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Article

An Introduction to Cosmos Thermodynamics

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Abstract: Most astrophysicists today believe that the present universe was produced in a big bang. This article explores the big cycle of matter and energy in the universe, with the big bang as an important part of the cycle. The authors approve of the idea that the universe is gravitationally closed. That is, its average density is higher than the critical value. All the matter and radiation cannot fly out the closed universe. The 3k background radiation is a vast heat ocean in the closed universe, stable and eternal; it is not the afterglow of the thermal radiation of the decoupled fire ball, 380,000 years after the big bang, as many people believed so far. The big bang and the following big expansion drove the matter of more than 2×10^{12} galaxies to the remote space. Their potential energies become higher and higher, while their huge kinetic energies that they derived from the big bang become smaller and smaller until drop down to zero. The galaxies will then return back one after another, passing the central region of the universe with tremendously great kinetic energies. They of course cannot all return back directly to their start point of the big bang, restoring to the original core of the universe. They will rush to pass the central region and fly to the other sides of the universe, and shuttle around the central part ceaselessly. From the big bang to the following expansion, to the numerous galaxies, to the more than 2×10^{23} stars, and to the stars releasing huge nuclear energy due to their internal nuclear fusion each for about 10^{10} years, all these enormous processes are irreversible, resulting in enormous increase in entropy. These processes produce large amount of light and other radiations and pour them into the extremely vast heat ocean. These light and other radiations will also be shuttling ceaselessly in the closed heat ocean until, by their interaction with the rare dusts in the galaxies and maybe something else, they eventually mingle into the 3K heat ocean. In all the galaxies, there are various black holes. Every black hole, since its birth, ceaselessly extracts the matter and radiation that approach it, and gets larger. In the shuttling of all the galaxies, numerous stars and black holes in these galaxies have many chances to approach even meet each other. A black hole can annex other celestial bodies that it meets, including annex other black holes. All these processes carry on and on, resulting in the matter of these celestial bodies to concentrate again and again. The number of all the celestial bodies including the black holes reduces ceaselessly, and the mass of the survived black holes become larger, with their shuttling amplitudes become shorter. The larger black holes and the shorter amplitudes result in the rate of concentration process of mass to be faster. Eventually, all the matter in the universe will be concentrated to form a tremendously large central black hole. The central black hole has an astonishingly large Schwarzschild sphere, absorbing the thermal radiation from the vast heat ocean very rapidly and ceaselessly until some threshold value of its internal energy is exceeded, and a new big bang breaks out. The black holes provide a way in the Universe to re-concentrate matter and energy again. Black holes are Maxwell's demons in the Nature.

Keywords: closed universe; an eternal 3K heat ocean; the big cycle of matter and energy; matter shuttling and radiation shuttling; black holes are demons in the Nature; cosmos thermodynamics

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1. The Re-Concentration of All the Matter that Have Scattered into the Space by the Big Band

Most of today's astrophysicists approve of the theory of the Big Bang. The future fate of the universe depends on its average density: If the average density is less than 1, the universe is open; if the average density is equal to 1, the universe is flat; if the average density is greater than 1, the universe is closed.

The authors of this article approve of the idea that the universe is closed, that is, its average density is greater than 1. The cause of its close is of course the extraordinary huge mass within it. All the galaxies, the dark matter, even the mass of the heat ocean, and so on, may all be the contributors of the gravitational close of the universe.

Billions over billions of galaxies produced in the big bang are now flying outward with various fierce speeds, with their individual potential energy increasing ceaselessly [1,2]. After reaching their individual far-most sites, they return back one after another, passing the central part of the heat ocean with huge kinetic energies, and fly on to the opposite far most sites, then, they turn back again, and in such a way, shuttling ceaselessly.

The ceaseless shuttles offer many opportunities for the numerous various celestial bodies in all these galaxies to approach even meet each other. There are also many black holes among these celestial bodies. Annexation occurs when a black hole meets another celestial body or another black hole. After an extremely long shuttling process, the total number of the black holes and other celestial bodies will finally reduce. The mass of each survived black hole will become larger, and their shuttling amplitudes become smaller. As the black holes become larger and their shuttling amplitudes become smaller, the general annexations processes will become faster and faster. Eventually, all the matter within the closed universe should concentrate together to form an extremely large **central black hole**.

At that time, the picture of the universe becomes very simple: The whole universe is an extraordinary immense and very dilute heat ocean at a temperature of about 3K, and at the center of the heat ocean, there is an extremely massive central black hole, containing all the genuine matter of the universe. The whole geometric pattern is rather similar to the one of a hydrogen atom.

The formation of the central black hole accomplishes **the first preparation** for the next big bang: the re-concentration of matter. Black holes contribute an adhesion mechanism in the re-concentration of all the matter scattered by the big bang.

Meanwhile, the great amount of the kinetic and potential energy of the galaxies (they keep to be macroscopic energy, capable to do work) are also re-concentrated into the central black hole.

Black holes have another special and very important re-concentration function: to re-concentrate an extraordinary immense amount of "the exhausted energy" which have been discarded into the 3K heat ocean by all the various and numerous irreversible processes in the big bang and the following processes, accomplishes **the second preparation** for the next big bang.

2. Within the Closed Universe there is an Eternal Immense Heat Ocean at a Temperature of about 3K

In 1965, Penzias and Wilson unexpectedly discovered the 3K microwave background radiation coming from remote space [3]. The background radiation shows three fundamental characteristics: (1) long term stability, (2) perfect isotropy, (3) its spectrum coincides with Planck's formula for equilibrium thermal radiation at a temperature of 3K. They are exactly the same fundamental characteristics of the equilibrium radiation in a cavity within a solid at a constant temperature. Accordingly, what Penzias and Wilson discovered is an extremely immense and stable ocean of 3K equilibrium thermal radiation within the closed universe.

In any direction in the 4π solid angle, all the observations inform us that the uniform and stable 3K background thermal radiation comes from extremely remote space.

People are curious, how deep is the heat ocean? How large is its volume?

The background radiation is an equilibrium thermal radiation. It is impossible to measure its depth directly by whatever an astronomic observation.

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The heat ocean at the temperature of 3K is impossible to be infinitively large, its volume must be limited. Otherwise, according to the discussions by many scholars in the history since Newton, it would have been instable and collapsed down.

The 3K heat ocean is limited in the closed universe. It could not fly off and go far away and never return back. Otherwise, the amount of the thermal radiation in the heat ocean would decrease ceaselessly, a stable heat ocean would be impossible to exit as we see it now [4,5].

Many scholars regard that the 3K background radiation is the afterglow of the thermal radiation of the decoupled fire ball 380,000 years after the big bang when the temperature of the fire ball dropped down to 3000K. The electrons and protons in the plasma in the fire ball combined to become hydrogen atoms. The fire ball decoupled. The particle matter in the fire ball become transparent, it no longer interacts with the thermal radiation. They regarded further that the thermal radiation got free, flied out freely to the vast cosmic space, and expanded adiabatically until it converted to a 3K thermal radiation, with its spectrum changed to a Planck's spectrum of the temperature of 3K.

What is the meaning by their "**adiabatic expansion**"? It is of course impossible to be a quasi-static expansion occurred in a piston-cylinder like space. It was a free ejection of radiation, similar to the free ejection of the light and heat of the sun or any other star. The radiation of the light and other radiations of a star 1 million light years away from our earth are free ejection, when they reach our earth, the volume intensity of the radiation became extremely weak, but its spectrum is still the same one as it just left from its mother star. The same thing happened to the decoupled thermal radiation. The decoupled 3000K radiation was then a free ejection, just like the light and other radiations of the sun or other stars. It kept to be a spectrum of 3000K. It would not convert to a 3K equilibrium radiation through an "adiabatic expansion".

Let us go on.

The big bang and many of its follow up processes are all immense irreversible processes. All of these processes produce entropy, and according to the second law of thermodynamics, entropy can only be produced, never be reduced. All these processes emitted (discarded) tremendous amount of light, heat and other radiations into the heat ocean.

First, the big band is a big explosion, and which, together with the following expansion of the primitive fire ball, are certainly huge irreversible processes. The surface of the fire ball kept scattering great amount of light, heat and other radiations into the surrounding space, and finally, into the vast 3K heat ocean.

About 380,000 years after the big bang, the temperature of the expanding primitive fire ball dropped to about 3000K, the electrons and protons in the plasma in the fireball combined to become hydrogen atom. The matter in the fire ball became transparent. The thermal radiation and the matter in the fire ball no longer exchange heat each other. They decoupled. All the remnant thermal radiations in the fire ball got free, ejected out in all the directions, and entered the vast heat ocean (for more details, please read the Appendix A of this article.)

In the big expansion of the Universe, numerous galaxies were formed, these processes were also irreversible. And, in all the galaxies, numerous nebulae developed into even more numerous stars. These processes were also irreversible. Then in a long period, there formed more than 2×10^{23} stars in the whole universe. Like the sun, each star has a lifetime of about 10^{10} years, ejecting ceaselessly light and heat and so on due to the energy produced in their internal nuclear fusions. And so on.

All these irreversible processes in the various stages of the universe have a common point: they all finally release huge amount of energy in the forms of light, heat and other radiations, pouring into the 3K heat ocean. After entering the heat ocean, all these light, heat and other radiations, also shuttered around the central part of the universe ceaselessly in various directions, and gradually (with a very long relaxation time) mingled into the 3K thermal radiation of the heat ocean.

From another point of view, all the above processes are sending energy ceaselessly into the heat ocean. Although the 3 K heat ocean is very dilute, its volume and total mass are both extraordinary large. Hence, all the input energy of light and heat, might only raise the temperature of the heat ocean very slightly. The temperature of the heat ocean is fundamentally stable.

Now, let us surmises briefly the structure of the 3K heat ocean itself.

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First, let us calculate the mass density of the 3K heat ocean.

From the Stefan-Boltzmann's law, the radiation intensity of the surface of a black body at T = 2.73K is

$$j = \alpha T^4 = 3.15\times10^{-6}\, jm^{-2}s^{-1}\cdot \tag{1}$$

As is well known, the relation between the radiation intensity of the surface of a black body j and the energy density of the equilibrium thermal radiation in a solid cavity at the same temperature u is

$$j = \frac{1}{4}cu, \tag{2}$$

Hence, we have, at T = 2.73K

$$u = \frac{4}{c}j = 4.20\times10^{-14}\, Jm^{-3} \tag{3}$$

Then, the mass density of the 2.73K thermal radiation in the heat ocean is,

$$\rho = \frac{u}{c^2} = 4.67\times10^{-31}\, kg/m^3 \tag{4}$$

Now, in our surmise, the central part of the heat ocean is the galaxy region, represented by a very small circle in Figure 1. Next, containing the galaxy region and within the radius of R_1, is the T = 2.73K region, as shown by the blue part in Figures 1 and 2. Then, from R_1 to R_2 is the thermal radiation decaying region, as shown by the light blue part in Figures 1 and 2, with the temperature falls down gradually from 2.73K to 0K, and a mass decaying distribution function

$$\rho = \rho(R) \tag{5}$$

as shown in Figure 2. Finally, beyond R_2, is the infinitively vast empty space, u = 0.

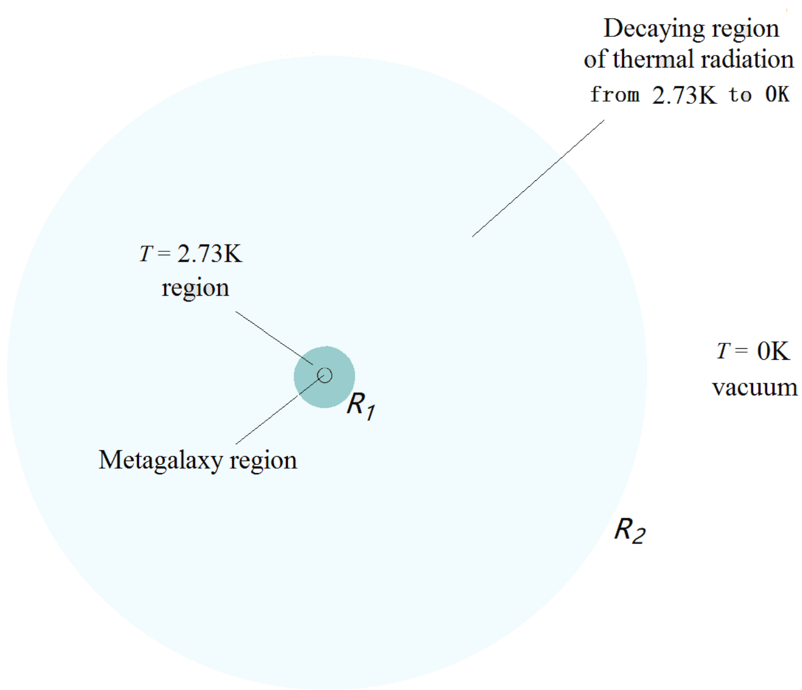

Figure 1. A self-closed heat ocean model. The central small spot is the region of all the galaxies. And the blue bigger circle is the 2.73 K region, with, surppose, R_1 = 400 x 10⁹ light years. Then the thermal radiation density decaying region from R_1 to R_2, with R_2 = 4000 x 10⁹ light years. Out of R_2, is the infinitively vast empty cosmic space, u = 0.

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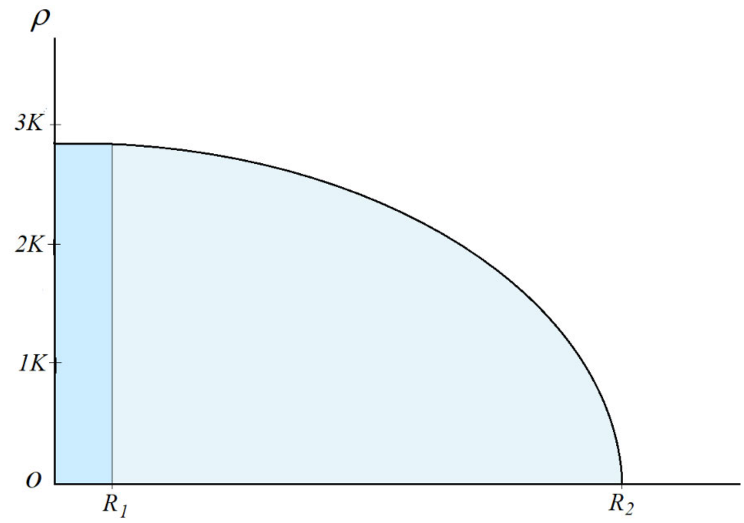

Figure 2. The central part of the heat ocean, as have been supposed, is a spherical region of a radius R_1 = 400 x 10^9 light years, filled up with 2.73K thermal radiation. Stretched outward from R_1, the density (and also the "temperature") of the thermal radiation decreases gradually. At R_2 = 4000 x 10^9 light years, the density and temperature drops down to zero, with all the outer space be totally ideal vacuum. .

In the 2.73K region, and, also in the thermal radiation decaying region, all the outward flying photons undergo red shift. Strictly to say, an outward flying photon is almost impossible (or very scarcely to be) precisely along the radius of the black hole. So, eventually, guided by their tangential kinetic energy, the photons will return back and fly towards the central part of the heat ocean, undergoing blue shift. All the photons in the heat ocean will keep shuttling ceaselessly in such a way, with the whole closed heat ocean keeps fundamentally stable and equilibrium.

As the heat ocean is extremely large, its total mass may also have some contribution to the gravitational close of the universe.

The authors allege, the tremendously vast 3K background radiation is a stable and eternal heat ocean. It existed before the Big Bang. It exists at present. It will exist in the future. It is not the afterglow of the thermal radiation of the decoupled fire ball. For details, read the Appendix A, please.

2. Re-Concentration of the Discarded and Exhausted Energy (the waste heat) from the Heat Ocean

Within the immense heat ocean, in the galaxy region, the 2.73K thermal radiation ceaselessly travels everywhere. For any black hole, the surrounding 2.73K thermal radiation pours into it from all the directions at the speed of light. Every black hole absorbs ceaselessly the 2.73K thermal radiation from the heat ocean since its birth, throughout its extremely long lifetime.

Let us see such behaviors of black holes of 3 different grades.

(1) A black hole with a mass of 10 times of the sun, as shown in Figure 3 (a).

The value of its mass is

$$M_1 = 10\, M_\odot = 10\times(2\times10^{30}) = 2\times10^{31}\ \text{kg}. \tag{6}$$

Its Schwarzschild radius is

$$R_1 = \frac{2GM_1}{c^2} = 2.96\times10^4 \approx 30km. \tag{7}$$

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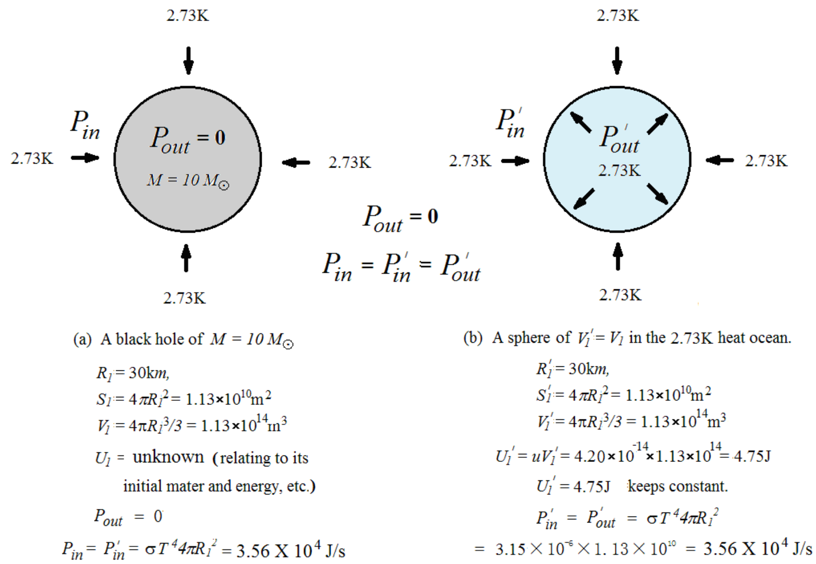

Figure 3. (a) A black hole of M = $10M_{\odot}$, R_1 = 30km, V_1 = 1.13×10^{10}m^3; (b) In the heat ocean, in a same volume V_1'= 1.13×10^{14}m^3 , the energy of the 2.73K thermal radiation is U_1'= 4.75J.

When the M_1 = 10 $M_{\odot}$ star collapsed down to form a black hole, most of its original matter and energy entered into the central region of the new born black hole. With the radius R_1 = 30km, the volume of the black hole is much smaller than the original M_1 = 10 $M_{\odot}$ star. The huge amount of **the potential energy** of all the matter of the original star first converted to kinetic energy in the collapsing process, and finally concentrated into the central region of the new born black hole. So, the internal energy of the black hole must be extremely great and highly concentrated, the final situation may be considered corresponding to some extremely high temperature.

The M_1 = 10 $M_{\odot}$ black hole is immersed in the immense ocean of 2.73K thermal radiation. So, it extracts the thermal radiation from the heat ocean ceaselessly in all the direction at the light speed.

The volume and surface area of this black hole are

$$V_1 = (4p/3)R_1^3 = 1.13\times10^{14}\text{m}^3. \tag{8}$$

$$S_1 = 4pR_1^2 = 1.13\times10^{10}\text{m}^2. \tag{9}$$

respectively.

Now, imagine a same volume in the heat ocean,

$$S_1' = S_1 = 4pR_1^2 = 1.13\times10^{10}\text{m}^2, \tag{10}$$

$$V_1' = V_1 = 1.13\times10^{14}\text{m}^3. \tag{11}$$

Its temperature is 2.73K. The energy of the 2.73K thermal radiation in $V_1'$is

$$U_1'=u\ V_1'= 4.20\times10^{-14}\times1.13\times10^{14} = 4.75\text{J}. \tag{12}$$

The M_1 = 10 $M_{\odot}$ black hole swallows in energy from the heat ocean with a power

$$P_1 = sT^4 4pR_1^2 = 3.15\times10^{-6}\times1.13\times10^{10} = 3.56\times10^4\text{J/s}. \tag{13}$$

In each second, the M_1 = 10 $M_{\odot}$ black hole swallows in from the heat ocean a number of 2.73K thermal radiation of V_1', the corresponding number N_1 is

$$N_1 = P_1 / U_1' = 3.56\times10^4 \div 4.75 = 7494 \approx 7500, \tag{14}$$

In one day, the corresponding number is

$$N_{day} = 86400\times7500 = 6.5\times10^8. \tag{15}$$

In one year, the corresponding number is

$$N_{year} = 365\times6.5\times10^8 = 2.37\times10^{11}. \tag{16}$$

In one million years, it is

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$$N_{10^6\ years} = 2.37\times10^{11}\times10^{6} = 2.37\times10^{17}. \quad (17)$$

One million years is a twinkle of an eye in the long lifetime of any black hole.

Hence, we see, compared to the 2.73K thermal radiation in the extremely cold heat ocean, the interior of a black hole is in a state of very high internal energy, that means, it corresponds to an extremely high temperature. And, the extremely high temperature is rising ceaselessly.

We conclude that, the 2.73K thermal radiation pouring ceaselessly into a black hole at the light speed is a process of spontaneous heat transfer from a very low temperature region to an extremely high temperature region.

Such a process is obviously in contradiction to the Clausius statement of the second law of thermodynamics [6]. It results in the decrease of entropy.

The event horizon of a black hole permits thermal radiation to pass from its low temperature exterior to its extremely high temperature interior, never the reverse. So, **it is an ideal single-way membrane for the radiations, a Maxwell's demon in the Nature** [7,8].

Numerous and various black holes in all the billions over billions of galaxies ceaselessly absorb great amount of heat from the vast heat ocean throughout their individual extremely long lifetimes. That is obviously an great energy concentration process.

A black hole of a mass of a galaxy, for an example, the central black hole of a galaxy.

Such a black hole often has approximately a mass of 10^{10} times as M_1, i.e., $M_2 \approx 10^{10}\times10\ M_\odot$, and its spherical surface S_2 is about 10^{20} times of S_1. It absorbs the 2.73K thermal radiation from the heat ocean at a rate

$$P_2 = sT^4 4pR_2^2 = 3.15\times10^{-6}\times1.13\times10^{10}\times10^{20} = 3.56\times10^{24}\text{j/s}. \quad (17)$$

And the number N_2 is

$$N_2 = P_2/\ U_1' = 3.56\times10^{24}\div4.75 = 7494\times10^{20} \approx 7500\times10^{20}. \quad (18)$$

The rate of absorption of the thermal radiation from the heat ocean by the $M_2 = 10^{10}\times10\ M_\odot$ black hole is extremely higher compared to the $M_1 = 10\ M_\odot$ black hole.

The total rate of absorption of energy by all the black holes with a mass of the magnitude of a galaxy in the universe from the heat ocean is even more tremendously great.

As all these two kinds of black holes unite step by step to form eventually a central black hole, they will carry all the energy that was collected by them from the heat ocean in their individual long lifetimes together to enter the central black hole.

(2) The central black hole of the universe, containing all the matter of the Universe, and its mass is mostly much greater than the mass of 2×10^{12}galaxies.

The central black hole also absorbs the 2.73K thermal radiation ceaselessly at the light speed from the immense heat ocean. It has an extraordinarily large Schwarzschild spherical surface. Hence, its rate of absorption of energy of the thermal radiation from the heat ocean is astonishingly high. The internal energy of the central black hole rises extremely fast and monotonically. Notice please, now, all the real matter has already been concentrated into the central black hole, there is no longer any new matter falls in. So, the average energy possessed by per unit mass in the central black hole just rises and rises ceaselessly. The interior matter should undergo a series of endothermic reactions. By the end of all these endothermic reactions, the energy possessed by per unit mass of the interior matter reaches an extremely high level. The authors regard that the matter in such a state is closely identical to the "initial matter" or "ylem" described by Gamow et al in their theory of **the thermal big bang**.

The central black hole continues to absorb energy extraordinarily rapidly from the heat ocean. Its total internal energy continues to increase. That means, **its internal repulsive factor continues to increase**. Such an unidirectional process should not go on without an end. When a threshold value is reached and exceeded, a new big bang breaks out.

So far, we have accomplished the description of an extraordinarily big cycle of matter and energy in the universe. The explosion of the big bang is a special turning point in the big cycle.

The big bang and the big re-concentration of the matter and energy in the universe is a big cycle. Such an idea leads to the birth of a new branch in astrophysics: **cosmos thermodynamics**.

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5. Some further questions

How large is the heat ocean? How much is the total mass of the thermal radiation in the heat ocean? Is this mass also an important contributor to the gravitational close of the universe?

How much real matter (all the galaxies and so on) is there in the whole universe? How does the mass of all the real matter contribute to the gravitational close of the universe?

What is dark matter? How much is it altogether? How does it contribute to the gravitational close of the universe?

What is "ylem"? What a totally new and unknown matter state is the "ylem" in?

All these questions wait the future physics and astrophysics to answer.

Appendix A

The 3K background radiation is not the afterglow of the thermal radiation of the decoupled fire ball

Many researchers regarded that, 380,000 years after the big bang, the temperature of the expanding fire ball dropped down to about 3000K, the electrons and protons in the plasma within the fire ball combined to become neutral atoms. The thermal radiation and the particle matter no longer interact each other. That means, the particle matter in the fire ball became transparent for the thermal radiation. The thermal radiation got free and flied away at the speed of light in all the directions into the vast space.

They regard further that the 3000K thermal radiation then expanded adiabatically for an extremely long time to become finally the 3K background radiation of today.

The process of such an adiabatic expansion, from the initial 3000K equilibrium thermal radiation to the final 3K equilibrium thermal radiation, is very difficult to be conceived. How about the numerous intermediate states? Were they all in thermal equilibrium states, always had a certain temperature and a spectrum coincide with the Planck's formula at that temperature? Was it a quasi-static adiabatic expansion?

Such or such a process is beyond any people's imagination.

Actually, once the primitive fire ball was decoupled and changed to be transparent, all the thermal radiation in the decoupled fire ball began to fly away at the speed of light into the vast cosmic space in all the directions.

Their ejection is in some extent similar to the free light ejection of the sun and other stars. All of them are free radiation at the speed of light, without any delay, without any obstacle. In such a free ejection, as the distance get farther, the intensity of the radiation should become weaker. However, the spectrum of the radiation kept the same as it had been when it left its mother source, the decoupled fire ball.

The intensity of the light ejected from a star one million light years away from our Earth become extremely weak when it reaches us, but its spectrum is unchanged. It is still the same spectrum as it left its mother star, and coincides with Planck's formula.

The authors of this article think that the so called "adiabatic expansion" is totally nonsense.

Let us have an examine on the actual process of how the remnant 3000K thermal radiation of the decoupled fire ball flied outward in all the directions at the light speed into the vast space farther and farther.

First, as shown in Figure A1 (a), the small blue ball with the diameter ab in the central part of the figure represents the decoupled fireball, 380,000 years after the big bang. The diameter ab is about $ab = 2 \times 10^{22}$ m = $2 \times 500,000$ light years ,and the radius is $oa = ob \approx 1 \times 10^{22}$ m ≈ 500, 000 light years.

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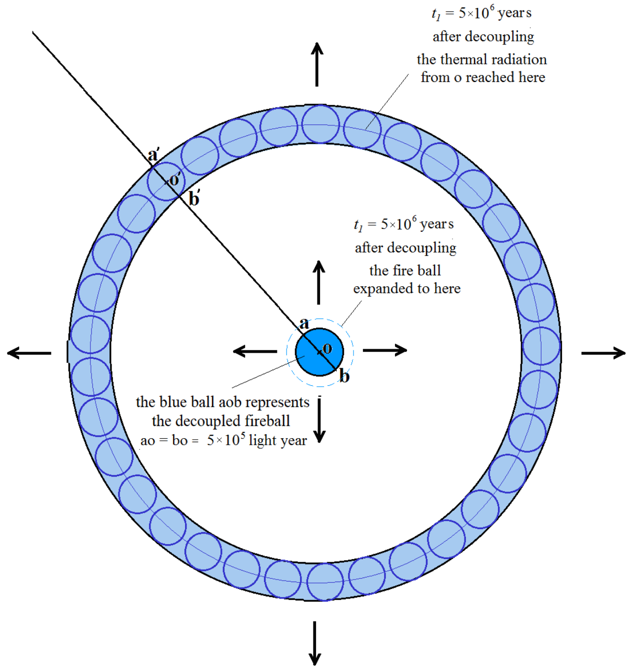

Figure A1. The radius of the decoupled fire ball was ao = ob ≈ 500,000 ly (380,000 years after the big bang), and the thermal radiation within it began to eject freely to leave the fire ball in all the directions. 5,000,000 years later, in the direction of oo′, the thermal radiation from o reached o′, the radiations from all the points of the sphere aob reached a new place of the sphere a′o′b′. And all the thermal radiation in the other directions within the 4⊚⊚silid angle from all the points of the sphere aob reached the spherical layer a′b′.

5,000,000 years after the decoupling, the thermal radiation from point o in the direction of oo′ arrived at the point o′, on a spherical surface of the radius of oo′ = 5000,000ly (10 times of oa = ob), also as shown in Figure A1. The thermal radiation from point a reached a′, the thermal radiation from point b reached b′, all the thermal radiations from the different points of the original small ball aob now all reached the corresponding points of a small ball a′o′b′, witch lay in the spherical layer a′b′.

$$a'b' = ab = 2 \times 500{,}000 \text{ ly} = 1{,}000{,}000 \text{ ly (light years)}.$$

And all the radiations ejected in different directions from all the different points of the original small ball aob all reached points in the spherical layer a′b′.

50,000,000 years after the decoupling, the thermal radiation from point o in the direction of o o″ arrived at point o″, on the spherical surface of the radius of oo″ = 50,000,000 ly, as shown in Figure A2. The thermal radiation from point a reached a″, the thermal radiation from point b reached b″, all the radiations in the direction oo″ from the other different points of the small ball aob all reached the corresponding points of a small ball a″ o″ b″ ,witch lay in a spherical layer a″ b″. And, all the radiations in other different directions from all the points of the small ball aob now all reached the spherical layer a″ b″.

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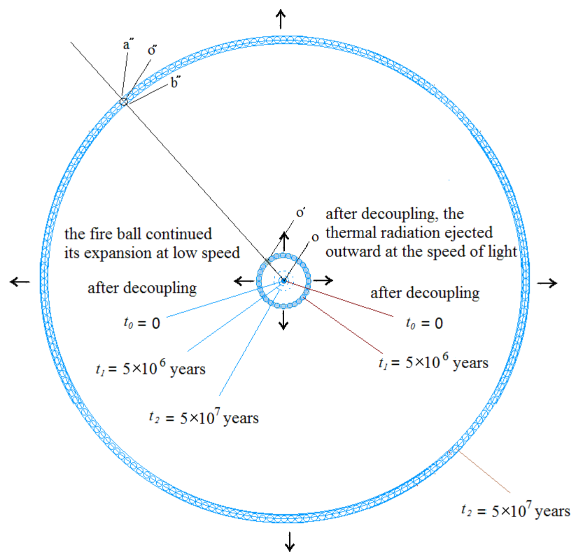

Figure A2. 5 ×10⁶ years after the decoupling, in the direction of oo″ ,the radiation from o reached point o″ ,and the radiation from a reached a″ , the radiation from b reached b″ . The radiation from all the points of the ball aob reached the corresponding points of ball a″ o″ b″ . And, the radiation from all the points of ball aob in all the directions in the 4◎◎solid angle reached the spherical layer a ″ b″ .

Obviously,

a″ b″ = a′b′ = ab = 1,000,000 ly.

And, 500，000,000 years later，5,000,000，000 years later, and so on, as the thermal radiation from the decoupled fireball flied continuously at the speed of light, it always kept within the spherical layer always with a width of 1,000,000 light years.

The expanding of the spherical layer of the thermal radiation with a width of 1,000,000 light year layer, a′b′, a″ b″ , and so on, should not go on and on without an end. The space of the universe is closed, when some utmost site is reached, the 1,000,000 light year layer of the thermal radiation will no longer fly away further. It will return back to the central region of the universe again, and then shuttle ceaselessly, and, getting more and more dispersive. Finally, after a very long relaxation time, by the interactions (exchange heat) with the rare dusts and so on in the galaxy region, it will mingle into the 3K heat ocean.

The authors allege, the 3K background radiation discovered by Penzias and Wilson is not the afterglow of the decoupled fire ball. It itself is just an eternal 3K vast heat ocean in the closed universe. It had existed before the big bang. It exists now. And it will exist in the future. It is always a stable and eternal extraordinary immense heat ocean in the closed universe.

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