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Quantized Phenomena in Astronomy and Astronomic Quantum Theory

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Abstract: The Titius-Bode law may be represented to a new form $r_n = an^2$. From this we can develop a quantum theory, and obtain the quantum constants $H = (aGM_{\odot})^{1/2}$ of the solar system, and derive the astronomical Schrodinger equation. So many quantities of the solar system can be quantized, and the distance rule is a statistical result of planet evolution. Here Neptune, many satellites, some exoplanets and ten satellite galaxies of Galaxy agree with the same form. Further, there should be the extensive quantum theory, which has different quantum constants but similar formulations. Its mathematical base is fractal. The anthropic principle is derived exactly. Using the geometric average method, three different values of the quantum constants of man, cell and macromolecule may be derived for biological, chemical and physical discrete systems with different scales. Based on the quantized phenomena in astronomy and the extensive quantum theory, quantizations of red-shift and celestial rings, binary stars and some new hypothesis, etc., are researched. Then, the quantum vacuum and the similarity between celestial bodies and particles are discussed. Finally, some problems on the evolution of galaxies, cosmos and so on are investigated from the general relativity and the qualitative analysis theory.

Key words: astronomy, quantum theory, solar system, quantum constant, Schrodinger equation, binary stars, ring, vacuum, galaxy, cosmos

New form of the Titius-Bode law and astronomical quantum theory

The Titius-Bode law describes approximately the average distances between the Sun and various planets in the solar system. The law has implied a quantized phenomenon in the solar system. We developed the Titius-Bode law to a new form [1,2]:

$$r_n = an^2, \qquad (1)$$

where *a* is a constant and *n* is integer. All planets are divided into two groups: the terrestrial and Jovian planets. Let $a_1 = 0.042$ (astronomical unit), the values *n*=3,4,5,6 correspond to the terrestrial planets, and *n*=7,8 to asteroids. For $a_2 = 1.2$, and n=2,3,4,5,6, this form describes the Jovian planets and Pluto [1,2].

When the Titius-Bode law is applied to distances between various planets and their satellites, the conclusion is unsatisfactory. While these distances between planets and their satellites agree approximately with the formula (1) [1,2], for example, the satellites of Saturn, which include new largest ring [3]. Each of planets has its own value of *a*, which should belong to different gravitational fields.

The formula (1) agrees with Neptune, but deviates about 10% for Pluto. Since some new planets Quaoar (2002LM60) in 2002, and Sedna in 2004 [4], and 2003UB313 in 2005 were discovered, we compared terrestrial and Jovian planets (the units of mass and diameter are 3.3×10^{23} and 1.0×10^{26} kg, and 4880 and 49500km), respectively, and calculate quantitatively to obtain results:

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Table 1. Comparison of masses and diameters on terrestrial and Jovian planets

Terrestrial Planets	Mercury	Venus	Earth	Mars	Ceres
Mass	1	14.8	18.1	1.94	1/282
Diameter	1	2.48	2.61	1.39	1/4.65

Jovian Planets	Jupiter	Saturn	Uranus	Neptune	Pluto
Mass	19	5.7	0.87	1	1/7692
Diameter	2.88	2.42	1.05	1	1/22.1

According to table 1, Pluto as ninth major planet is very unsuitable, whose mass and diameter are too small. Therefore, the structure of the solar system should be a symmetric mode of eight major planets [5,6]:

Table 2. A symmetric mode of eight major planets

Terrestrial Planets	Mercury	Venus	Earth	Mars		Asteroids
Jovian Planets	Jupiter	Saturn	Uranus	Neptune		Kuiper Belt (including Pluto, etc)

It is a conclusion of astronomic observation, and is affirmed by IAU in 2006. The mode of eight major planets of the solar system shows a wonderful symmetry, and its number is consistent completely with the Chinese Eight Trigrams.

There is a similarity between the solar system and the Rutherford-Bohr model [7]. An essential similarity exists possibly between microscopic and macroscopic phenomena, since the cosmology has been combined with particles during the early stage of cosmological evolution.

The formula (1) is the same with the orbital radius formula of the Bohr atom, so the quantum constant of the solar system is

$$H = (aGM_{\odot})^{1/2} = 1.15203218 \times 10^{10} a^{1/2} \ m/sec. \qquad (2)$$

And $$H_1 = 9.1317 \times 10^{14} m^2 / \sec, H_2 = 4.8811 \times 10^{15} m^2 / \sec. \qquad (3)$$

The both dimensions of Hm and $\hbar$ are the same. Let m is the solar mass, so

$$HM_{\odot} / \hbar = 1.7223 \times 10^{79} \text{ and } 9.2061 \times 10^{79}. \qquad (4)$$

They are just about the square of the Dirac large number 7×10^{39}. Such many quantities of the solar system can be quantized [1,2].

According to the Madelung fluid mechanical model of the early quantum mechanics, let the fluid density $\rho = \psi\psi^*$, $\psi = \sqrt{\rho}\exp(-idivV / H)$ and $g = grad\varphi$, we can derive

$$iH\frac{\partial \psi}{\partial t} = -\frac{1}{2}H^2\nabla^2\psi + (U - Q)\psi, \qquad (5)$$

where Q is a quantum potential [8] $-H^2\nabla^2\sqrt{\rho} / 2\sqrt{\rho}$ in the astronomy.

It is called the Schrodinger equation in the astronomy. This equation and its dimension connect only with space-time, and are not obvious relations with energy and mass.

In this case the orbits are only those positions of the maximum probability for the nebular density

in the evolution of the solar system. It is a statistical result in the evolution of planets [2]. The formation of planets, at least the early stage, is a stochastic process in the nebular theory.

Applications of astronomical quantum theory

We think that so long as the origin of planets is the same, the planets of other star systems should agree with the same orbital rule. The exoplanets are discovered more than 370 [9]. For the distances of exoplanets, the distances of three planets of pulsar PSRB1257+12 to pulsar are 19%, 36% and 47% of the distance of Earth to Sun [10,11], their ratio is 0.4:0.77:1, i.e., the ratio of Mercury, Venus and Earth to Sun. It shows that three distances agree with the new form (1). Three planets in 55 Cancris are discovered in June of 2002. Their distances to this star are 17×10^6 km, 36.8×10^6 km and 5.5 astronomy units (AU), i.e., 825×10^6 km, respectively. According to Eq.(1), the first two planets are similar to the terrestrial planet with n=2 and 3, since $(2/3)^2=164/369\approx170/368$. The last is similar to the Jovian planet, and the distance of Jupiter is 5.2 AU. In October of 2004, Okamoto, et al., reported that the Beta Pictoris nearby the solar system is a hotbed of the formation planet, and it is surrounded by a dust and gaseous loop. At present it is discovered that the distances of three peaks of the dust distribution to the central star are 6.4, 16 and 30 AU [12], respectively. Their distances do not agree with the usual Titius-Bode law, but equal approximately 4:9:16 (9/4=2.25, 16/6.4=2.5, and 16/9=1.78, 30/16=1.87), i.e., it agrees with Eq.(1) [13]. Qian, et al., found three planets orbiting the eclipsing polar HU Aqr, whose distances agree with n=5 and 6 of Eq.(1).

Perhaps the deviation is caused from interference of other forces. Moreover, further evolution will return possibly to better agreement.

Now it is observed that the Milky Way Galaxy possesses ten satellite galaxies, and they compose a cluster of Galaxy [14]. We find that their distances to Galactic Center agree with Eq.(1), in which *a* is divided into two values (0.11 and 0.89):

Table 3. Distances to Galactic Center for ten Satellite Galaxies

Galaxy	Distances to Galactic Center (10^4 light-year)	n	Calc. (*a*=0.11)
Large Magellanic Cloud	16	12	15.84
Small Magellanic Cloud	19	13	18.59
Ursa Minor Dwarf Galaxy	21.5	14	21.56
Draco Dwarf Galaxy	25	15	24.75
Sculptor Dwarf Galaxy	25.5		
Sextans Dwarf Galaxy	29.5	16	28.16
		17	31.79
Carina Dwarf Galaxy	35	18	35.64
			Calc. (*a*=0.89)
Fornax Dwarf Galaxy	44	7	43.61
		8	56.96
Leo II Dwarf Galaxy	72	9	72.09
Leo I Dwarf Galaxy	89	10	89

Further, the corresponding quantum constants of the cluster of Galaxy are:

$$H^G = (aGM_G)^{1/2}, M_G \approx 10^{12} M_O = 2\times 10^{42} kg. \quad (6)$$

Here $H_1^G = 1.178\times 10^{26} m^2/\sec, H_2^G = 3.3515\times 10^{26} m^2/\sec.$ $H_1^G / H = 1.29\times 10^{11}$ is possibly related with 10^{11} stars in the Galaxy.

The extensive quantum theory and various quantum constants

Further, we proposed the extensive quantum theory, which has different quantum constants but similar formulations [2,13]. The quantized Hall effect has exhibited macroscopic quantized phenomena [15]. From the above method, the astronomical quantum theory, whose formations are the same with the usual quantum theory, can be constructed similarly. Perhaps, there are some quantized systems, whose formulations are similar to each other, only whose quantum constants are different [2]. These symmetrical constructions are the basis of extensive quantum theory, which exist widely in the nature. Its mathematic base is fractal.

C.Weiman and E.Cornell (1995) carry through supercoding for the 2000 rubidium atoms, and derive the Bose-Einstein condensation (BEC), and form an independent quantum entity. It is a macroscopic quantum. In essence superconductivity, superfluidity and Bose-Einstein condensation are macroscopic quantum phenomena [16].

For superfluid a macroscopic wave function $\psi_0(r) = \sqrt{n_0(r)}e^{i\theta(r)}$ is the order parameter of the He II phase, where $\theta(r)$ is a phase [16].

For a quantization of the superfluidity the macroscopic wave function $\psi(r) = \psi(r)e^{i\Delta\theta}$, in which $\Delta\theta = 2\pi n$. k=hn/m→h=km/n. The density matrix allows us to define a suitable effective single particle macroscopic wave function.

For superconductivity Ginzburg and Landau (GL) postulated the existence of an order parameter denoted by ψ, which is assumed to be some (unspecified) physical quantity which characterizes the state of the system. It is assumed to obey:

$$\psi = \begin{cases} 0 & T > T_c \\ \psi(T) \neq 0 & T < T_c \end{cases} \quad (7)$$

ψ obeys the Schrodinger equation [16]:

$$-\frac{\hbar^2}{2m^*}\nabla^2\psi + a\psi + b\psi|\psi^2| = 0. \quad (8)$$

The new parameter m* plays the role of an effective mass for the quantum system with macroscopic wave function. We may assume $\frac{\hbar^2}{2m^*} \rightarrow \frac{(\hbar')^2}{2m}$, so $\hbar$ is changeable.

In this case Ginzburg-Landau theory is macroscopic. The concept of the macroscopic wave function is central to understanding atomic Bose-Einstein condensates, superfluid and even superconductivity with the Ginzburg-Landau theory. The macroscopic wave function, and its phase, is not a true wave function in the sense of elementary quantum mechanics. In particular it does not obey the fundamental principle of superposition, and one cannot apply the usual quantum theory of measurement or Copenhagen interpretation to it. The macroscopic wave

function behaves much more like a thermodynamic variable [16]. The macroscopic coherent state corresponds to the microscopic interaction.

Various soliton waves, which are wave and are analogue for particle, exist widely from small particle to gigantic universe [17]. This implies that the wave-particle duality is a cosmic universal property. Based on the cosmic duality, we can develop the cosmic quantum theory. Furthermore, based on the fluid dynamical equation, which corresponds to diffuse matter existing widely in the universe, or on statistics and stochastics possessed generally in the cosmic evolution [18,19], the Schrodinger equation and the cosmic quantum theory may be derived. Moreover, the form of the Schrodinger equation of free particle may be derived by a diffusion equation that corresponds to the big bang universe.

Based on the astronomical Schrodinger equation, various models and different forms, which had represented or explained quantum mechanics, can be applied to astronomy [7]. From the statistical model and this form in quantum mechanics, the general Liouville equation can be introduced in astronomy, which corresponds to Liouville gravity [20]. The statistical and stochastic chaotic nebulae can evolve to the ordered quantized symmetrical star system. The known science has shown that if fluctuations of a classical system with infinite degree of freedom are treated, a noncommutative operator will be introduced naturally, and a certain wave equation which does not contain the Planck constant will appear necessarily. In the astronomical evolutionary process the gaseous nebulae with the infinite degree of freedom possess various fluctuations, it may produce the astronomical quantum theory yet.

There is a known relationship between quantum field theory and statistical physics [21], and statistics are universal. The two aspects are combined each other, so the extensive quantum theory will also be produced. It is a system whose mathematical forms and fundamental properties are invariant when the scaling (quantum constant) is transformed. This is similar to the extensive relativity [22] in which the formulations are the same with the relativity, only c is used instead of various invariant velocities C_h (a scaling transformation).

Moreover, we introduced a principle of equivalence for the electromagnetic field: A non-inertial system with an acceleration is equivalent to a certain electromagnetic field, in which the ratio of charge to mass is the same [23]. From this principle can be derived an electromagnetic general relativity (GR) whose formulations are completely analogous to Einstein GR. In the electromagnetic case, the field is regarded as a type of curved space-time for charged bodies, where space-time is separated into many layers, whose curvatures are different for different ratios of charge to mass. In a general case, electrodynamics can be obtained from this theory. But its high-order approximation will deviate from the present electromagnetic theory. Therefore, we discuss the four possible tests for this theory and some notable problems. Further, the most universal principle of extended equivalence and the extensive GR are proposed [23].

These extensive theories possess the scaling invariance, and should correspond to a certain renormalization group, and have some fundamental characters of fractal.

There has a wonderful similarity between the solar system and the atomic structure, we compared the two regions quantitatively [2]: The ratio between the average distance of the earth to sun and the Bohr atomic radius is about 2.8270×10^{21}, it is a scale stridden across space. Assume that the extensive quantum theory is suitable for man, cell and macromolecule inside this scale, so the quantum constant is:

$$\hbar_1 = H_1 m_1 = (HM_O\hbar)^{1/2} = 4.3764\times 10^5 kgm^2/\sec = \hbar\times(large\ number).\ (9)$$

The mass of man is taken above *57.678kg*, so

$$H_1 = 7.5876\times 10^3 m^2/\sec. \qquad (10)$$

It agrees approximately with various man quantum. characteristic values of man, and may be called a

This corresponds to the uncertainty relation $\Delta(mv)\Delta x \approx \hbar_1$ of man probably. In this case the space size is *2.8136m*. Matthews proved that the maximum height of man is about *3m* by a similar Press theory [24]. It is an exact anthropic principle.

Further, there is nucleus around which cytoplasm and chondriosome, etc., exist in a cell. If the cell quantum constant is $\hbar_2$, and

$$\hbar_1/\hbar_2 = \hbar_2/\hbar,$$

$$\hbar_2 = (\hbar_1\hbar)^{1/2} = 6.7933\times 10^{-8} gcm^2/\sec = \hbar\times(large number)^{1/2}.(11)$$

Such the space size will be

$$r_2 = (2.8136\times 5.2918\times 10^{-7})^{1/2} = 1.2202\times 10^{-3} cm. \qquad (12)$$

This corresponds to the scale of cell, while the size of usual cell is about $(35-0.05)\times 10^{-3} cm$. In this theory the masses will be

$$(m_{man}m_p)^{1/2} = 3.1060\times 10^{-10} g,\ (m_{small}m_e)^{1/2} = 4.6103\times 10^{-13} g.\ (13)$$

Since cells are varied, the above values seem to correspond to the masses of some cell nucleus or chondriosome and so on. A usual cell nucleus is smaller along with ripening, conversely, they are larger. It is analogous to the total volume of a star from larger to smaller in the evolutionary process of the star.

A geometric average is taken between the Bohr radius and above scale, the space size is:

$$r_3 = (1.2202\times 5.2918\times 10^{-12})^{1/2} = 2.5411\times 10^{-6} cm = 25.411nm. \quad (14)$$

Here the masses are $2.2793\times 10^{-17} g$ and $2.0493\times 10^{-20} g$. While length of myosin molecule is about $4.9\times 10^{-6} cm$, molecular masses of macromolecule for protein and nucleic acid, etc., are $10^3 - 10^7$, i.e., $10^{-21} - 10^{-17} g$. For instance, the molecular masses are about 10^6 for rRNA, and are 2×10^4 for tRNA. The quantum constant of a macromolecule is

$$\hbar_3 = (\hbar_2\hbar)^{1/2} = 8.4539\times 10^{-18} gcm^2/\sec. \qquad (15)$$

Now it is found that DNA of some cell nucleus has a satellite belt besides main belt. Short small satellite DNA, even middle satellite DNA, have been found in the genes of human insulin and α -globin and so on [25]. Perhaps, a new quantum biology which has different quantum constants is suitable for those quantum biological phenomena, which are applied to the biological macromolecule, cell and their interactions, or which are used by the general principles and methods of the quantum mechanics. In these cases the quantum constants in the Schrodinger equation are different [26,27]. But the constant of the usual quantum biology, which studies only electronic structure of the biomolecule, is still $\hbar$.

In the extensive quantum theory those quantum constants may be different, and can have discrete values of big transition. Perhaps the different constants show a certain aspect of different essence in various systems. But they are not absolutely continuous values, otherwise theory will be not quantized. In the extensive quantum biology the minimum life element is a quantum, which may be different life quantum, for example, gene, cell, individual, man and so on. If they are decomposed, the corresponding life will not exist.

Now the researches on artificial atoms and superatoms, artificial molecules and supramolecular materials, artificial crystals, etc., generate the biological systems, nonbiological structures with dimensions of 1 to 100 nanometers [28-31]. Various materials of nanostructures possess some new effects, and it provides probably a wide applicable field for the extensive quantum theory.

The different classical limits are related with by dualities that generalize the Motonen-Olive duality [32,33] $e \leftrightarrow 4\pi\hbar c/e$. From the appearance of $\hbar$ in this formula, such dualities are symmetries that exist only in the quantum world. From the Motonen-Olive duality the Seiberg-Witten invariants theory is obtained [34]. Based on T-duality and S-duality that generalize the Motonen-Olive duality in superstring theory, the duality symmetry points out that description on a small spacetime, whose scale is *R*, is just the same with one on a large spacetime, whose scale is *1/R*. The duality symmetry described a mirror symmetry, which is a relationship between two spacetimes. The two dual worlds are equivalent. The modern duality [35] is consistent with some results in the extensive quantum theory.

Various quantized phenomena and redshift in astronomy

In the Solar system the rotation periods of the eight major planets, except Mercury with the smallest mass and Venus with opposite rotation, may are classified by three types: 24h (Mars, 24.6h and Earth,23.9h), 17h(Uranus, 17.2h and Neptune, 16.1h), 10h(Saturn, 10.7h and Jupiter, 9.9h), and the periods are smaller with increasing mass. Further, these periods may be represented approximately by a quantized form:

$$T=10+7n, \qquad (16)$$

in which n=0, 1, 2.

The known Jovian planets (Jupiter, Saturn, Uranus and Neptune) all have rings. These rings and satellites agree approximately with the formula (1) [1,2]. Perhaps, all huge gaseous planets have rings, include the exoplanets. Kirkwood (1866) discovered some interspaces in the asteroid belt, which are on some ratios for the average movement between asteroid and Jupiter are the simple fractions, for example, 3/1, 5/2, 7/3 and 2/1, etc. It is also a quantization.

The integer and fraction quantum Hall effects at low temperature correspond possibly to the rings of planets at low temperature, both have all ratios. These are similar with asteroid belt, or combine chaos to continuous distribution. Hall effect corresponds to the lowest Landau energy level, whose percent of fill (corresponding ring) is $\nu = N/G$, here N is a total number of electron, the total magnetic flux $\Phi = G\phi_0$. The circularity of superfluidity has a

macroscopic quantization, for example, the magnetic flux of circulation is quantization $\oint p_s dl = n\hbar$, and $\hbar \rightarrow$H perhaps corresponds to the quantization in the solar system. Both may be developed by analogy each other. The planets move around Sun may think are the 'astronomic superfluidity'.

The usual redshift z=Hr is a linear relation. Let z=lnA and r=lnb, so $A = b^H$. Or it may be a bilinear. From this we can discuss the fractal theory of structure and velocity, etc. Further, based on some progresses on the redshift in astronomy, we proposed a hypothesis of energy redshift:

$$z = \frac{E'-E}{E}. \qquad (17)$$

From this a difficult redshift quantization may belong to the energy quantization. It is an extensive quantum theory with the cosmic scale [36]. The redshift quantization is

$$\Delta z = \Delta v / c = 72 kms^{-1} / c = 2.4 \times 10^{-4}, \qquad (18)$$

in which Δv is an expanding velocity. Or it is

$$\Delta z / 2 = 1.2 \times 10^{-4}, \text{ or } \Delta z / 3 = 8 \times 10^{-5}. \qquad (19)$$

It is an extensive energy quantization

$$H = h / \Delta z = h / (8 \times 10^{-5}) = 8.28 \times 10^{-30} Js, \qquad (20)$$

or its 3 times, etc. The redshift quantization is based on a value of 2.6657kg/s, and different multiple for different types of galaxy. It is similar with the quantum energy level. This explains possibly that the cosmic expansion is layered and quantized. They may perhaps connect with the extensive quantum theory.

Since the gravitation is bigger along distance of black hole more near, the gravitational redshift is also more. In the general relativity the gravitational redshift is:

$$z = \Delta \nu / \nu = -\Delta U / c^2 = \sqrt{g_{00}} - 1. \qquad (21)$$

Some big redshifts originate probably the gigantic black hole. And the redshift even may reach an infinite at a horizon of black hole [37]. The unified model of the active galactic nuclei (AGN) and the mechanism as power source, which includes quasars, is just the black hole-accretion disk-jet model [38]. Some parts of big redshift, for example, gamma-ray bursts (GRB) and so on, are also this mechanism. It is an interpretation of black hole for some abnormal redshift.

It is known that the 'blue-shift' phenomena exist generally for the absorption band of nano-particles. For example, the infrared absorption frequencies of nano- and big carborundum are respectively 814 and 794/cm, i.e., the 'blue-shift' is (814-794)/794=20/794~1/40. Such some special stars with the nano-structure should be 'blue-shift'. This is an internal property of stars with 'redshift or blue-shift', and corresponds possibly to new different structures of matter. These redshifts are not the Doppler effect of velocity

Celestial bodies, astronomic evolution, binary stars and quantum theory

Astronomy from Copernicus and Newton to Kant and Laplace, from stable cosmos to the big bang cosmos is all from the existing to the evolutional astronomy (the cosmogony). In *Cosmological Physics* Peacock discussed the galaxies and their evolution, and the quantum

gravity [38], which combines the general relativity and quantum theory.

Assume that the fractal dimension of the extensive quantum theory is D=lnV/lnr. According to the dimensional analysis,

$$\text{V=(H/mc)}\, R_0^{D-1} = r^D, \qquad (22)$$

whose logarithm is:

$$\log(H/mc) + (D-1)\log R_0 = D\log r, \qquad (23)$$

so $$D = \frac{\log(H/c) - \log m - \log R_0}{\log r - \log R_0} = \text{constant.} \qquad (24)$$

For different constants H of various extensive quantum theories [1,2], suppose m is invariant, such D has two parameters m and R_0. If m is a variant, and is a character mass, there is only a parameter R_0.

According to the corresponding principle, the cosmic quantum theory should derive the celestial mechanics and some known results. But, they are not results of the quantum constant H→0. Further, some new results should be obtained. The orbits of asteroids and comets are ellipses, and correspond possibly to the associated Legendre function with $l \neq n-1$.

An infinite gravitational collapsing process of any supermassive stars should pass through an energy scale of the grand unified theory (GUT) of particle physics. After nucleon-decays, the supermassive star will convert nearly all its mass into energy. It should become a lepton star that is possibly substable or unstable [39]. The model produce the radiation of GUT, and may probably explain some ultrahigh energy puzzles in astrophysics, for example, gamma-ray bursts (GRB) and quasars, etc. It is similar with a process of the Big Bang Universe with a time-reversal evolution in much smaller space scale and mass scale. In this process the star seems be a true white hole [39]. According to the Horava-Witten theory [40], the gravity will also flow into this point.

For the extensive quantum mechanics, perhaps the discrete spectrums are planets, and the continuous spectrums are rings. In this case, the path integral method of quantum mechanics may apply to astronomy, and investigate a symmetry on the ellipticity of planets, which corresponds to the second quantum number. The castade shower is a fractal paragon from microscopic to macrostructure, from single particle 10^{-13} cm to tens sq.km, which is magnified about 10^{20} times. The quantum effects should exist in some celestial bodies, for example, white dwarf and neutron star, etc.

For Hopf bifurcation, the central point becomes a ring movement of planet, and corresponds to a limit cycle, or an asteroid belt. On the one hand, the extensive quantum mechanics derives the astronomical Schrodinger equation [1,2], and through synergetics [41] obtains

$$\psi' = a\psi - b\psi^3. \qquad (25)$$

On the other hand, the hydromagnetics derives the nonlinear equation and obtains:

$$\psi' = a\psi - b\psi^3. \qquad (26)$$

Further, the nonlinear equation (26) may be developed to:

$$\psi' = a\psi - b\psi^3 + c\psi^5. \qquad (27)$$

From this we can derive the four stars system. When ψ'=0, we obtain a usual solution ψ=0, and an equation:

$$\psi^4-(b/c)\psi^2+(a/c)=0, \quad (28)$$

$$\psi^2=(b\pm\sqrt{b^2-4ac})/2c. \quad (29)$$

1.When *a*>0, 1).If b^2>4*a*c, the solutions will be

$$\psi_{1,2}=\pm[(b+\sqrt{b^2-4ac})/2c]^{1/2},\ \psi_{3,4}=\pm[(b-\sqrt{b^2-4ac})/2c]^{1/2}. \quad (30)$$

2).If b^2<4*a*c, there will be only a real solution ψ_0=0.

2.If *a*<0, b>0 and c>0, there will be $\sqrt{b^2-4ac}>b$, and be three real solutions ψ_0 and $\psi_{1,2}$.

In these cases, the n-solutions of the nonlinear equation correspond to a possibility on the formation of the n-stars system.

Lombardi, et al., discussed the post-newtonian models of binary neutron stars [42]. Bonazzola, et al., studied the numerical models of irrotational binary neutron stars in general relativity [43]. A known equation with damped single pendulum motion is:

$$\theta''+2\mu\theta'+\omega_0^2\sin\theta=0. \quad (31)$$

It may describe a single star, or the binary stars converged to two positions. This corresponds to the hard Duffing equation from the binary stars become to two disperse orbits under a certain condition.

Based on the basic equations of a rotating disk on the nebula, we applied the qualitative analysis theory of nonlinear equation, and obtained a nonlinear dynamical model of formation of binary stars [44]. Under certain conditions a pair of singular points results in the course of evolution, which corresponds to the binary stars. Under other conditions these equations give a single central point, which corresponds to a single star. Steinitz and Farbiash established the correlation between the spins (rotational velocities) in binaries, and show that the degree of spin correlation is independent of the components' separation. Such a result might be related for example to Zhang's nonlinear model for the formation of binary stars from a nebula [45]. Then based on the hydrodynamics and hydromagnetics of nebula, from Alfver equation of the cosmical electrodynamics [46] we discussed the formation of binary stars by the qualitative analysis theory [47]. Based on the Lorenz model derived from the equations of hydrodynamics of nebula, we discuss the formation of binary stars by the qualitative analysis theory of nonlinear equation. Here the two wings in the Lorenz model form just the binary stars, whose Roche surface is result of evolution under certain condition. Further, the base of the most exact evolutionary theory of large scale structures should be the general relativity, whose 2+1 dimensional plane equations of gravitational field are calculated. Based on these equations, we discussed the evolutions of disk nebula by the qualitative analysis theory, in which the binary stars or single star are formed for different conditions. This is the most exact model of formation of binary stars [48]. The nonlinear interaction plays a crucial role, and is necessary condition of the

formation of binary stars and of multiple stars. So the binary stars are very common in astronomy. Any simple linear theory only may form a single star system [44,47,48]. This method and model may be extended and developed. It can combine the metric field of uniform or chaos nebula and hydromechanics, etc.

Quantum vacuum and similarity between celestial bodies and particles

The vacuum is a special state of matter as the existence of the quantum field, and is a ground state with the lowest energy. It is known that the fields have many types. Under different conditions, the quantum fields have different ground states with various symmetries. The vacuum is a state, which is not excited by any field quantum. Different vacuums imply different Hilbert spaces, are namely different universes.

When the vacuum fluctuates, the virtual particles create continuously and vanish in the vacuum. The vacuum fluctuations and interactions with the real fields or particles derive the radiative correction and the polarization effect of the vacuum. For the Yang-Mills vacuum, A.M.Polyakov, et al., (1975) discovered that there have different vacuums with infinite topological structures, and some instantons, which create continuously and vanish, and have different scales, pass through different vacuums. The symmetry is spontaneous breaking in the vacuum. It includes the bag model of the nontopological solitons [49], etc.

The vacuum possesses the diversity: Since for different fields and quantum fields, and different interactions there are different types of the ground states under different conditions, so different types of vacuum states exist. And various vacuums may transform each other, or some vacuum phases may coexist.

We use the extensive quantum theory to explain the binary stars. It is similar with the bi-atomic molecule, and may combine both different characters. Further, we may be analogy of the charge formations of particle, atom and molecule, and discuss the formation and evolution of the electromagnetic field on stars. Generally, the solutions of various equations on particle and celestial body may be compared, and be applied and developed each other.

The wave property of binary stars originates the cosmic quantum theory, the cosmic wave-particle duality and the cosmic wave function. From this or the microscopic particles with interactions, we derive the nonlinear Schrodinger equation:

$$iu_t \pm u_{xx} + \alpha u + \beta |u|^2 u = 0. \qquad (32)$$

It may become an ordinary differential equation:

$$\pm \phi'' + \alpha\phi + \beta\phi^3 = 0. \qquad (33)$$

When α <0, both results derived from $\pm\phi''$ correspond to the binary stars and a single star.

Assume that the evolution of nebula is described by Landau equation of turbulence

$$d\psi / dt = \alpha\psi - \beta\psi^3. \qquad (34)$$

When a single star becomes the binary stars, it is namely a stable state α <0 and ψ =0 becomes α >0 and $\psi = \pm\sqrt{a/b}$. This is a bifurcation. Moreover, the topology of the evolutional process of the binary stars should be researched.

The cosmic Wheeler-de Witt (WDW) equation is:

$$(\hbar^2 G_{ijkl}\frac{\delta}{\delta g_{ij}}\frac{\delta}{\delta g_{kl}}+\sqrt{G^3}R)\psi(g)=0\,. \qquad (35)$$

It describes the change of the cosmic wave function, and has the nonlocality. In this case, different closed circles correspond to different levels of various nebula, stars and galaxies, etc., which are all discrete structures for smaller scale and continuous shapes for bigger scale. Further, it may be developed to the many worlds or multiverses, and the extensive quantum mechanics [1,2] and the extensive general relativity [23].

Simultaneously, from the simplest binary stars to various complex elliptical galaxy, lens galaxy, spiral galaxy, barred spiral galaxy and irregular galaxy, the composition of galaxy is partially similar to a molecule composed of atoms, from double atom molecule to various polyatomic molecule, macromolecule and high polymer. The mathematical forms and some characters of the two types of system, whose scales have enormous difference, can be used each other for reference.

These wonderful similarities agree without prior consultation with a Chinese theory on universe-man unification, and with Greek thinking on the similarity between man and the Universe expounded by Alcmaeon and Plato.

Galaxies

Based on the nonlinear equations of the density wave theory, we derived the evolutionary direction and the observable conditions on spiral galaxies by the qualitative analysis theory [50]. Its base is the galaxy formed from liquid [51-53]. This theory is the nonlinear dynamics, and the equations are [50]:

$$u_t+uu_r+(v/r)u_\vartheta-v^2/r=\phi_r\,, \qquad (36)$$

$$v_t+uv_r+(v/r)v_\vartheta+uv/r=\phi_\vartheta/r, \qquad (37)$$

in which the focus corresponds to the spiral galaxy. It may combine the continuity equation:

$$\frac{\partial\rho}{\partial t}+\nabla(\rho v)=0\,, \qquad (38)$$

Euler equation

$$\frac{\partial v}{\partial t}+(v\nabla)v=-\frac{1}{\rho}\nabla p+g\,, \qquad (39)$$

The equations of the gravitational field

$$\nabla\times g=0\,,\quad \nabla g=-4\pi G\rho\,. \qquad (40)$$

For post-newtonian mechanics [37], the celestial bodies regard as ideal liquid, and may apply the post-newtonian equations of hydrodynamics in the general relativity, whose equations are:

$$\frac{\partial}{\partial t}[\rho(1-v^2-2\phi)]+\nabla[v(\rho+p+\rho v^2-2\rho\phi)]=\rho\frac{\partial\phi}{\partial t}\,, \qquad (41)$$

$$\frac{\partial}{\partial t}[v(\rho + p + \rho v^2 - 2\rho\phi)] + \nabla[vv(\rho + p - 2\rho\phi + \phi v^2)] = -\nabla[p(1+2\phi)] -$$
$$\rho\nabla(\phi + 2\phi^2 + \psi) - \rho\frac{\partial\varsigma}{\partial t} - \rho(v^2 - 2\phi)\nabla\phi + \rho v \times (\nabla \times \varsigma) + 4\rho v\frac{\partial\phi}{\partial t} - \quad (42)$$
$$(3p + \rho v^2)\nabla\phi + 4p\nabla\phi + 4\rho v(v\nabla\phi).$$

For the general isotropic uniform cosmos, we select the Robertson-Walker metric [37]:

$$g_{tt} = -1, g_{it} = 0, g_{ij} = R^2(t)\tilde{g}_{ij}(x), \quad (43)$$

For the time component of the Einstein equations [37]:

$$\ddot{R} = -\frac{4}{3}\pi G(\rho + 3p)R, \quad (44)$$

For the space components [37]:

$$\ddot{R} = 4\pi G(\rho - p)R - \frac{2}{R}(\dot{R}^2 + k), \quad (45)$$

$\ddot{R}$ is deleted:

$$\dot{R}^2 + k = \frac{8}{3}\pi G\rho R^2. \quad (46)$$

For Eqs.(45) we obtain a pair equations:

$$\dot{R} = y, \quad \dot{y} = 4\pi G(\rho - p)R - \frac{2}{R}(y^2 + k), \quad (47)$$

whose characteristic matrix is

$$\begin{pmatrix} 0 & 1 \\ 4\pi G(\rho - p) + 2(y^2 + k)/R^2 & -4y/R \end{pmatrix}. \quad (48)$$

The characteristic equation is

$$\lambda^2 + 4y\lambda/R - A = 0, \quad (49)$$

$$\lambda = -\frac{2}{R}y \pm 2\sqrt{\pi G(\rho - p) + \frac{3}{2}(\frac{y}{R})^2 + \frac{k}{2R^2}}. \quad (50)$$

$$(\frac{y}{R})^2 \approx (\frac{\dot{R}}{R})^2 \approx \frac{8}{3}\pi G\rho. \quad (51)$$

Usually $\rho >> p$, $k = \pm 1, 0$. When A>0, (R, $\dot{R}$) is a saddle point.

The space components of the Einstein equation with a cosmic constant Λ [37] extracts:

$$\dot{R} = [\frac{\Lambda}{3}R^2 - k + \frac{2\alpha}{3\sqrt{|\Lambda|R}}]^{1/2}. \quad (52)$$

In de Sitter model, k= α =0, Λ >0. In Lemaitre model, k=+1 and α >0, Λ >0. In Eddington-Lemaitre model, k=+1 and α =1. The space-space components should be:

$$R\ddot{R} + 2\dot{R}^2 = \frac{2}{3}\Lambda R^2 - 2k + \frac{4\alpha}{3\sqrt{|\Lambda|}R}. \qquad (53)$$

$$\dot{R} = y, \quad \dot{y} = -\frac{2y^2}{R} + \frac{2}{3}\Lambda R - \frac{2k}{R} + \frac{4\alpha}{3\sqrt{|\Lambda|}R^2}. \qquad (54)$$

From the characteristic matrix of Eqs.(54), the corresponding characteristic equation

$$\lambda^2 + 4y\lambda / R - A = 0, \qquad (55)$$

we derive a solution:

$$\lambda = -\frac{2}{R}y \pm \sqrt{6(\frac{y}{R})^2 + \frac{2}{3}\Lambda + \frac{2k}{R^2} - \frac{8\alpha}{3\sqrt{|\Lambda|}R^3}}. \qquad (56)$$

When Δ<0, (R, $\dot{R}$) is a focus. When Δ>0, (R, $\dot{R}$) is a nodal point (for A<0) or a saddle point (for A>0). When A<0, $\dot{R}$/R>0 is a stable sink, and $\dot{R}$/R<0 is an unstable source. For de Sitter model k=α=0,

$$\lambda = -\frac{2}{R}y \pm \sqrt{6(\frac{y}{R})^2 + \frac{2}{3}\Lambda}. \qquad (57)$$

They are two different real numbers, and (R, $\dot{R}$) is a saddle point.

At a certain extent, (the general relativity)+(hydrodynamics)=(galactic dynamics)=cosmism. The galactic clustering [38] and phase transformation are similar with solid and crystal become from liquid. The cosmic string produces the huge electromagnetic field, which connects the electromagnetic general relativity [23].

For galaxies and cosmism, we may derive some results by the qualitative analysis theory, in which the source or sink correspond perhaps to the continuous expanding cosmos or the re-contraction cosmos.

We discussed the Dirac's negative energy state, which should be a negative matter, whose new main characteristics are the gravitation each other, but the repulsion with all positive matter. Such the positive and negative matters are two regions of topological separation in general case, and the negative matter is invisible. This is the simplest candidate of dark matter, and can explain some characteristics of the dark matter and dark energy. Recent phantom on dark energy is namely a type of negative matter. Based on a basic axiom and the two foundational principles of the negative matter, we researched its predictions and possible tests. The negative matter should be a necessary development of Dirac theory [54-56]. Further, we proposed that in quantum fluctuations the positive matter and negative matter are created at the same time, and derive an inflation cosmos. This corresponds to the cosmological mode created from nothing to all things. It may form the parallel worlds, or the many-worlds, or multiverse, etc. The Higgs mechanism is possibly a product of positive and negative matter [57]. Moreover, we proposed the three basic laws of the negative matter. The existence of four matters on positive, opposite, and negative, negative-opposite particles will form the most perfect symmetrical world [54-57].

The astronomical quantum theory corresponding to non-relativistic classical mechanics has been discussed. Future developments should connect with relativity, especially, the general relativity,

it is namely the gravity quantum. Furthermore, the research of the cosmic and extensive quantum theory, as a quantized physics, will converge into the discrete science developing increasingly.

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