him. For example, an observer on the Earth's north or south pole observes that, the relative velocity of the aircraft to the west relative to him is expressed as V_1-V, while the relative velocity of the aircraft to the east relative to him is expressed as V_1+V; both the length contraction and time delay of the two aircraft are significantly different. That is, observers using different reference systems will observe that, the same object will be provided with different length contractions and relative time delay, which, though different, shall be both considered as the real observation.

Under normal circumstances, the relative time delay is different from the absolute time delay. However, if an observer is located at the center of a circle of the object being in circular motion or within the stationary area relative to this center of a circle, i.e. the area where the absolute motion of the object has been accepted as mentioned before, then the observer will observe the relative velocity of the object being in circular motion relative to him, i.e. the absolute velocity of the object being in circular motion; the relative time delay of the object shall be referred to as the absolute time delay. For example, the relative time delay of the particle being in circular motion in synchrocyclotron as observed by us shall be referred to as the real absolute time delay of the particle.

The experimental results obtained by J· C· Hafele and R· E· Keating show that, when a stationary object undergoes a motion process before returning back to rest, the rest length and rest mass of the object will not be changed, while the time progress of the moving object is different from the time progress of a non-moving object. (When the aircraft returns to the ground, the time progress of the aircraft's caesium atomic clock is different from the time progress of the ground caesium atomic clock). Also, such changes in time progress shall be related to the motion history of an object, e.g. the aircraft's flight direction, velocity, flight time, etc.

Based on the foregoing analyses, we can easily calculate the corresponding time process with respect to different motion histories of an object. For example, according to the time standard of one hour (as expressed in h) relative to the Earth's axis, we can leave a clock at the terrestrial latitude (45°) on the Earth for n_1h, then on the Moon for n_2h and then on the Sun's x planet for n_3h, and then return it to the ground. According to the above motion history, we can calculate the cumulative absolute time process of this clock as per the following formula:

$$\left(n_1\sqrt{1-0.2153/2C^2}+n_2\sqrt{1-V_m^2/C^2}+n_3\sqrt{1-V_x^2/C^2}\Big/\sqrt{1-V^2/C^2}\right)h$$

We can give a very simple and clear explanation of the twin paradox problem. For example, twins A and B can be placed at two locations with an absolute time interval of T_A and T_B; if T_A is less than T_B, i.e. the time motion velocity of time zone T_A is slow, when A and B meet each other at one location after a period of time, A will inevitably become younger than B; on the contrary, if T_A is greater than T_B, B will inevitably become younger than A. Taking the experiment conducted by J· C· Hafele and R· E· Keating as an example, suppose B is located on the equatorial ground, when A travels by aircraft to the east around the Earth and then returns to the ground to meet B after a period of time, A will inevitably become younger than B; however, when A travels by aircraft to the west around the Earth and then returns to the ground to meet B after a period of time, B will inevitably become younger than A.

V. Maximum Absolute Time Delay

By using the synchrocyclotron, human beings can accelerate the absolute velocity of particles so as to be close to the speed of light, so as to extend the life of particles by dozens of times. However, for an object with a certain mass, even only with one gram of mass, human beings have not yet accelerated the velocity of such object so as to be close to the speed of light; it is more difficult to accelerate the velocity of an object with one gram of mass to 0.1C than to send a one-ton-heavy-object to the moon. However, It can't be ruled out that, along with progress of technologies, it is possible for human beings to accelerate the velocity of heavy objects so as to be close to the speed of light. So, there is a traveling theory that human beings might extend their life by several times by taking a spacecraft with a velocity close to the speed of light. However, from theoretical analysis, time travel should be impossible.

As previously described, only an object being in circular motion can be provided with absolute velocity and absolute time delay; moreover, only the circular motion can be provided with the eternally unchangeable state of moving in cycles. For example, the motion of the Moon and the Sun's planets are eternal. The linear motion can only be provided with the relative velocity and relative time delay, going away forever, infinitely apart from an starting point as time goes on, that is, unrelated to the time travel of human beings. Therefore, when discussing the time delay, we will only analyze the situation of the circular motion.

By using a synchronization, the motion velocity of particles can be accelerated so as to be close to the speed of light; however, when the human travels by spacecraft, it is impossible to achieve a high-speed motion in the corresponding synchrocyclotron. The main reason is not that it is difficult to make a magnificent spacecraft synchrocyclotron, but that human beings can not bear the centrifugal force generated in such high-speed circular motion. Calculations show that, if the human has reached a motion velocity of one ten thousandth of the speed of light (i.e. V=30km/s; the mass of the human can be taken as per 50Kg; the radius of the synchronization is assumed as 50km), the centrifugal force to be borne by the human will be up to 90,000N [equivalent to 1,800 times of a human's gravity (about 500 N)]. It is very difficult for the human to bear such a large centrifugal force.

Since the universal gravitation between planets in the universe (its mass being expressed as M) can counteract the centrifugal force generated in circular motion, a realistic approach for human beings to obtain the absolute velocity and absolute time delay is by traveling around the planet in spacecraft, Assuming the mass of a human being is m, the radius of rotation of m around M is R, and the velocity of rotation is V, then the centrifugal force mV^2/R will be inevitably equivalent to the universal gravitation GMm/R^2 (G-gravitational constant) when the rotation of m around M reaches a stable equilibrium state. It can thus be obtained:

$$V = \sqrt{GM/R} \quad (7)$$

However, formula (7) only applies to the object being in low-speed motion. If the velocity of rotation of the object is high, formula (7) shall not apply. The main reasons are as follows:

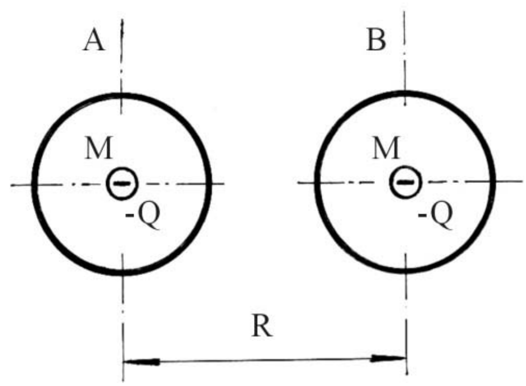

Fig. 1: The gravitational mass of an object being a constant unrelated to motion

As shown in the Figure above, both object A and B have the same mass M, carry the equivalent negative charge -Q; the distance between them is set as R. If the mutual gravitation between A and B happens to be equivalent to the repulsive force mutually generated by the negative charge -Q contained in them, A and B shall be in an equilibrium state. The distance between object A and B is constant without any changes.

It appears to another observer being in motion at any arbitrary velocity V that A and B shall be inevitably in an equilibrium state; he will not see A and B come into collision with or gradually separate from each other. The only possibility which meets this condition is that, the observer also observes that, the universal gravitation between A and B is equivalent to the electrostatic repulsion between A and B. Experiments have demonstrated that, when an object is in motion, its carried charge will remain unchanged. Therefore, only if the gravitational mass is also independent of the motion of an object, the universal gravitation between A and B can be identically equivalent to the electrostatic repulsion between A and B. Thus, we can inevitably draw the following conclusion: as with the carried charge, the gravitational mass can also considered as a constant unrelated to the motion of object.

Experiments have demonstrated that, the inertial mass of an object is related to its motion velocity

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of, i.e. $m' = m\big/\sqrt{1-V^2/C^2}$. Where, m represents the rest mass; it can be assumed that the rest mass is equivalent to the gravitational mass. Therefore, in the case of circular motion of an object, the centrifugal force formula shall be changed into $m'V^2/R = mV^2\big/R\sqrt{1-V^2/C^2}$; replace this formula with the centrifugal force formula of equation (7), and we will get:

$$\frac{V^2}{\sqrt{1-V^2/C^2}} = \frac{GM}{R} \tag{8}$$

Solve equation (8), and we can get the (real root):

$$V = \frac{1}{\sqrt{2}}\sqrt{-\frac{G^2M^2}{C^2R^2} + \sqrt{\frac{G^4M^4}{C^4R^4} + 4\frac{G^2M^2}{R^2}}} \tag{9}$$

It can be seen from equation (8) or (9) that, in order to increase the velocity of rotation of a spacecraft around the planet, it is necessary to select the planet with large M and small R. Obviously, the black hole is the optimum selection. According to the black hole theory, for a black hole about the same size as a football field, i.e. a spherical black hole with a diameter of 120m; its mass can be up to 4 times that of the Sun. Accordingly, it can be calculated from equation (8) or (9) that, the velocity of rotation of a spacecraft around the black hole can be up to 0.999C; [if calculated as per equation (7), the velocity of rotation of the spacecraft around the black hole can be up to 10C]. This shows that, the black hole should be considered as the optimum planet where the human beings can achieve time travel by spaceship. However, it can be seen from further analysis that, the black hole is unlikely to be a kind of real substance. There are two main reasons:

As explained above, the gravitational mass of an object is unrelated to the motion of the object, while the inertial mass of an object is related to the motion of the object. This shows that, the gravitational mass and inertial mass of an object should belong to different categories of physical quantities; both are unlikely to be equivalent to each other. Suppose that the gravitational mass is equivalent to the inertial mass, i.e. the equivalence principle is the basis of general relativity, then the equivalence principle fails to be tenable, and the general relativity naturally fails to be entirely true. Only when the motion velocity of an object relative to the speed of light is very small, for instance, the Sun's planets, satellites or other stars generally have a motion velocity of less than one ten thousandth C, and there is a numerically constant proportional relationship between the gravitational mass and inertial mass, then can it be considered that the inertial mass is equivalent to the gravitational mass. In such case, the equivalence principle is tenable; the judgment on the general relativity is naturally realistic, e.g. it is practical to judge the Mercury's perihelion precessional motion, GPS positioning and other factors according to the general relativity. However, when the motion velocity of an object is very high, there will be a bias with judgment using the general relativity; It was natural for the black hole to be divorced from reality, which is inferred under high-speed conditions according to the general relativity. It can be imagined that, if the gravitational mass is equivalent to the inertial mass, when the motion velocity of an object is close to the speed of light, the gravitational mass of the object will become extremely huge, resulting in the creation of the black hole; the equivalence principle fails to be tenable; the gravitational mass becomes constant; so certainly the black hole would not exist.

Another reason is that, according to the black hole theory, for a black-hole sphere with a diameter of 120m, its mass is equivalent to the total mass of four suns, i.e. the total mass of 1.3 million earths, while the Earth's volume is 10^{15} times greater than that of the black-hole sphere with a diameter of 120m; in other words, the density of black-hole matter is 10^{21} times greater than that of the Earth; it means that, the mass of a black-hole matter about the same size as a grain of rice should be greater than 1000 times the total mass of all persons on the Earth (taking the average mass of a person at 50kg). It is well-known that, all the matters in the universe consist of several elements among the 118 kinds of elements known. So far, no other cosmic matters have been found to make an exception yet.

However, according calculations based on the density of black-hole matter, the atomic size of black-hole matter is only equivalent to $1/10^{21}$ of the atomic size of matter on the Earth. This is clearly impossible. The reason is that, if we assume that the black hole is also composed of atoms, after all atoms of the black hole are collapsed, all the electrons around such atoms fall on protons and change them into neutrons, and these neutrons are also gathered together to become a large-sized neutron, then the volume of such a large-sized neutron will be one million times greater than the theoretical volume of the black hole. Obviously, there is no possibility of such atoms in reality. Thus, it can be concluded that, it is impossible for the black hole to be composed of real atoms, that is, it is impossible for the black hole to exist as a real matter.

The possibility of the black hole as an existence of real matter can be ruled out. In the current astronomical observations, only fixed star A1 has a large mass but not too large radius; the mass of fixed star A1 is equivalent to 150 times that of the Sun; its diameter is equivalent to 114 times that of the Sun (Reference 4). Suppose that any other human beings (similar to earth humans) live on the planet adjacent to the fixed star A1, and also a spacecraft can fly around the stellar surface, then the calculated velocity of the spacecraft can be up to 501km/s; the obtained absolute time delay is up to 271 seconds each year. Obviously, this maximum absolute time delay is far from meeting the requirements for time travel.

VI. Conclusion

From the above analysis, the time delay can be divided into two types, including relative time delay and absolute time delay. The relative time delay is real delay as is the absolute time delay. Relative time delay refers to an observation obtained when an observer observes the time variation of another reference system being in motion from a reference system; absolute time delay refers to a real time delay of an object being in circular motion. The outstanding experiments conducted by J· C· Hafele and R· E· Keating have not only provided a reliable evidence for the existence of absolute time delay, but also served as a valuable reference for the explanation of various phenomena related to time delay. The only way for human beings to obtain real time delay is by making circular movement around a celestial body in an spacecraft. Strictly speaking, since the equivalence principle fails to be tenable, it is impossible for the black hole to exist as a real matter. As a result, the time delay (271 seconds each year) obtained in traveling around fixed star A1 by spacecraft shall be considered as the maximum absolute time delay obtainable by human beings.

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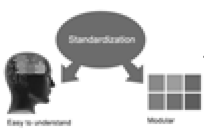

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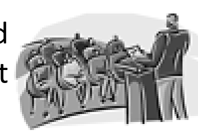

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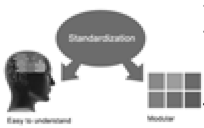

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5.STRUCTURE AND FORMAT OF MANUSCRIPT

The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

Papers: These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

(a)Title should be relevant and commensurate with the theme of the paper.

(b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.

(c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.

(d) An Introduction, giving necessary background excluding subheadings; objectives must be clearly declared.

(e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.

(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

(h) Brief Acknowledgements.

(i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and to make suggestions to improve briefness.

It is vital, that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

Format

Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.

Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than 1.4 × 10-3 m3, or 4 mm somewhat than 4 × 10-3 m. Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

Structure

All manuscripts submitted to Global Journals Inc. (US), ought to include:

Title: The title page must carry an instructive title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) wherever the work was carried out. The full postal address in addition with the e-mail address of related author must be given. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining and indexing.

Abstract, used in Original Papers and Reviews:

Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy and planning a list of possible keywords and phrases to try.

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

Acknowledgements: Please make these as concise as possible.

References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

The Editorial Board and Global Journals Inc. (US) recommend that, citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

Tables, Figures and Figure Legends

Tables: Tables should be few in number, cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g. Table 4, a self-explanatory caption and be on a separate sheet. Vertical lines should not be used.

Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.

Preparation of Electronic Figures for Publication

Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. Please give the data for figures in black and white or submit a Color Work Agreement Form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution (at final image size) ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs) : >350 dpi; figures containing both halftone and line images: >650 dpi.

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6. AFTER ACCEPTANCE

Upon approval of a paper for publication, the manuscript will be forwarded to the dean, who is responsible for the publication of the Global Journals Inc. (US).

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Acrobat Reader will be required in order to read this file. This software can be downloaded

(Free of charge) from the following website:

www.adobe.com/products/acrobat/readstep2.html. This will facilitate the file to be opened, read on screen, and printed out in order for any corrections to be added. Further instructions will be sent with the proof.

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Before start writing a good quality Computer Science Research Paper, let us first understand what is Computer Science Research Paper? So, Computer Science Research Paper is the paper which is written by professionals or scientists who are associated to Computer Science and Information Technology, or doing research study in these areas. If you are novel to this field then you can consult about this field from your supervisor or guide.

TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

1. Choosing the topic: In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. Evaluators are human: First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

3. Think Like Evaluators: If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

4. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

5. Ask your Guides: If you are having any difficulty in your research, then do not hesitate to share your difficulty to your guide (if you have any). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work then ask the supervisor to help you with the alternative. He might also provide you the list of essential readings.

6. Use of computer is recommended: As you are doing research in the field of Computer Science, then this point is quite obvious.

7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

8. Use the Internet for help: An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

9. Use and get big pictures: Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

10. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right! It is a good habit, which helps to not to lose your continuity. You should always use bookmarks while searching on Internet also, which will make your search easier.

11. Revise what you wrote: When you write anything, always read it, summarize it and then finalize it.

12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. Pick a good study spot: To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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