起源于跑动惯性的宇宙学红移

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摘要：本论文提出并解释了一种红移量与星系之间的距离成正比的宇宙学红移原理，这是一种与多普勒红移完全不同的红移机制。该原理表明，在星系际间的大尺度宇宙背景下，偏离局部等效原理的德布罗意动量—波长关系可以导致这样一种红移，其效应与相互远离运动所产生的多普勒红移等同。本文还证明，哈勃红移也可以用星系引力的相对潮汐加速度效应来解释，理论给出的非线性红移方程恰好符合高红移Ia型超新星的观测结果。于是，哈伯常数可以被逻辑地推导出来，但其理论公式仅与银河系的引力场和真空光速相关，并不涉及宇宙的膨胀速率、尺度和年龄，这意味着哈勃常数的物理意义需要被重新定义。

关键词：暗能量，宇宙学红移，多普勒红移，哈勃定律，哈勃常数，跑动的惯性，潮汐力。

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The cosmological redshift originated from running inertia

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Abstract: This paper suggests a model of cosmological redshift, in which the amount of redshift is proportional to distances between the galaxies. Rather than the effects of Doppler redshift, this principle of redshift arises from both of the running inertia deviated from the local equivalence principle at cosmological distances and the de Broglie's basic equation related the wavelength to the momentum. This paper proves that the Hubble's redshifts can also be explained as the relative tidal acceleration effect of galactic gravity, and the theoretical redshift equation fits in well with the observation data of high-redshift type Ia supernovae. The result also shows that the Hubble's constant can be logically derived, however its theoretical formula is only related to the galactic gravitational field and the speed of light in vacuum rather than with the expansion rate, size and age of the universe, therefore the physics meaning of Hubble's constant has to be redefined.

Key words: Dark energy, Cosmological redshift, Doppler redshift, Hubble's law, Hubble's constant, Running inertia, Tidal force.

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0 Introduction

In cosmology, the redshift of a distant galaxy can be measured by the atomic spectrometry[1], and the relative redshift is defined as the change in the wavelength of the light, that is

$$z = \frac{\Delta\lambda}{\lambda_0} = \frac{\lambda_D - \lambda_0}{\lambda_0}, \tag{1}$$

where z is the relative amount of redshift; λ_0 and λ_D are the emitted and observed wavelengths, respectively. If this redshift can be regarded as a Doppler frequency shift, then one can infer that the receding velocity of the distant galaxy would be

$$z = \frac{v}{c}, \tag{2}$$

where v is the receding velocity of the distant galaxy traveling away from the observer, which refers specifically to the relative velocity globally defined between distant galaxies flying away from each other, and c is the velocity of light.

In this case, if associating the redshift of the distant galaxies with the distances between the galaxies to the earth, there turned to be a linear relationship which can be expressed as redshift velocity

$$v = H_0 D, \tag{3}$$

where D is defined as the proper distance from an observer to a galaxy; H_0 is the Hubble constant and has the SI unit of s^{-1}. This became known as Hubble's law [2, 3, 4, 5] as shown in Fig.1. This famous law provided the basis observational evidence for expansion of the universe and helped establish the standard cosmological model, in which the redshift of galaxies was attributed to the intergalactic Doppler redshift as the reliable physical basis, and the dark energy problem arises.

However, the question is whether the redshift of these remote galaxies might be due to some other causes[6, 7, 8]. Is the receding velocity of the distant galaxy the only possible explanation of Hubble's redshift? While we are developing a theory of relativistic astrodynamics to explain the flat galaxy rotation curves without the need of dark matter[9], as an important conclusion derived, we find out that, in large galactic and cosmological distance, the ratio of the inertia mass to the gravitational mass of an object appears the phenomenon of running between the different local inertial viewers. Therefore, in contrast with the redshift of receding velocity, this effect of running inertia may introduce a new kind of redshift which would result in a completely different cosmological framework.

Sir Fred Hoyle and Jayant Narlikar had got more closer to the solution of the redshift of running inertia, in contrast to the Big-Bang cosmology, they thought that the Hubble's redshift can be interpreted as arising from particle masses varying with epoch in a steady-state universe[10]. However, it is a pity that this idea is still needed to explain an expanding universe.

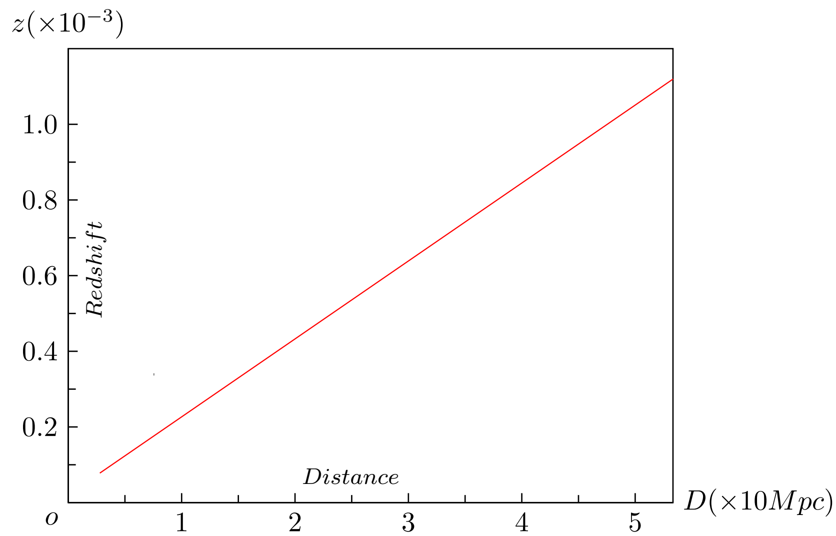

图 1: The Hubble Diagram

1 The cosmological redshift caused by running inertia

1.1 The galactic rotation curve and the running of the equivalence principle

In the previous paper[9], we proved that the aberration of gravity propagation produced additional "accelerated" effect and made the orbits of celestial bodies in outer region of a galaxy to become equiangular spiral type. And there is a singular characteristics of equiangular spiral orbits that makes any objects on the equiangular spiral orbit keep the same speed regardless their orbital radius, therefore led to flat galactic rotation curves (the illusion of dark matter).

In the case of our Milky Way galaxy, the rotation curve is shown in Figure 2, there is a inflection point on the rotation curve called critical radius r_0, the overall mass of the galaxy's matters almost contained within radius r_0, and $r_0 < r_\odot \approx 8.29 \pm 0.16kpc \approx 2.6 \times 10^{17}km$[11], where $r_\odot$ is the Sun's orbital radius around the galactic centre.

According to the local equivalence principle, at the radius r_0 , we can define the equivalence relation that the inertial mass m_I is equal to the gravitational mass m_G of an object in galactic gravitational field, then the law of conservation of angular momentum for the object around the galactic centre holds the following equation

$$m_I v_c r = m_G v_c r_0, \qquad (r \geqslant r_0), \tag{4}$$

where v_c is the circular velocity of the object around the galactic centre, and keeps a constant according to its equiangular spiral orbit, then we get an equation of modified mass

$$m_I = m_G \frac{r_0}{r}, \qquad (r \geqslant r_0). \tag{5}$$

Under Einstein's modification of Newton's law, the inertia mass of an object may vary with speed, now we have seen that it is also the function of gravitational potential energy (here, expressed as distance). The equation (5) accurately shows the relativity of inertia mass of an object in the gravitational field.

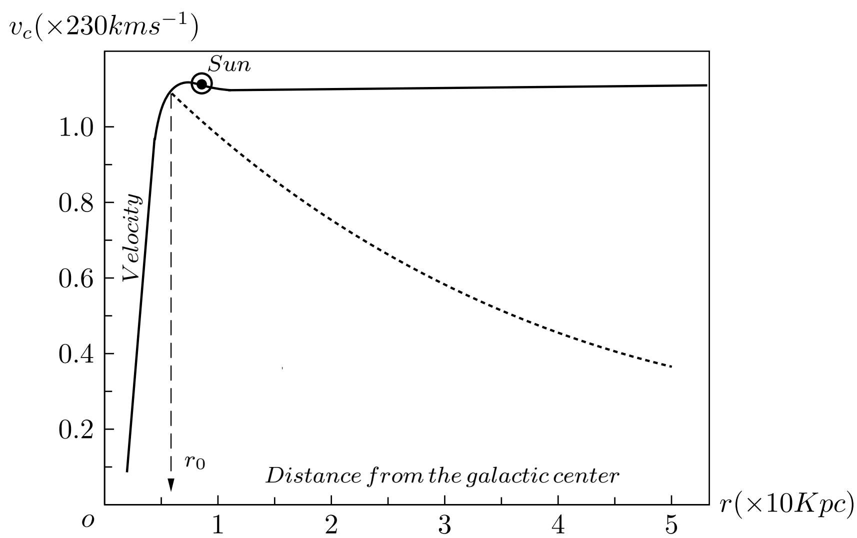

图 2: Rotation curves of the Milky Way galaxy: the solid-line is predicted by the relativistic astrodynamics and has been observed; the dotted line is expected by Newton's theory.

However, the origin of coordinates of equation (5) is at the galactic centre, just to be clear and simple, the origin of coordinates can also be moved to the location of the critical radius r_0, then we have

$$m_I = \frac{m_G}{1 + \Lambda_0 \cdot r}, \tag{6}$$

where Λ_0 is a scale factor, and when $r = 0$, there is $m_I = m_G$. The equation (6) will be further proved in the section 2.2.

1.2 The cosmological redshift

Because the range of gravitational force is infinite, the effect of formula (6) is marching into infinity. For the promotion of formula (6), we choose the hydrogen atoms as our test particle to introduce a model of cosmological redshift. In the ground state of hydrogen atom, the spin-spin interaction of the hyperfine splitting can tear the ground state, which could emit or absorb the photons with the accurate frequency, that is[12]

$$\nu_0 = 1.420405751768(1) \times 10^9 Hz. \tag{7}$$

For the energy of photons emitted or absorbed there must be

$$h\nu_0 = E_H - E_L, \tag{8}$$

where, E_H and E_L represented the energy of high level and the energy of the low level of the hyperfine structure splitting respectively, and h is the Planck constant. According to the de Broglie relation[13], and for the local point of view: $m_I = m_G$, we have

$$\lambda = \frac{h}{p} = \frac{h}{v \cdot m_I} = \frac{h}{v \cdot m_G}, \tag{9}$$

where, m_I is the electron's inertia mass; m_G is the electron's gravitational mass; v is the orbital velocity of the electron in the ground state; p is the momentum of the electron; λ is the wavelength of the matter wave which refers specifically to the momentum of the electron. At the ground state in a hydrogen atom, the orbital speed of electron is a constant, and there is $v = \alpha \cdot c$, where the α is defined as the fine structure constant and there is $\alpha = v/c \approx 1/137$. For using above relations and for

$$\nu = E/h = c/\lambda,$$

we have

$$\begin{aligned} \nu_0 &= \frac{E_H}{h} - \frac{E_L}{h} = \frac{c}{\lambda_H} - \frac{c}{\lambda_L} \\ &= \frac{c}{\lambda_0}, \end{aligned} \tag{10}$$

and

$$\lambda_H = \frac{h}{v \cdot m_{IH}}; \qquad \lambda_L = \frac{h}{v \cdot m_{IL}}, \tag{11}$$

where m_{IH} and m_{IL} are the electron's inertia mass of the high energy level and low energy level in the tearing ground state respectively, λ_H and λ_L are the wavelength of the matter wave of the electron respectively. Thus this quantum jumping between two states produces the photons with the wavelength

$$\lambda_0 = \frac{h}{(m_{IH} - m_{IL}) \cdot v}. \tag{12}$$

In equations (11) and (12), although the λ_H and λ_L are not measurable quantity, the wavelength λ_0 can always be observed precisely, which is just the famous signature 21-centimeter emission line of hydrogen sources, and the frequency ν_0 is showed in (7).

In the view of observer on our Earth, the observed wavelength λ_D of the light from the distant galaxies might be different. Taking into consideration of equation (6), the measured hyperfine splitting wavelength of the hydrogen atoms from the distant galaxies should be

$$\begin{aligned}\lambda_D &= \frac{h}{[(m_{IH}/(1+\Lambda_0\cdot r)-m_{IL}/(1+\Lambda_0\cdot r)]\cdot v}\\ &=(1+\Lambda_0\cdot r)\frac{h}{(m_{IH}-m_{IL})\cdot v}\\ &=(1+\Lambda_0\cdot r)\lambda_0.\end{aligned} \tag{13}$$

Substituting (12) and (13) into (1), we obtain the amount of redshift

$$z=\frac{\lambda_D-\lambda_0}{\lambda_0}=\Lambda_0\cdot r. \tag{14}$$

This redshift is proportional to the distance from the hydrogen atoms of distant galaxies to us, and should have the same amount of receding Doppler redshift. By means of Hubble's law, we let

$$z=\Lambda_0\cdot r=\frac{H_0}{c}\cdot r, \tag{15}$$

where r is defined as the proper distance from an observer on Earth to a distant galaxy; H_0 is the Hubble's constant and has the SI unit of s^{-1}, and c is the velocity of light. Thus we get

$$\Lambda_0=\frac{H_0}{c}. \tag{16}$$

By using equations (12) and (13) to determine the wavelength and redshift of the hydrogen atoms, the only restriction is demand for a universal fine structure constant. The experiment on Earth gives the precise result by [14]

$$\alpha=7.2973525698(24)\times10^{-3}. \tag{17}$$

In universe observation, the first detection of a variation in α found that, over the last 10∼12 billion years, the relative amount of variation in α has a slight increase, which is [15]

$$\Delta\alpha/\alpha=(-5.7\pm1.0)\times10^{-6}. \tag{18}$$

Therefore, the tiny change of α can be ignored completely.

1.3 The nonlinear redshift vs. the accelerated expansion of the universe

In 1998, observations of type Ia supernovae discovered that the expansion of the universe has been accelerating from the distance corresponding to the redshift of $z\approx0.5$ in Hubble Diagram.[16, 17, 18]

However, if we consider the nonlinear effect of (6) and (9), there turned out to be a nonlinear relationship between redshift z and distance r which would result in the same appearance as cosmic acceleration. Now we take the derivative of (9), there is

$$d\lambda=\frac{-h}{m_I^2 v}\cdot dm_I=\frac{-\lambda}{m_I}\cdot dm_I, \tag{19}$$

and take derivative with respect to (6), that is

$$dm_I = \frac{-m_G\Lambda_0}{(1+\Lambda_0\cdot r)^2}\cdot dr = \frac{-m_I\Lambda_0}{1+\Lambda_0\cdot r}\cdot dr. \tag{20}$$

Substituting (20) into (19), we get

$$d\lambda = \frac{\lambda\cdot\Lambda_0}{1+\Lambda_0\cdot r}\cdot dr, \tag{21}$$

and

$$dz = \frac{d\lambda}{\lambda} = \frac{\Lambda_0}{1+\Lambda_0\cdot r}\cdot dr = \Lambda\cdot dr, \tag{22}$$

where

$$\Lambda = \frac{\Lambda_0}{1+\Lambda_0\cdot r}, \tag{23}$$

obviously, there is $\Lambda = \Lambda_0$, when $r = 0$.

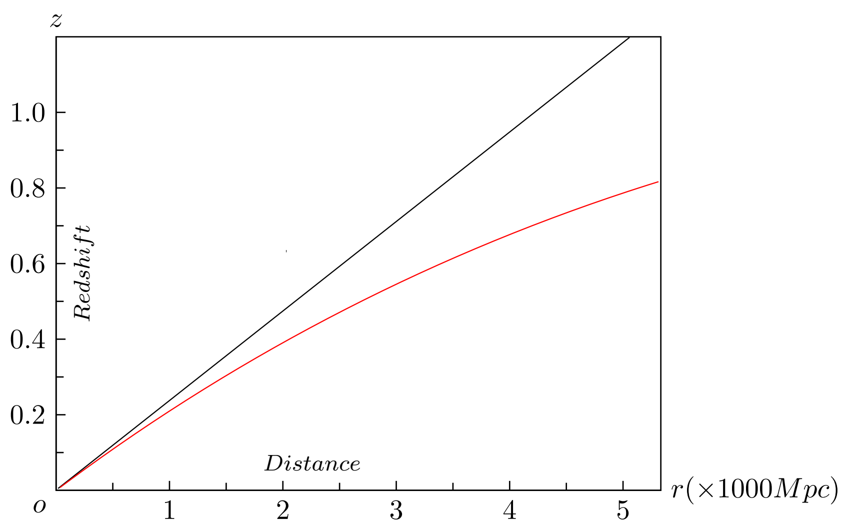

图 3: The Hubble Diagram for nonlinear redshift. The solid black curve is the standard Hubble's redshift with $\Lambda_0 = H_0/c$; the solid red curve is the theoretical curve for nonlinear redshift described by formula (25) with $\Lambda = \Lambda_0/(1+\Lambda_0\cdot r)$, which looks as if there is an universe accelerated expansion.

Thus the redshift z becomes

$$z = \int \frac{\Lambda_0}{1+\Lambda_0\cdot r}\cdot dr = \ln(1+\Lambda_0\cdot r) + z_0, \tag{24}$$

where z_0 is an integration constant, by boundary conditions $r = 0, z = 0$, we get $z_0 = 0$, finally, we get the result

$$z = \ln(1+\Lambda_0\cdot r). \tag{25}$$

When $\Lambda_0 \cdot r \ll 1$, (25) will go back to (15), that is

$$z = \ln(1 + \Lambda_0 \cdot r) \approx \ln e^{\Lambda_0 \cdot r} = \Lambda_0 \cdot r = \frac{H_0}{c} \cdot r, \qquad (\Lambda_0 \cdot r \ll 1). \tag{26}$$

The nonlinear cosmological redshift indicated by equations (25) can be observed, which acts just as described by the hypothesis of accelerated expansion of the universe as shown in Fig.3

1.4 The distances determined by redshift

Since measuring redshift z is much easier than measuring distance r, now, however near or far, the distance can be determined uniquely by formula (25), that is

$$D_z = \frac{e^z - 1}{\Lambda_0} = \frac{e^z - 1}{H_0/c}. \tag{27}$$

Table 1 and Figure 4 (based on Table 1) show the redshift distances D_z determined by formula (27) and the luminosity distance D_L as the comparison of samples for 10 high-redshift type Ia supernovae in the redshift range $0.30 \leq z \leq 0.97$, in which the data was from Table 5 of the observational evidence[18].

表 1: The distances determined by redshift for 10 high-redshift type Ia supernovae[18].

SN (1)	z (2)	μ_0 (3)	σ_{μ_0} (4)	$D_z(Mpc)$ (5)	$D_L(Mpc)$ (6)	σ_{D_L} (7)
1996E	0.43	41.74	0.28	2323.51	2228.44	287.34
1996H	0.62	42.98	0.17	3714.66	3944.57	308.81
1996I	0.57	42.76	0.19	3322.57	3564.51	311.89
1996J	0.30	41.38	0.24	1513.06	1887.99	208.67
1996K	0.38	41.63	0.20	1999.27	2118.36	195.11
1996U	0.43	42.55	0.25	2323.51	3235.94	372.55
1997ce	0.44	41.95	0.17	2390.33	2454.71	192.17
1997cj	0.50	42.40	0.17	2805.56	3019.95	236.43
1997ck	0.97	44.39	0.30	7083.72	7550.92	1043.20
1995K	0.48	42.45	0.17	2664.37	3090.30	241.93

Note:
(1) IAU Name assigned to supernova.
(2) Redshift of supernova.
(3) The distance modulus.
(4) Distance modulus uncertainty.
(5) The predicted redshift distances (Mpc) determined from formula (27).
(6) Luminosity distance (Mpc).
(7) Luminosity distance uncertainty.

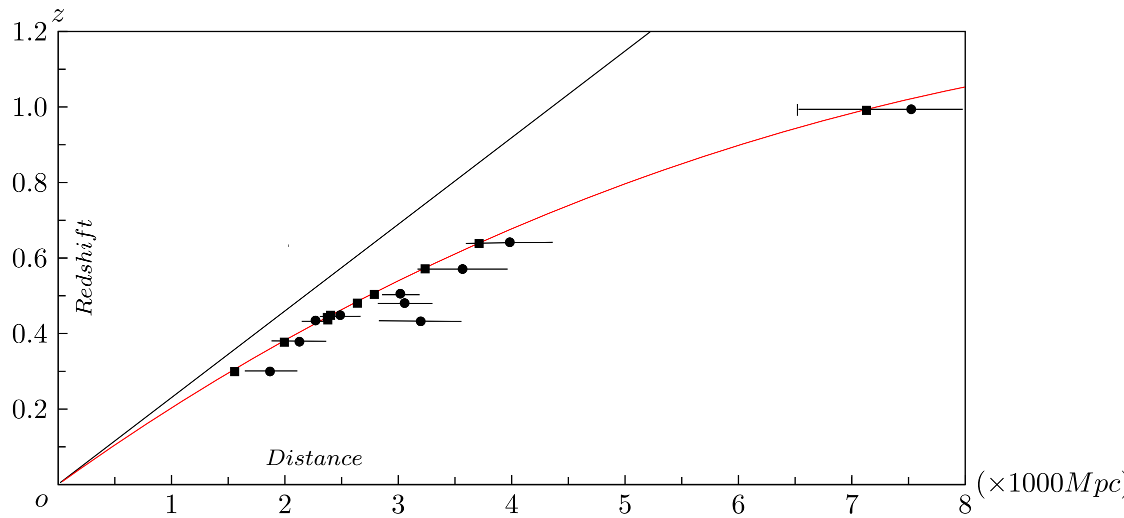

图 4: The nonlinear Hubble diagram for 10 high-redshift type Ia supernovae. The solid black curve is the standard Hubble's redshift by formula (26); the solid red curve is the theoretical curve for nonlinear redshift described by formula (27), which fits in with the data of Table 1.

The details of the calculation method that show the distances determined by the cosmological redshift formula (27) are shown in a separate paper[19]. In that article, we present the results of 43 high-redshift ($0.172 \le z \le 1.755$) type Ia supernovae. Also, the results show that the distances determined by the cosmological redshift formula (27) and the Standard Candle Method have a good match within the measurement uncertainties.

2 The cosmological redshift formula and relative tidal acceleration

2.1 The relative "anti-gravity" of the galactic tidal effect

Further, in this section it is proved that the Hubble's redshift can also be explained by the mechanism of tidal gravity, by which not only we get the same formula as (25), but also a new theoretical formulation of Hubble's constant and other results.

The gradient of the galactic gravitational field along the radial makes the tidal effect. If there is a object m in outer region of the Milky Way galaxy, it must be attracted by the mass of our galaxy, the gravitational force is

$$F = -G\frac{M_0 m_G}{r^2}, \tag{28}$$

where r is the distance from the galactic center to m; M_0 is the overall mass of the galaxy's matters contained within radius r_0; m_G is the gravitational mass of the object; G is the gravitation constant and a minus sign here to indicate the force is attractive.

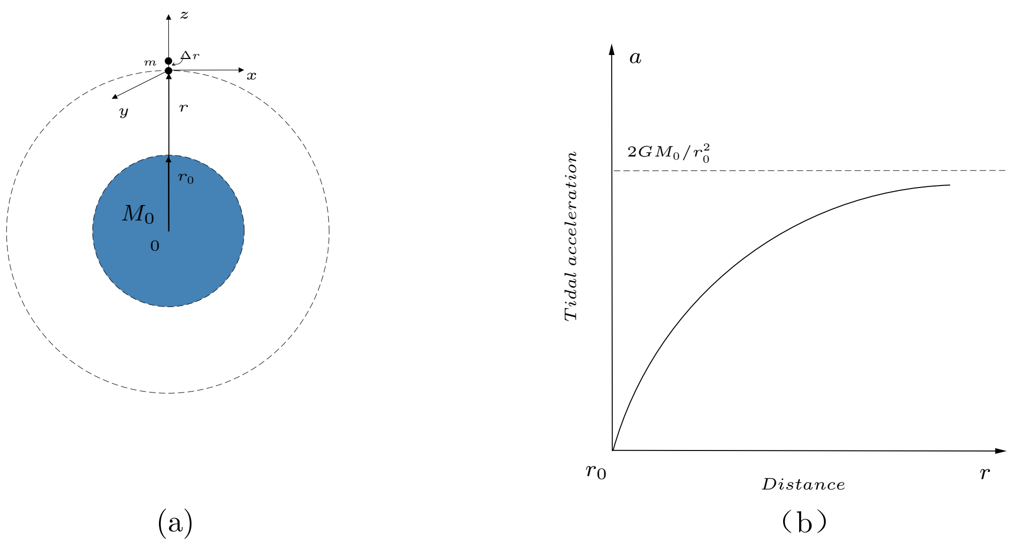

图 5: The galactic tidal gravity led to the relative repulsive force and relative acceleration. (a): A free falling reference frame with a follow-up coordinate system (x, y, z), its origin of coordinates is instantaneously in the location (0, 0, r). (b): When $r > r_0$, the relation between relative tidal acceleration and distance.

As a free falling reference point m, if there is a follow-up coordinate system attached to it and the z axis of the coordinate system is parallel to the radius direction, as shown in Figure 5(a), the gravitational field can be eliminated by transformation. However, in such a free falling local coordinate system, the tidal effect of galactic gravity cannot be eliminated because of the non-uniform properties of the field. Now, if there is another object m with the gravitation mass m_G at the location (0, 0, $\triangle r$) within the follow-up coordinate system, along the radial direction and relative to the origin of follow-up coordinate system, the tide generating force is

$$\triangle F \approx \frac{2GM_0 m_G}{r^3} \triangle r. \tag{29}$$

Relative to the origin of the follow-up coordinate system, this is a kind of repulsive force, and its strength of relative "anti-gravity" is proportional to the distances between two points (0, 0, $r + \triangle r$) and (0, 0, r). Due to the effect of long range of the gravity, the galactic tidal effect could reach much farther into the depths of the universe even the limits of the observable universe, therefore we expect the tide generating force will cause such relative tidal acceleration as shown in Fig.5(b).

The gradient of the galactic gravitational field along the radial makes the tidal effect. If there is a observer at the location (0, 0, r) in the barycentric reference system of the Milky Way galaxy, as shown in Figure 5(a), and another object m with the gravitation mass m_G at the location (0, 0, $r + \triangle r$), relative to the observer, the tide generating force of the gravitational field is

$$\triangle F \approx \frac{2GM_0 m_G}{r^3} \triangle r. \tag{30}$$

This is a kind of relative repulsive force, and its strength of relative "anti-gravity" is proportional to the distances between two points (0, 0, $r + \triangle r$) and (0, 0, r).

Due to the effect of long range of the gravity, the galactic tidal effect could reach much farther into the depths of the universe even the limits of the observable universe, therefore we expect the tide generating force will cause such relative tidal acceleration as shown in Fig.5(b).

2.2 The gravity and inertia in a free-falling frame of reference

In the previous paper[9], We've shown that, the aberration effect of relativity is the cause of logarithmic spiral tracks of the celestial bodies, which results in the flat rotation curves of the galaxy and the Modified Newtonian Dynamics. It is also derived that, at large galactic and cosmological distances, the equivalence relation of the inertia mass to the gravitational mass of an object has been cut off. All these results are from the necessary relativistic shift of Newton's gravity(28), that is

$$F(r) = -\kappa\, G\frac{M_0 m_G}{r^2}, \tag{31}$$

and

$$\kappa = (\frac{1 + v_c/c}{\sqrt{1 - v_c^2/c^2}})^2 = \frac{1 + v_c/c}{1 - v_c/c} \approx 1 + \kappa' + \kappa'' = 1 + 2v_c/c + 2(v_c/c)^2, \tag{32}$$

where, $\kappa' = 2v_c/c$ is the first-order correction coefficient, $\kappa'' = 2(v_c/c)^2$ is the second-order correction coefficient.

As a free falling reference point m, if there is a follow-up coordinate system attached to it and the z axis of the coordinate system is parallel to the radius direction, as shown in Figure 5(a), the gravitational force can be seemingly eliminated by the equivalence principle. However, because the point m is free falling along the geodesic of logarithmic spiral orbit, the vanished forces only are Newton's force and its first-order reinforcing effect,

$$F(r) = -(1 + 2v_c/c)\, G\frac{M_0 m_G}{r^2}, \tag{33}$$

otherwise, the second-order correction would created a reinforced force

$$F = -\kappa''\frac{GM_0 m_G}{r^2} = -(2v_c^2/c^2)\frac{GM_0 m_G}{r^2}. \tag{34}$$

In the free falling reference system, there must be an inertial force in equilibrium with this reinforced force, that is

$$m_I \frac{v_c^2}{r} = (2v_c^2/c^2)\frac{GM_0 m_G}{r^2}. \tag{35}$$

So let's get rid of v_c, we get

$$m_I = \frac{2GM_0 m_G}{c^2 r}. \tag{36}$$

Now, take derivative m_I with respect to r along the axis z , that is

$$\frac{dm_I}{dr} = -\frac{2GM_0 m_G}{c^2 r^2}; \tag{37}$$

substituting equation(5) into the equation(37), we get

$$\frac{dm_I}{dr} = -\frac{2GM_0 m_I}{c^2 r_0 r}. \tag{38}$$

At $r = r_0$, there is

$$\frac{dm_I}{dr} = -\frac{2GM_0 m_I}{c^2 r_0^2}, \tag{39}$$

and the solution is

$$m_I = m_G \cdot exp(-\frac{2GM_0}{c^2 r_0^2} r). \tag{40}$$

Around a small neighborhood of m, above formula evolves into

$$m_I = m_G \cdot exp(-\frac{2GM_0}{c^2 r_0^2} r) \approx \frac{m_G}{1 + \frac{2GM_0}{c^2 r_0^2} r}, \tag{41}$$

the reason is that, when $x \ll 1$ there is $e^{-x} \approx \frac{1}{1+x}$.

In the free falling reference system, around a small neighborhood of m, there is only a local inertial system. However, according to the theory of our previous paper[9], all the objects travel at the same constant speed in $r \geqslant r_0$, which makes it look as if the cosmic space would be the **pseudo-euclidean flat space**. Therefore, the validity of equation(41) would have global significance with the **constant speed of light in universe**. Now we let

$$\Lambda_0 = \frac{2GM_0}{c^2 r_0^2}, \tag{42}$$

then the equation(41) becomes

$$m_I = \frac{m_G}{1 + \Lambda_0 r}, \tag{43}$$

which is the law of relative inertia of a body in a freefall frame of reference of the galactic gravitational field.

Now let's look at the relative gravity in a freefall frame of reference of the galactic gravitational field. By formula (34), we get

$$F = -\kappa'' \frac{GM_0 m_G}{r^2} = -(2v_c^2/c^2)\frac{GM_0 m_G}{r^2} = -m_I a_n, \tag{44}$$

where a_n is the acceleration in equilibrium with this reinforced force,

$$a_n = (2v_c^2/c^2)\frac{GM_0 m_G}{m_I r^2}, \qquad (r \geqslant r_0). \tag{45}$$

Substituting equation(5) into the equation(45),

$$a_n = (2v_c^2/c^2)\frac{GM_0}{r_0 r}, \qquad (r \geqslant r_0). \tag{46}$$

Then, take derivative a_n with respect to r along the axis z , that is

$$\frac{da_n}{dr} = -(2v_c^2/c^2)\frac{GM_0}{r_0 r^2}, \qquad (r \geqslant r_0); \tag{47}$$

at radius $r = r_0$,

$$a_n = \frac{GM_0}{r^2} = \frac{GM_0}{r_0^2}, \qquad (r = r_0); \tag{48}$$

and

$$v_c^2 = \frac{GM_0}{r_0}, \qquad (r \geqslant r_0); \tag{49}$$

thus we get an incremental acceleration equation

$$da_n = \frac{GM_0}{r^2}(-\frac{2GM_0}{c^2 r_0^2}dr) = a_n(-\frac{2GM_0}{c^2 r_0^2}dr), \qquad (r \geqslant r_0). \tag{50}$$

The solution is

$$a_n = \frac{GM_0}{r_0^2}exp(-\frac{2GM_0}{c^2 r_0^2}r) \approx \frac{GM_0}{r_0^2}\frac{1}{1+\dfrac{2GM_0}{c^2 r_0^2}r} = \frac{GM_0}{r_0^2}\frac{1}{1+\Lambda_0 r}, \qquad (r \geqslant r_0); \tag{51}$$

the corresponding force is

$$F = -m_I a_n = -\frac{GM_0}{r_0^2}\frac{m_I}{1+\Lambda_0 r}, \qquad (r \geqslant r_0); \tag{52}$$

by substituting equation(43) into the equation(52), we get the result

$$F = \frac{-GM_0 m_G}{r_0^2(1+\Lambda_0 r)^2}, \qquad (r \geqslant r_0), \tag{53}$$

which is the law of relative gravity in a freefall frame of reference of the galactic gravitational field.

2.3 The cosmological redshift formula derived by relative tidal acceleration

In the previous paper[9], it has been proved that the orbits of celestial bodies in outer region of a galaxy (orbit radius $r \geqslant r_0$) are the planar equiangular spiral which is geometric projection or expand of conical spiral. However a conical spiral is the geodesic on the surface of a cone (a developable curved surface with the nature of plane in two-dimensional intrinsic space), which is embedded in the three dimensional Euclidean space. That way, for an observer on the earth, the cosmic space from the critical radius r_0 to infinity, all the curved space caused by the galactic gravitational field would not be the Riemann sphere (a sealed universe) but a kind of Euclidean linear space (an open universe). And also in fact, the flat galactic rotation curve shows that, there is the Galileo's inertia space in the regions of $r > r_0$. It is certainly a direct result of the running of the equivalence principle.

Therefore, the relative tidal field (30) in a freefall frame of reference of the galactic gravitational can be written as

$$\triangle F = \frac{2GM_0 m_G \cdot \triangle\Lambda_0 r}{r_0^2(1+\Lambda_0 r)^3}. \tag{54}$$

So, we get the relative tidal acceleration between two points (0, 0, $r + \triangle r$) and (0, 0, r), which is

$$\triangle a = \frac{2GM_0 m_G \cdot \triangle\Lambda_0 r}{m_I r_0^2(1+\Lambda_0 r)^3} = \frac{2GM_0 \cdot \triangle\Lambda_0 r}{r_0^2(1+\Lambda_0 r)^2}. \tag{55}$$

For an observer on r_0, the accumulated relative tidal acceleration along the radial direction would be

$$a = \int_0^r \frac{2GM_0\Lambda_0}{r_0^2(1+\Lambda_0 r)^2} dr = \frac{2GM_0}{r_0^2} - \frac{2GM_0}{r_0^2(1+\Lambda_0 r)}, \tag{56}$$

which is increasing with distance r and has a limit value as shown in Figure 5(b). However, at r_0, the background tidal acceleration is

$$a_0 = \frac{2GM_0}{r_0^2}, \tag{57}$$

therefore, the net effect of tidal acceleration is

$$\sum a = a_0 - a = \frac{2GM_0}{r_0^2(1+\Lambda_0 r)}. \tag{58}$$

This repulsive tidal acceleration will allow us to give the new explanation for the mechanism of cosmological redshift.

If a photon emitted from a stationary atom at (0, 0, $r_0 + \triangle r$) is observed by the stationary observer at (0, 0, r_0), because the movement of the photon in the relatively tidal force field is free "fall-up", in other words, it is a free falling photon in a anti-gravity field, then the stationary observer at (0, 0, r_0) would see the redshift of frequency. Letting the energy of the photon at (0, 0, $r_0 + \triangle r$) is $E_0 = h\nu_0$, where h is the Planck constant; ν_0 is the frequency of the photon on launch, therefore the corresponding mass of the photon (not a static mass) is $h\nu_0/c^2$, after "falling" by distance $\triangle r$ in the tidal force field, its mass would become a little lighter because of the decrease of the energy by $(h\nu_0/c^2)\sum a \triangle r$, that is

$$E = h\nu_0(1 - \frac{\sum a \triangle r}{c^2}) = h\nu_0(1 - \frac{2GM_0}{c^2 r_0^2(1+\Lambda_0 r)} \triangle r), \tag{59}$$

the corresponding frequency is $\nu = E/h$, that should give such results of

$$\nu = \nu_0(1 - \frac{\sum a \triangle r}{c^2}) = \nu_0(1 - \frac{2GM_0}{c^2 r_0^2(1+\Lambda_0 r)} \triangle r); \tag{60}$$

and

$$\triangle z = -\frac{\triangle \nu}{\nu_0} = -\frac{\nu - \nu_0}{\nu_0} = \frac{2GM_0}{c^2 r_0^2 (1 + \Lambda_0 r)} \triangle r, \tag{61}$$

this is clearly a redshift. Then, according to that, when $r > r_0$, the space is the Euclidean linear space, and the speed of light is always the same in such linear space, so the formula (61) can be integral by

$$z = \int_0^r \frac{2GM_0}{c^2 r_0^2 (1 + \Lambda_0 r)} dr, \tag{62}$$

and in view of formula (42), that is

$$\Lambda_0 = \frac{2GM_0}{c^2 r_0^2},$$

we get

$$z = \ln(1 + \frac{2GM_0}{c^2 r_0^2} r) = \ln(1 + \Lambda_0 r), \tag{63}$$

that is exactly the formula (25).

In the nearly astronomical distances, where $\Lambda_0 r \ll 1$, nonlinear redshift formula (63) will go back to a asymptotic linear law, that is

$$z = \ln(1 + \Lambda_0 r) \approx \ln e^{\Lambda_0 r} = \Lambda_0 r, \qquad (\Lambda_0 r \ll 1), \tag{64}$$

this is obviously the Hubble's law. Comparing formulas (64) and the Hubble's law, there must be

$$\Lambda_0 = \frac{H_0}{c} = \frac{2GM_0}{c^2 r_0^2}, \tag{65}$$

so the end result is

$$z = \ln(1 + \frac{H_0}{c} r). \tag{66}$$

2.4 Discussions on Hubble's constant

By the scale factor Λ_0, described as formula (65), we get the Hubble's constant

$$H_0 = \frac{2GM_0}{c r_0^2}. \tag{67}$$

The equation (67) shows that the derived Hubble's constant consists only of three parts: the gravitation constant, the observed mass distribution of the Milky Way galaxy, and the speed of light in a vacuum, that are timeless and have nothing to do with the density of the universe. This means that the Hubble's redshift has nothing to do with the expansion of the universe or not. In turn, the critical radius r_0 of the Milky Way galaxy by measuring the Hubble's constant, and then according to the radius r_0 we should get the observed mass of the Milky Way galaxy.

Because of that, at $r = r_0$, the circular velocity of the object around the galactic centre should be determined by the following formula

$$m_I \frac{v_c^2}{r_0} = \frac{GM_0 m_G}{r_0^2}, \tag{68}$$

and there, $r = r_0$, it should be $m_I = m_G$, so we get

$$v_c^2 = \frac{GM_0}{r_0}, \tag{69}$$

then substituting (69) into (67), we get

$$H_0 = \frac{2v_c^2}{cr_0}, \tag{70}$$

that is

$$r_0 = \frac{2v_c^2}{cH_0}. \tag{71}$$

With the experimental data $H_0 \approx (69.32 \pm 0.80) km\, s^{-1} Mpc^{-1}$ [3]; $v_c \approx 239 \pm 5 kms^{-1}$[11], and $c \approx 3 \times 10^8 ms^{-1}$, we get the critical radius of the Milky Way galaxy $r_0 \approx 5.49 kpc \approx 1.65 \times 10^{17} km$, then substituting this value of r_0 into the formula (67), the total mass of Milky Way galaxy shall be $M_0 \approx 1.41 \times 10^{41} \approx 7.05 \times 10^{10} M_\odot$, where $M_\odot \approx 2.0 \times 10^{30} kg$ is the mass of the Sun. These values are broadly consistent with the estimates without dark matter.[20]

3 Why is the sky so dark at night?

3.1 The spatial distribution of the distant cosmic radiation sources in the infinite and homogeneous universe

Now, according to the equation (66), we get a picture of large-scale universe as shown in Fig.6, which is the relationship between the nonlinear redshift described by formula (66) and an infinite homogeneous universe. And if the cosmological principle is correct, all galaxies should be distributed uniformly on the largest scales along any direction of the universe. Hence, in Fig.6, if there are two distant galaxies in (D) and (E) respectively on r axes, their redshift are "accumulated" at (z_d) and (z_e) on z axes, however according to Hubble's law (the straight line in Fig.6), their distances are neither (D) nor (E) but seem to be "compressed" to (B) and (A) on r axes.

For more distant galaxies or other weak radiation sources (because they are much farther away from us), the redshift would be more strongly "accumulated" in a narrow range of z_∞, and seem to be "saturated". This is why these distant galaxies or weak radiation sources look as if with the spatial distribution of higher density in further cosmic distances.

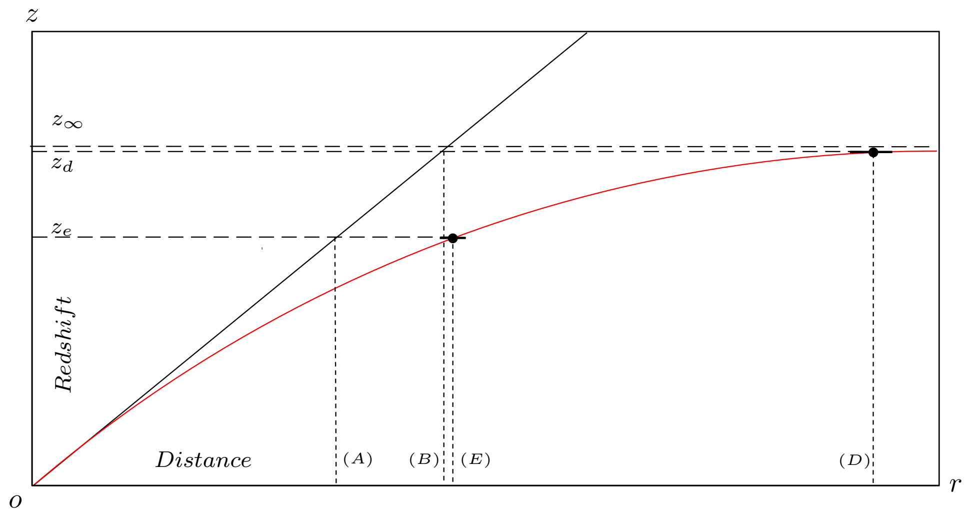

图 6: The nonlinear redshift curve tells us, because of the illusions of ”accumulated” redshift and ”compressed” distances, the universe appears to be accelerating expansion.

3.2 The origin of the cosmic microwave background

So, by such a model, how should we explain the existence of the cosmic microwave background? Although there are many such radio sources in the universe that will be the same frequency range within the cosmic microwave background radiation, these are not the sources of the microwave background radiation, because the counting results of these radio sources do not conform to the observed microwave background radiation intensity.

Now, by taking derivative of the equation (66) with respect to r, we get

$$\frac{dz}{dr} = \frac{\frac{H_0}{c}}{1 + \frac{H_0}{c} \cdot r}, \tag{72}$$

and there is

$$\lim_{r \to \infty} \frac{dz}{dr} = 0. \tag{73}$$

It turns out that the redshift of those distant galaxies or remote weak radiation sources are no longer increasing significantly as the space distance is far enough.

The above analysis shows that any redden wave length from the weak radiation sources of infinite universe would be focused in a low frequency band, and make up the background radiation. Because all the radiations come from infinity in every direction, therefore, the radiations are homogeneous and isotropic to a very high precision.

3.3 The Olbers paradox

The problem is that, if the universe is infinite, and according to the cosmological principle, there should be filled with countless stars in the universe, this could lead to a corollary that the whole sky must have been as bright as the Sun, as if there is a "light wall" in the sky no matter day or night. However it is actually not the case, the contradiction between the logical thinking and observation is called the Olbers paradox[10].

In the modern cosmological model the universe is expanding, there is no Olbers paradox, it is just shifted away from the difficult issues temporarily. However, the Olbers paradox is an applicable proposition only in the framework of steady state and infinite universe, therefore, we do not think there are right answers for Olbers paradox in the framework of a limited space.

If the Hubble redshift is due to radial Doppler effect, moreover, the Doppler effect is the phenomenon in Euclidean space, then the redshift mechanism becomes the most important reason for Olbers paradox. Although it is possible to explain "why the sky is dark at night", the redshift mechanism also brings us another problem: the night sky will be dark too thoroughly, this inference is not difficult to understand by the Hubble's law (the linear relationship between the redshift and distance in Fig.(6)), because there are no any cosmic microwave background to the infinite redshift.

If the universe is infinite, as described by equation (66) and Fig.(6), there would be no infinite redshift from infinity light of the stars, but just be "accumulated" and falled in the microwave portion of the radio spectrum, also, the redshift from infinity radiation would not lay particular stress on any direction. Therefore the Olbers's question can also be explained like this: the night sky is dark, because of the nonlinear redshift of light from infinity stars, the "light wall" in the sky is precisely the cosmic microwave background, which is outside of the range of light visible to the naked eye. This is just the appearance of the infinite universe and no paradox.

4 Conclusions

1. We have described a cosmological redshift on steady state universe which originated from the deviation of the local equivalence principle. This result shows there is a link between the Hubble's redshift and the phenomenon of dark matter in universe. Experiments and observations can validate the correctness on the relativistic astrodynamics as well as the effect of running inertia obtained by this theory.

2. These results present a different explanation of Hubble's redshift and the accelerated expansion of the universe other than the receding velocity of the distant galaxies.

3. In contrast with the redshift of receding velocity, the redshift of running inertia and the blueshift of gravitational field may introduce a new kind of observed effect of change in the

wavelength which would result in there are no phenomena of receding redshift within galaxies and cluster of galaxies.

4. Also the nonlinear redshift formula (66) is applicable to any distant objects, even for determining the distances of remote observed quasars.

5. The only condition which make the cosmological redshift model hold is just an infinite and homogeneous universe on large scale, and has nothing to do with the average density of the universe.

6. The Hubble's redshifts can also be explained as the relative tidal acceleration of the galactic gravity which shared the same physical mechanism and the formula of redshift with the cosmological redshift originated from running inertia.

7. Until now, the widely accepted concept for Hubble's constant is based on the Doppler receding effect that indicates the rate at which the universe is expanding. However, we present the significance of the different physical meaning for Hubble's constant which is only related to the parameters of the our Milky Way galaxy, it would bolster the view that the universe were not expanding.

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