Liquid universe and gravitational wave

Zhi Cheng

(Baiyun District, Guangzhou, China. gzchengzhi@hotmail.com)

Abstract: According to the universe model based on virtual space-time physics, the universe has two states, liquid and gaseous. The current universe is in a state of liquid universe. This can be supported by some important observational evidence. The liquid universe theory predicts that microwave background radiation and cosmic rays are gases that the liquid universe naturally evaporates, the temperatures of the two should be equal. At present, there are many research results of hydroacoustic theories in related disciplines, so we can use some hydroacoustic theories to deal with the propagation of gravitational waves in the liquid universe, and we can get some inspiring conclusions. This provides a broader theoretical support for us to study and discuss some important laws of gravitational waves in more detail. This paper gives a rough estimate of the gravitational wave data generated by the huge mass of the center of the Milky Way. It is found that the radiation of the gravitational wave in the center of the Milky Way can be used to explain the periodic variation of sunspots.

Keywords: Cosmic model; Gravitational wave; Liquid universe; Microwave background radiation

Russian abstract

Жидкая вселенная и гравитационные волны

Аннотация: Согласно модели Вселенной, основанной на физике виртуального пространства-времени, Вселенная имеет два состояния: жидкое и газообразное. Текущая вселенная находится в состоянии жидкой вселенной. Это может быть подтверждено некоторыми важными наблюдательными данными. Теория жидкой вселенной предсказывает, что микроволновое фоновое излучение и космические лучи - это газы, которые жидкая вселенная естественным образом испаряет, температуры двух должны быть равны. В настоящее время имеется много результатов исследований гидроакустических теорий в смежных дисциплинах, поэтому мы можем использовать некоторые гидроакустические теории для борьбы с распространением гравитационных волн в жидкой вселенной, и мы можем сделать некоторые вдохновляющие выводы. Это обеспечивает более широкую теоретическую поддержку для более подробного изучения и обсуждения некоторых важных законов гравитационных волн. Эта статья дает приблизительную оценку данных гравитационных волн, генерируемых огромной массой центра Млечного Пути. Установлено, что излучение гравитационной волны в центре Млечного пути может быть использовано для объяснения периодического изменения солнечных пятен.

Ключевые слова: космическая модель; Гравитационная волна; Жидкая вселенная; Микроволновое фоновое излучение

1 Introduction

Not long ago I proposed a model of the liquid universe [1]. The model points out that there are two states in the universe we are in now, namely gaseous and liquid. These two physical states are very similar to the gases and liquids that we are exposed to in our daily lives. Cosmic gas is mainly composed of various basic particles, including photons, neutrinos, electrons, protons and various composite particles. This actually includes microwave background radiation, cosmic neutrino flow, and various cosmic rays. And the various materials that are grouped together are part of the liquid universe. Including a variety of stars, galaxies and so on.

Since it is in liquid form, it means that these cosmic substances have the basic fluidity of liquids. The basic equations of fluid mechanics are met physically. For example, satisfy the Stokes theorem, Bernoulli's law, and so on.

The fundamental reason for the formation of the liquid state of the universe lies in the limited speed of gravitational propagation. Since gravitational interactions are related to distance, it is also necessary to consider the time required for gravitation to travel further. If this propagation time is a few seconds, a few days or even thousands of years, it can be said that gravity can still interact. But if the gravitational spread time reaches tens or even tens of billions of years, then in our knowledges of the life cycle of the universe, it can be said that at such a long distance, gravitation does not interact.

So at the scale of the universe, in a short enough time, gravitation becomes a force similar to the intermolecular interaction in a liquid, which can actually be seen as a short-range force. The short enough time mentioned here may be within tens of millions of years.

Thus, if there is an observer who observes the matter in the universe on a cosmic scale, then the material in the universe he sees is like the same basin of water. However, some of them have fluid mechanics such as eddies and surges.

If the liquid universe model is correct, then we have a lot of very effective tools to deal with various cosmological problems. A series of theories often used in fluid mechanics and corresponding calculation methods can be borrowed to deal with the universe. For example, you can start with the viscosity of liquids to understand the interaction of substances among galaxies and the various phenomena that may occur. If cosmic fluids also have turbulence, we can use nonlinear fluid mechanics tools to analyze the origin of the galaxy and possible future changes. This turbulence phenomenon is ubiquitous in spiral galaxies. For example, in the galaxies in Figure 1, the spiral arms have very obvious turbulence. The reason for this turbulence is that the galaxies at different levels operate at different speeds, and there is gravitational interaction among them, resulting in nonlinear interactions, which in turn lead to phase transitions and conversion into turbulence. The Pinwheel Galaxy in Figure 1 can clearly see the turbulence if it is seen as a vortex of water flow. And the closer to the center, the more obvious the turbulence phenomenon. At the periphery, the laminar flow is very smooth.

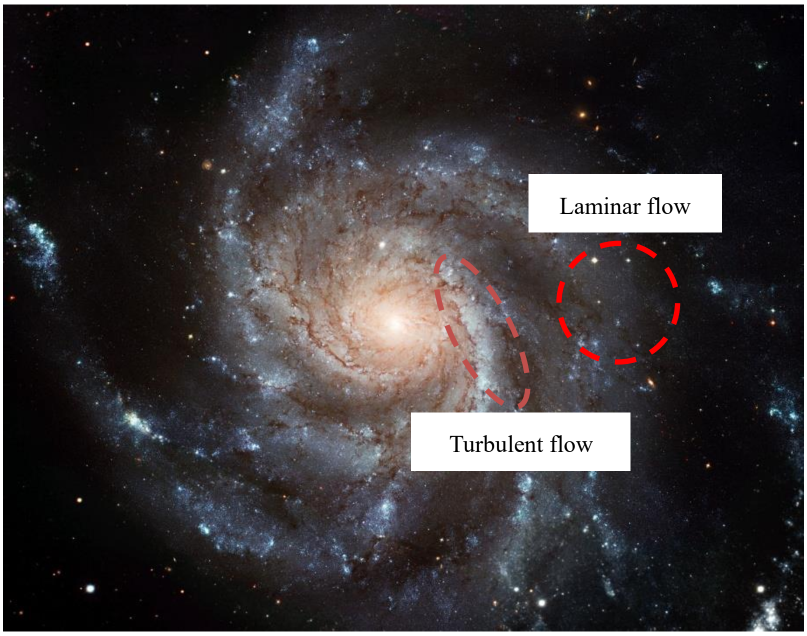

Figure 1 Turbulence in the Pinwheel Galaxy

From the hydroacoustic theory that specializes in the propagation of sound waves in water, we seem to be able to deal with the propagation of gravitational waves in the universe.

This paper attempts to explore the law of gravitational wave propagation in the universe, in the hope of obtaining some problems that other theories have not noticed.

2 Some properties of cosmic fluids

If the entire universe is a closed system, even if the universe is in a fluid state, the fluid will be a very calm, evenly distributed, wave-free liquid. Therefore our current universe must be an open system. However, there are already very rich facts that prove that the total energy in the universe is conserved. That is to say, in the entire universe, energy is always constant, and there is no external system that can absorb energy from the universe or release energy to the universe.

In order to meet such energy conservation and open system requirements, the use of virtual space-time physics is a better solution [2]. Of course, other theories also point out that dark matter may exist in the entire universe, so that dark matter may exchange material and energy with visible cosmic matter. Here we use the assumption that virtual space time exist. That is to say, in addition to the real space time we are now in, there is a virtual space-time, and there is an exchange of energy between the virtual space-time and the real space time. This form of energy exchange takes place in a way that exchanges between mass and energy. And the total energy of the universe can be expressed in the form of a plural:

$$\mathrm{E} = h\nu + imc^2$$

Where hv is the energy of the virtual photon, reflecting the momentum of the material in real space time motion. And m is the mass of the substance. The front i uses it to represent the energy of the virtual space-time.

Since energy and mass can be converted by Einstein mass-energy equation, this means that the energy of real space time or virtual space-time can be exchanged freely. This free exchange also shows that real space time is no longer a closed system, but an open system that can exchange energy with other systems.

For such an open universe system, when energy to mass or mass to energy conversion process occurs, the movement of matter occurs, which is manifested by the rapid flow of cosmic fluid. This flow can form a variety of hydrodynamic forms, including laminar and turbulent phenomena.

Figure 1 shows the material around the black hole being attracted by the black hole and falling into the direction of the black hole. This is consistent with the shape of the vortex in the turbulence of the water.

According to the theory of virtual space-time physics [2], the inside of a black hole is actually a virtual space-time. The boundary of a black hole is a boundary between real space time and virtual space-time. Therefore, the black hole attracts real space time matter into the virtual space-time, and the energy is converted into mass. It can be used to reflect the direction of the flow of cosmic fluids. Of course, this is also the basic cause of the fluid flow in the universe.

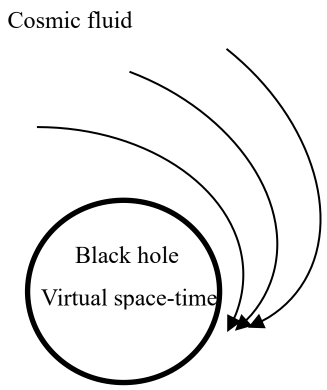

Figure 2 Energy to mass conversion

For galaxies that do not have black holes, such as the solar system, the planets always move around the sun. This is because the energy inside the sun forms a form like a dam that blocks energy outside the Schwarz radius, and does not allow material to flow quickly into the virtual space-time.

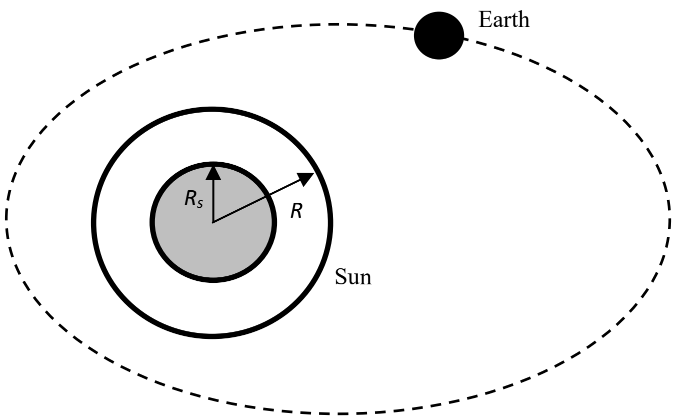

Figure 3 The radius of the sun prevents the material from entering the Schwarzschild radius

In Figure 3, R is the radius of the sun, and R_s is the Schwarzschild radius. Since the radius of the sun is larger than the Schwarzschild radius, this prevents the sun from collapsing into a black hole. Therefore, other external planets will be able to revolve around the sun.

However, the situation shown in Figure 3 does not mean that cosmic fluids (planetary matter) will always be able to operate in this way. After all, the interior of the sun is still experiencing energy consumption. The change of stellar temperature means the change of mass. The real space time energy is still transforming into the energy of virtual space-time (or the opposite process, that is, the mass is continuously converted into real space time energy). In addition, these galaxies are usually in a larger galaxies, such as the Milky Way. The center of these larger galaxies usually has a large black hole.

Therefore, due to the energy exchange between the virtual space-time and the real space time, it directly leads to the continuous flow of the cosmic fluid in a space-time, both the fluid flowing out from real space time to the virtual space time, and the fluid flowing from the virtual space-time into the real space time. Both processes exist at the same time.

3 Evaporation of cosmic fluids

3.1 Cosmic gas

The molecules or atoms that make up the gas are free to move. In general, the interaction between molecules or atoms in a gas is very small. The interaction force between molecules or atoms of an ideal gas is negligible.

The substances that make up the cosmic gas are not the same as those of the Earth's atmosphere. The Earth's atmosphere mainly includes various molecules and inert gas atoms. Cosmic gas is mainly composed of various basic particles. The most basic of these are electrons, protons, photons, and neutrinos. In addition, the cosmic gas also contains various composite particles, such as various baryons and mesons.

Under the most extreme conditions, the entire universe may consist entirely of this cosmic gas. This time corresponds to a very high temperature condition of the universe.

Another very extreme condition is that the entire universe may be in an absolute zero liquid state or solid.

As to whether there is a solid state of the universe, this deserves further study. Because if the entire universe is in a solid state, the galaxies in the universe will form a very strong crystal structure with each other. Planets or stars are either bound in the crystal lattice or can move freely in the crystal lattice. However, unlike the interaction between solid ions, gravity is only attractive and has no repulsive force. The formation of such a crystal structure may require more severe conditions.

If the probability of the universe being in different states is equal, then the probability that the universe is completely composed of cosmic gas is very small. The more probable case is when the universe is at a normal temperature or a relatively low temperature (larger than absolute zero) liquid state. This is like liquid water, and even if it does not reach the boiling point, there is still a large amount of water vapor on the surface of the water.

Considering that a cosmic liquid with an absolute temperature of zero will evaporate a certain amount of cosmic gas, there will be a certain amount of free elementary and composite particles in the present universe. Including the photons, neutrinos, electrons and protons mentioned above, which do not decay, and various other leptons and baryons.

Since these naturally evaporating gases have the same temperature as the liquid, the temperature of the universe we are in now can be obtained by measuring the temperature of the cosmic gas.

3.2 Microwave background radiation

Microwave is a kind of photon, so if our current cosmic temperature is not absolute zero, then the cosmic liquid will be able to evaporate a large number of photons. This photon appears in the form of microwave background radiation.

Of course, the photons evaporated by the cosmic liquid have a very broad spectrum. It is only in different cosmic temperature conditions that the spectral distribution of photons in the universe is very different. Therefore, the microwave background radiation referred to herein refers to an average frequency width.

The Big Bang theory also predicts the presence of microwave background radiation. Although microwave background radiation was discovered under the prediction of the Big Bang theory. However, in recent years, a large amount of experimental evidence has found that there are some problems in which the theoretical and observed values are not consistent. For example, if the big bang theory is correct, the measured microwave background radiation should have a certain directionality. However, the result of the observation now is that the microwave background radiation is isotropic, that is to say, the microwave background radiation is very uniform. In addition, according to the prediction of the Big Bang theory, there should be shadows of microwave background radiation at certain locations in the universe. However, actual observations deny such predictions.

If the microwave background radiation is the composition of the gas evaporating from the cosmic liquid, there is no such problem. Just as the gas evaporating from the surface of a stationary liquid does not have directionality at the two-dimensional plane position of the surface of the liquid, the gas evaporated from the cosmic liquid must be very uniform and isotropic in three dimensions.

Of course, in different locations of the universe, the microwave background radiation temperature should still be different, just as the temperature of the water vapor on the surface of the ocean at different locations on the earth will be very different. If more advanced technologies are available in the future to help us measure microwave background radiation at more distant locations, we may find that the temperature of the microwave background radiation in different regions may differ.

3.3 Sources of cosmic rays

High-energy particle cosmic rays are also one of the vaporized cosmic gases. Of course, the source of cosmic rays is also a problem that plagues astrophysicists. There is now relatively clear evidence to prove the source of a high-energy neutrino beam. Although the number is small, the statistical effects are not obvious, but at least give us a better way to understand the source of cosmic rays. This also provides a basis for understanding the source of high energy particles. The liquid model differs from the big bang model in that, from the liquid model, the high-energy particles we now detect are naturally evaporated from the cosmic liquid around the detector. Of course, this "surrounding" includes both nearby galaxies and distant galaxies billions of light years away. This seems to be different from the temperature distribution of the gas evaporated from the surface. Generally, the gas evaporating from the horizontal surface mainly comes from liquid molecules near the observation point. However, it is noted that on the cosmological scale, we are more suitable to use the four-dimensional Minkowski space to deal with the problem, so time is also an important dimension of the interaction that needs to be considered.

An important conclusion of the liquid universe model prediction is that the average temperature of the high energy particles should be consistent with the microwave background radiation. Since cosmic rays and microwave background radiation are components of cosmic gas, the average temperature of cosmic rays should be exactly equal to the temperature of microwave background radiation. The current measurement results show that the average energy density of cosmic rays around the Earth is about 1 eV/cm^3, which is about 1.6×10^{-13} J/m^3. The average energy density of microwave background radiation is about 4.8×10^{-14} J/m^3. Both are basically the same in order of magnitude.

This may be a coincidence if viewed from a model of the universe. However, from the liquid universe model, this is actually not a coincidence. This further confirms that the microwave background radiation and the cosmic rays together constitute the state of the cosmic gas that evaporates.

Of course, like microwave background radiation, the liquid universe model can also predict that the distribution of cosmic rays is also very uniform and isotropic.

4 The transmission of waves in the fluid

4.1 Comparison of three fluids

Fluids reflect the collective movement of matter. The most direct is the flow of water, the collective movement of water molecules. Electric current is the collective motion of electrons. The cosmic fluid reflects the collective movement of the stars. At the same time, fluid as a medium can also transmit various information. It is interesting to explore the transfer of information in fluids. In the water, information is transmitted mainly by sound waves of mechanical vibration, and information is transmitted by electromagnetic waves in the current. These messages are transmitted at a faster rate than water molecules or electrons.

In the cosmic fluid, there should also be a unique way of information transmission. Considering that the material interactions of cosmic fluids are mainly carried out by gravitation, it is natural to conclude that gravitational waves can be used for information transmission. There is already strong evidence to confirm the existence of gravitational waves.

But it is a pity that the transmission speed of gravitational waves is also the speed of light, which leads to a very long time for a galaxy to communicate with another galaxy. So is there a faster way to transfer information? This is a very interesting question. If it exists, it helps us to observe the development of distant galaxies. Below we can compare some properties of water flow, current and cosmic fluid.

Table 1 Comparison of three fluids

Types of	Water flow	Electric current	Cosmic fluid
Scale	Macro	Microscopic	Universe
Material interaction	Intermolecular interaction	Electronic-proton interaction	Gravity
Way	Space	Space	Space time
Information transfer	Sound wave	Electromagnetic wave	Gravitational waves?
Speed	Sonic speed	Speed of light	Speed of light?

From the above comparison, what is still not certain is the information transfer mode and propagation speed of the cosmic fluid. According to Einstein's general theory of relativity, there is mainly gravitational interaction among matter in the universe, so that the interaction among mass is only gravitational. Gravitational waves are generated by gravity. The speed of gravitational waves is the speed of light. If this is the way information is transmitted by the cosmic fluid, the speed of information transfer in the cosmic fluid will be limited by the speed of light. This also means that as the cosmic fluid continues to spread, the information exchange between the various parts will take longer and longer.

4.2 Gravitational waves

Through general relativity, Einstein obtained the equation of gravitational waves. The gravitational wave of the Einstein equation is a plane wave solution. However, you can pay attention to some of the conditions of Einstein's gravitational wave solution.

1. The solution is a weak field approximation. That is to say, to generate the gravitational wave solution, the gravitational field needs to be weak.

2. The solution is a linear solution. That is to say, it is necessary to make various approximations of the complicated gravitational field equations, and then obtain a linear equation. In this way, a plane wave solution similar to an electromagnetic wave can be obtained.

3. The existence of this solution requires a flat space. In order to meet the requirements of Hilbert's gauge condition, it is necessary to assume that the space is flat.

Of course, the above three assumptions are actually the weak field approximation. This weak field approximation reflects that the mass perturbation of space and time is relatively small. Therefore, the propagation of gravitational waves is a standard plane wave propagation.

Although there are so many restrictions, the plane wave solution of Einstein gravitational waves has a very wide application value. The reason is that gravitational waves will propagate out after the disturbance of great mass. From the available data, the gravitational wave propagation process is mostly spread in the weak gravitational field. Therefore, the gravitational wave measured by the observer is a very strict plane wave. The plane wave runs at the speed of light.

The disturbance of mass will produce gravitational waves, but the quality of the gravitational waves generated will be very different. For a spiral galaxy, a large mass of motion near the center position inevitably produces a large amount of gravitational waves. This gravitational wave is just like the sound wave effect produced by a vortex in a water stream. Compared with the gravitational waves generated by the combination of two giant black holes measured by LIGO, the giant black holes are combined with the large object disturbing liquid, just like the disturbance caused by the large stones being thrown into the water. What is currently detected is a very concentrated wavelength gravitational wave formed by a very concentrated mass object disturbance.

The gravitational wave of a spiral galaxy has a longer wavelength and is more common. Similar to the infrasound in sound waves.

4.3 Wave effect on fluid

The effect of sound waves on fluids can inspire us to understand the effects of gravitational waves on cosmic fluids. At present, the effects of sound waves on fluids are mainly reflected in the following aspects.

1. Sound wave propagation causes changes in water flow density

Since the sound wave is a longitudinal wave, the propagation of the sound wave causes a change in the density of the liquid.

2. Ultrasound causes polarization effects of liquid molecules.

A very weak sound does not cause a significant change in the liquid. However, if it is a relatively high-powered ultrasonic wave, it can have a polarization effect on liquid molecules. This polarization effect can significantly alter some of the important physical and chemical properties of the liquid.

However, the above effects are limited to relatively strong sound waves. As pointed out in Section 4.2, most of the ways in which gravitational waves propagate can be done with good weak field approximations. Therefore, the gravitational waves with strong energy are relatively rare in space. However, under some special conditions, the various physical effects of these strong gravitational waves on the cosmic fluid can still be detected. For example, in the LIGO experimental device, a strong gravitational wave generated by two black hole impacts can be detected by an artificially constructed massive object.

In addition, the reason why the sound wave can be felt by the living body is that the sound wave causes the vibration of the eardrum, and the vibration can be converted into an electrical signal of the nerve impulse through the neural network system. So here is a problem of mechanical wave to electromagnetic wave conversion. If there are substances in the universe that fulfill such energy conversion functions, when gravitational waves propagate to these substances, energy conversion may occur. For example, some ray or ion jets occur. If such a mechanism does exist, is there any part of the cosmic rays that we have detected that are some of the cosmic rays that are the product of the interaction between gravitational waves and matter?

4.4 Gravitational wave propagation characteristics in cosmic fluids

Some research conclusions of hydroacoustic can be extended to some important characteristics of gravitational waves propagating in cosmic fluids. These features include:

1. Gravitational wave propagation distance

Like the propagation of sound waves in seawater, the distance traveled by gravitational waves in cosmic fluids can also travel far. The entire liquid universe constitutes a channel for gravitational wave propagation.

2. galaxy interference

Because galaxies are a fast-moving area, they interfere with the spread of gravitational waves. This kind of interference may cause the phenomenon of attenuation, reflection, refraction, etc. of gravitational waves. Of course, changes in gravitational wave energy can also cause some observable changes in galaxies.

3. Energy conversion

In the process of interaction between gravitational waves and cosmic fluids, the propagation state of gravitational waves changes. At the same time, the physical state of the galaxy will also change some physical properties. Mainly because these materials absorb the energy of gravitational waves, resulting in changes in the structure, state, etc. of the material and evaporation of the elementary particles. Some gravitational waves are absorbed by galaxies into other forms of energy.

4. Gravitational wave scattering

When encountering galaxies of different masses, the effects of space time bending, expansion or compression may cause the scattering of gravitational waves.

5. Other gravitational and gravitational wave interference

Like sound waves, other strong gravitational fields and gravitational waves can also interfere with the gravitational waves that are being transmitted, and lead to the appearance of various gravitational wave noise signals.

6. The fluid state of the universe

Although the matter in the universe presents a fluid state as a whole, the flow of fluids in different regions is different. This will cause the gravitational waves to propagate in the process, and the propagation velocity and gravitational wave distribution will occur in different regions.

5 Gravitational waves cause evaporation of cosmic gas

Among the above interactions between gravitational waves and cosmic fluids, a relatively easy to observe phenomenon may be related to cosmic rays, photon radiation and other factors. Cosmic rays, photons, etc. are important components of cosmic gas. Therefore, when gravitational waves interact with galaxies, it is possible to transfer energy to these substances, thereby increasing the evaporation of substances in these fluid states. If you can observe these extra cosmic rays, photon radiation, etc., and can not find other possible causes (such as supernova explosions), then it is likely to be related to the interaction of gravitational waves.

According to the Kokkotas derivation [3], we can do some simply estimations on the parameters of the gravitational wave. According to the calculation of Einstein's field equation, the gravitational wave solution can be expressed as a weak field approximation.

$$\tilde{h}^{\mu\nu} = A^{\mu\nu} e^{ik_\alpha x^\alpha}$$

It can be seen that this is a plane wave solution. $\tilde{h}^{\mu\nu}$ reflects the fluctuation of gravity, which corresponds to the change of space-time metric.

Where $A^{\mu\nu}$ is a constant reflecting the amplitude of the plane wave. k_α is the wave vector of the plane wave, reflecting the momentum or energy of the plane wave. According to the Hilbert gauge condition, $A^{\mu\nu} k_\mu = 0$, that is, the two are orthogonal.

The wave speed of gravitational waves is the speed of light. Therefore, the frequency and wavelength of the gravitational wave can be determined according to the magnitude of the wave vector.

The plane wave solution described above seems complicated, but in fact many parameters are zero, so it can be greatly simplified. After simplification, the gravitational wave has two polarization directions under the weak field approximation. They are represented by a plus sign and a multiplication sign, namely h_+ and $h_\times$.

The propagation process of gravitational waves will cause distortion and oscillation in the space time that passes through. This spacetime distortion oscillation can be used to detect the presence of gravitational waves. For example, through the Michelson interferometer, the shape change of some relatively large substances can be detected to confirm the existence of gravitational waves. However, this twisting and oscillating effect of space is indeed too small compared to the human vision. Therefore, the most sophisticated equipment on the earth, such as LIGO, can only detect gravitational waves with relatively short wavelengths. This gravitational wave is usually emitted by the oscillation of the black holes or neutron stars.

Existing equipment and techniques are difficult to measure gravitational waves that are relatively low frequencies.

Gravitational waves must produce observable effects in the matter of cosmic galaxies, mainly by detecting the huge energy of gravitational waves being absorbed by matter and causing changes in the structure and state of matter. Although galaxies are enormous compared to humans. Fortunately, however, the effects of gravitational waves on galaxies may not be observed macroscopically, but from a human perspective, these relatively microscopic phenomena are easily observed by man-made equipment.

Therefore, equipment such as LIGO can find the gravitational waves by directly detecting the curvature of space time. If we want to observe that the galaxy material is affected by gravitational waves, we can mainly pay attention to the energy transmitted by gravitational waves.

For a gravitational wave propagating along the *z*-axis, only three components of the stress-energy tensor are not zero. They are:

$$t_{00}^{GW} = \frac{t_{zz}^{GW}}{c^2} = -\frac{t_{0z}^{GW}}{c} = \frac{1}{32\pi}\frac{c^2}{G}\omega^2(h_+^2 + h_\times^2)$$

Where 0 is the time dimension and *z* is the *z*-axis direction. GW is used to mark this as a gravitational wave tensor. Kokkotas gives an example. For a gravitational wave generated by a black hole formed by a 15Mpc, or about 50 million light years, 10 times solar mass ($10M_\odot$) supernova, the energy flux to the Earth is calculated as

$$F = 3 \times 10^3 \times \left(\frac{f}{1kHz}\right)^2 \left(\frac{h}{10^{-22}}\right)^2 \frac{J}{m^2 \cdot s}$$

In the above formula, f is the frequency of the gravitational wave, and h is the dimensionless amplitude of the gravitational wave.

Since the flux of gravitational waves is inversely proportional to the square of the distance of the source, we can estimate the energy flux of the different gravitational waves emitter to the solar system.

We can assume that there is a huge mass movement in the center of the Milky Way. According to Reid's data [4], a star was observed at a position of approximately 100 AU from the center of the Milky Way, with a linear velocity of 5×10^6 m/s. This reflects the existence of a huge mass in the center of the Milky Way. This may be a huge black hole of mass quality of the order of $10^6 M_\odot$. This paper assumes that the mass around the perimeter of the black hole is equal in magnitude to the black hole. Therefore, the mass of the core stars within the 2 light years of the center of the Milky Way is about $10^6 M_\odot$. In this way, according to the requirements of centripetal force and gravity, there are:

$$M\frac{r}{2}\omega^2 = G\frac{M^2}{\left(\frac{r}{2}\right)^2}$$

Where *M* is the mass of the central black hole of the Milky Way or the mass surrounding black hole, *r* is the radius of the core of the Milky Way, and *ω* is the angular frequency of the core mass rotation of the Milky Way. *G* is the gravitational constant.

Since the rough estimate is made, the general relativity effect is not considered here. It is assumed that the average mass around the central black hole of the Milky Way is located at half the core radius ($r/2=10^{16}m/2$). The gravitational force produced by the interaction of and the external bypass mass (M) of the black hole (M) is equal to the centripetal force generated by the circular motion of the external mass, and maintains a relatively stable equilibrium state.

This can be calculated

$$\omega^2 = G\frac{8M}{r^3} \sim \frac{8 \times 6.67 \times 10^{-11} \times 10^6 \times 2 \times 10^{30}}{10^{48}} \approx 12 \times 10^{-22}$$

Therefore, it can be estimated that the frequency of the gravitational wave generated by the mass rotation of the center of the Milky Way is approximately

$$f \sim 2 \times 10^{-10} Hz$$

These mass rotations are typically about a linear speed of

$$v = r\omega \sim 2 \times 10^5 m/s$$

Considering that the amplitude is inversely proportional to the distance, the energy flux is inversely proportional to the square of the distance. In contrast to the parameters estimated by Kokkotas, the amplitude of the gravitational wave reaching the solar system is approximately

$$h' = \frac{5000}{2.6} h = 2000h$$

Then consider the mass of the Milky Way center is about 10^5 times the mass of the black hole estimated by Kokkotas, and the distance is 1/2000 estimated by Kokkotas.

Substituting these data into the energy flux calculation formula can roughly estimate that the energy flux generated by the gravitational wave in the center of the Milky Way reaches the solar system is approximately

$$F = 3 \times 10^3 \times \left(\frac{2 \times 10^{-10}}{1kHz}\right)^2 \left(\frac{2000h}{10^{-22}}\right)^2 \times 10^5 \times 2000^2 \frac{J}{m^2 \cdot s}$$

That is

$$F \sim 10^{-4} \frac{J}{m^2 \cdot s}$$

This is a very large energy flux. Considering that the cross-sectional area of the sun's optical disc is about $\pi \times 7^2 \times 10^{16} \sim 10^{18} m^2$. The gravitational wave emitted from the center of the Milky Way radiates to the sun, which can reach $10^{14} J$ per second. It means that the power of the gravitational wave reaching the sun has reached $10^8 MW$. At present, the power of the Three Gorges Dam in China is about $2 \times 10^4 MW$. That is, the gravitational wave power radiated from the center of the Milky Way to the sun is about 10,000 times the power generation of the Three Gorges Dam. In 2017, the global power generation is about $10^{10} MWh$, which is equivalent to $2.7 \times 10^6 MW$. It can be seen that the gravitational wave power reaching the sun is about 50 times that of the global electricity consumption in 2017.

However, the gravitational wave frequency generated by the mass center of the Milky Way is much lower. Only $10^{-10} Hz$. This also means that the wavelength of the gravitation will be very long. About 10^{17}m, which is about 30 light years. This is longer than the diameter known to the current solar system. Since $h \sim 10^{-22}$, considering that the amplitude of the gravitational wave is inversely proportional to the distance, the magnitude of the dimensionless wave of the gravitational wave generated by the center mass of the Milky Way reaches the solar system is about $h' \sim 10^{-19}$. $\Delta l = lh$ (where l is the diameter of the solar system), it can be estimated that this amplitude is $\Delta l \sim 10^{-3}$m. It can be seen that at a cosmic scale, this is still a very small value. Therefore, it is very difficult to detect the gravitational waves emitted by the center of the Milky Way by directly measuring the magnitude of the space-time distortion.

However, we can notice that the gravitational wave energy flux emitted by the center of the Milky Way is very large. How such a large amount of energy encounters a suitable mass, produces a resonance effect, and can be completely absorbed, thereby producing an observable physical phenomenon. Such as various particle radiation. Here, this elementary particle radiation is regarded as a cosmic gas, which corresponds to the evaporation of the cosmic liquid caused by gravitational waves.

Another thing worth considering is that the gravitational wave interpretation solved by the Einstein equation is obtained under the weak field approximation. If it is not a weak field approximation, the gravitational waves generated in the center of the Milky Way will be much more complicated than the plane waves. It also contains some higher frequency harmonics. If such a high-frequency harmonic is present and the frequency is exactly the same as the resonant frequency of a star, it is easily absorbed by the star, producing a more pronounced observable effect.

6 Periodic changes of sunspots and gravitational waves

Although the energy flux of gravitational waves has been calculated, unfortunately we do not know how much gravitational wave energy can be absorbed by the sun or other stars. Of course, although the gravitational wave energy is not necessarily absorbed by the sun, it is believed that it should be able to disturb the plasma fluid on the surface of the sun, which in turn causes a change in the state of the fluid on the surface of the sun. Gravitational waves have a fixed period, so if there are gravitational waves in the Milky Way that can act on the sun, this will cause some periodic changes in some activities of the Sun due to the periodicity of the gravitational waves. The currently known sunspot change cycle is about 11 years. The gravitational wave wavelengths generated by the mass motion of the Milky Way center estimated above are on the order of 30 light years, which are basically the same in magnitude. The effect of gravitational waves is a more instructive explanation when there are no other better theories that can be used to explain the laws of the sunspot cycle. Of course, in turn, we can use the cycle of sunspot changes to more accurately obtain some important parameters of the center of the Milky Way.

At present, observations and research results have shown that sunspot activity is similar to the phenomenon of earth tides and tsunami. As early as 2009, NASA's STEREO spacecraft has observed this tsunami phenomenon of sunspot outbreaks. Some authors have also found that a shallow water model for dealing with earth tides and tsunami problems can be used for analysis [5]. The results of the analysis are close to those observed. This proves to some extent that the surface hydrodynamics of the solar surface is very similar to the seawater on the earth.

In this way, for sunspot activity, we can largely refer to the principle of the Earth's tsunami phenomenon and analyze the cause of the sunspot tsunami phenomenon.

The tsunami on Earth is mainly the result of geologic activities and external forces. The very large tsunami that has appeared on the earth in recent decades is mainly related to the earthquake under the sea. As early as about 100 million years ago, there was a huge tsunami caused by asteroids hitting the earth.

However, these tsunami phenomena on the earth are not regular and therefore difficult to predict. Unlike the tsunami caused by seawater on the earth, the similar tsunami caused by sunspot activity is very regular, usually repeated in a cycle of 11 years. This also shows that it is not enough to completely rely on the changes in the internal structure of the sun to explain the sunspot activity. This is like the fact that the Earth does not have a fixed-time periodic earthquake to cause a huge tsunami. The very high probability of causing intense activity of sunspots should come from the outside.

In addition, there is a strong tidal phenomenon on the earth, and the tidal phenomenon on the earth is closely related to the rotation of the moon around the earth. For the sea on Earth, the movement of the moon is an external factor. The regular movement of the moon caused the regularity of the tide phenomenon. In addition to the large tsunami that can be erupted, the sunspot plasma gas also has milder fluctuations similar to the earth's tides. These sunspots are very regular and usually occur every 11 years. As a huge burning gas such as the sun, its interior has a very complex nonlinear structure. The complete dependence on the internal structure of the sun cannot lead to the occurrence of this periodic sunspot explosion. Therefore, there must be some very regular external forces causing fluctuations and oscillations in the surface of the sun's magnetohydrodynamic (MHD).

One problem, however, is that the planets around the sun are too far and too small by comparing with the moon and the earth. The effects of these planets on the magneto-dynamics of plasma gases on the surface of the sun should be relatively small, which cannot cause the large-scale "tsunami" phenomenon. Another problem is that the planets fly around the sun for more than a year, and the sun's rotation is only a few days. The difference between the way the moon and the moon move around earth is very obvious. Therefore, these planets cannot be like the moon, causing huge sunspots and tsunamis on the surface of the sun.

If the factors in the solar system do not lead to periodic sunspot outbreaks, we can extend the range to the entire Milky Way. From the estimation results in the fifth section of this paper, the period of gravitational waves generated by the massive mass movement in the center of the Milky Way is basically the same as the period of the sunspot outbreak. Therefore, we can naturally speculate that the sunspot activity should have a great relationship with the gravitational waves emitted by the center of the Milky Way. As a wave, gravitational waves have peaks and troughs, and there is also a polarization direction. This means that during the process of energy transfer, peaks and valleys of energy occur in one cycle. When the peak of the gravitational wave energy is transmitted, the magnetohydrodynamic structure of the sun surface changes, which causes the disturbance of the plasma gas on the surface of the sun, resulting in the occurrence of sunspot eruption. When the energy peak of a cycle passes, the disturbance becomes smaller, and the sunspot burst begins to calm down, waiting for the next energy peak to arrive.

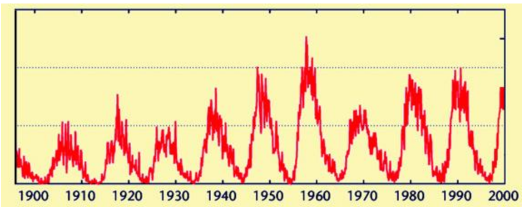

Figure 4 Cycle of sunspot outbreaks (Source: https://stereo.gsfc.nasa.gov)

Figure 4 shows the periodicity of sunspots that have erupted for more than a hundred years. It can be seen from the figure that in addition to the 11-year cycle of sunspot outbreaks, it seems that there is a larger period of amplitude change every 60 years. This periodic shape is very similar to an oscillating wave containing multiple harmonics. This waveform is difficult to interpret solely from changes in the internal hydrodynamic structure of the sun. This is because to generate a fixed periodic oscillation, there must be a boundary constraint. For example, the boundaries of rivers and oceans on Earth. However, in addition to gravity in the sun, we have not found any boundary conditions that can constrain the MHD oscillatory wave.

7 Summary

Using the assumption of virtual space time, our current universe has become an open system, which also provides a theoretical basis for the flow of mass and energy in our present universe. This is because if it is a closed system, the system will eventually evolve into the equilibrium state of entropy. In this equilibrium state, all material flows will also stop. After treating the universe as an open system, we can see that the universe can transform back and forth between the gaseous and liquid states, forming a very rich and unique cosmic hydrodynamic state. Through the analysis of this paper, we find that the liquid model of the universe can well explain the source of microwave background radiation and cosmic rays, which is in good agreement with the actual observations.

When matter and energy can flow, it means that a rich variety of fluid dynamic structures can be formed and the interaction of matter and waves can be produced. This is like the interaction of water and sound waves transmitted through the water. Passing gravitational waves in the universe. There are many similar characteristics of sound waves, electromagnetic waves and gravitational waves. Since the energy of gravitational waves is very large, when gravitational waves interact with galaxies, there are many unique phenomena that we can observe. These phenomena are difficult to explain with existing theories. This paper cites a periodic law of sunspot outbreaks, which may be caused by gravitational waves emitted by the center of the Milky Way. The estimated results show that the gravitational wave period generated by the mass center of the Milky Way is consistent with the sunspot burst period on the order of magnitude. Since it is still unclear why the sunspot outbreak has such a strong periodicity, the interpretation of the sunspot outburst caused by gravitational waves is very instructive.

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液体宇宙与引力波

程智

（中国广州白云区， gzchengzhi@hotmail.com）

摘要：按照基于虚时空物理学的宇宙模型，宇宙具备了两种状态，分别是液态和气态。目前的宇宙正处于液态宇宙的状态。这可以获得一些重要的观察证据的支持。液态宇宙理论预测，由于微波背景辐射和宇宙射线都是液态宇宙自然蒸发的气体，因此二者的温度应该是相等的。目前相关学科中，水声学的研究成果较多，因此我们可以借鉴一些水声学的理论来处理宇宙中引力波的传播问题，并可以获得一些有启发性的结论。这为我们更详细地研究和探讨引力波的一些重要规律提供了更广泛的理论支持。本文对银河系中心巨大质量所产生的引力波数据进行了比较粗略的估算。发现可以用银河系中心引力波的辐射来解释太阳黑子周期性变化的规律。

关键词：宇宙模型、引力波、液态宇宙、微波背景辐射

1 引言

在不久前我提出了一个液态宇宙的模型[1]。该模型指出，我们现在所处的宇宙存在两种状态，分别是气态和液态。这两种物态与我们日常生活中所接触到气体和液体有很大的相似之处。宇宙气体主要由各种基本粒子，包括光子、中微子、电子、质子以及各种复合粒子构成。这实际上包括了微波背景辐射、宇宙中微子流以及各种宇宙射线等。而各种聚集在一起的物质则是液态宇宙的组成部分。包括了各种星体、星系等。

既然是液体形态，意味着这些宇宙物质具备了液体所具备的基本流动性。在物理计算上满足流体力学的基本方程。比如满足斯托克斯定理、伯努利定律等。

之所以能够形成宇宙的液体状态，根本原因还是在于万有引力传播速度的有限性。由于万有引力相互作用除了与距离有关之外，还需要考虑万有引力传播到更远的地方所需要的时间。如果这个传播时间是几秒钟、几天甚至是几千年的时间，这都能够说明万有引力还是能够产生相互作用的。但是如果万有引力的传播时间达到了几千万甚至几百亿年，那就我们能够理解的宇宙的寿命周期来说，就可以说在这么远的距离，万有引力是不会产生相互作用的。

因此在宇宙的尺度，在足够短的时间中，万有引力就成为了一个类似于液体中分子间相互作用力，它实际上可以被看作是一个短程力。这里所说的足够短的时间，可能是几千万年以内的时间。

这样，如果存在一个在宇宙尺度来对宇宙中的物质进行观察的观察者，则他看到的宇宙中的物质就如同一盆清水一样。但是其中有一些地方存在漩涡、浪涌等流体力学现象。

如果液态宇宙模型是正确的，则我们现在处理各种宇宙尺度的问题就有了很多非常有效的工具来进行。在流体力学中经常使用的一系列理论以及相应的计算方法都可以被借鉴到处理宇

宙问题上来。比如可以从液体的黏滞性入手，了解星系之间物质的相互作用规律以及可能产生的各种现象。如果宇宙流体也存在湍流等现象，则我们可以借助非线性流体力学工具来分析星系的起源以及今后可能出现的变化。这种湍流现象在螺旋星系中是普遍存在的。比如下图 1 中的星系，其螺旋臂就有非常明显的湍流的存在。之所以形成这样的湍流，原因在于不同层次的星系物质运行速度不同，而它们之间又存在引力作用，导致出现非线性相互作用，进而出现相变，转换成湍流。图 1 中的 Pinwheel Galaxy，如果将其看作是一个水流的旋涡，就可以明显看出其中的湍流。而且越靠近中心位置，湍流现象越明显。而在外围，则流体流动非常平稳。

图 1 Pinwheel Galaxy 中的湍流现象

而从专门研究声波在水中传播的水声学理论出发，我们似乎也可以借用来处理宇宙中引力波的传播问题。

本文就尝试探讨一下引力波在宇宙流体传播规律，以期望获得其他理论没有注意到的一些问题。

2 宇宙流体的一些性质

如果整个宇宙是一个封闭系统，则即便宇宙处于流体状态，则这个流体也将是一个非常平静，分布均匀没有波浪的液体。因此我们现在的宇宙必然是一个开放系统。然而现在已有非常丰富的事实证明宇宙中的总能量是守恒的。也就是说，在整个宇宙中，能量始终保持恒定，并不存在任何外部系统能够从宇宙中吸收能量，或者向宇宙释放能量。

为了满足这样的能量守恒以及开放系统的要求，使用虚时空物理学是一个比较好的解决方案[2]。当然其他的一些理论也指出整个宇宙中可能存在暗物质，这样暗物质可能会跟可见宇宙物质之间进行物质和能量交换。这里我们采用虚时空存在的假设。即除了我们现在所处的实

时空之外，还存在一个虚时空，该虚时空与实时空之间存在能量的交换。这种能量交换的形式是以质量和能量之间进行交换的方式进行的。而宇宙的总能量可以用一个复数的形式表示出来：

$$\mathrm{E} = h\nu + imc^2$$

其中 $h\nu$ 为虚光子的能量，反映了物质在实时空运动产生的动能。而 m 则为物质的质量。前面用 i 表示它是属于虚时空的能量。

由于能量和质量之间可以通过爱因斯坦只能关系进行相互转换，这也意味着实时空或者虚时空的能量是可以自由地进行交换的。这种自由交换也就表现出实时空不再是一个封闭系统，而是一个可以与其他系统进行能量交换的开放系统。

对于这样的一个开放宇宙系统，当出现能量到质量或者质量到能量的转换过程的时候，就会出现物质的运动，其表现形式就是宇宙流体的快速流动。这种流动可以形成多种流体力学形态，包括层流和湍流等现象。

图 1 显示了黑洞周围的物质被黑洞吸引，掉入黑洞的方向。这跟水的湍流中的漩涡形态是一致的。

按照虚时空物理学理论【2】，黑洞内部实际上就是虚时空。黑洞的边界是一个实时空与虚时空的边界。因此黑洞吸引实时空的物质进入虚时空，其中的能量转换成了质量。可以用来反映宇宙流体流动的方向。当然这也是造成宇宙流体流动的基本原因。

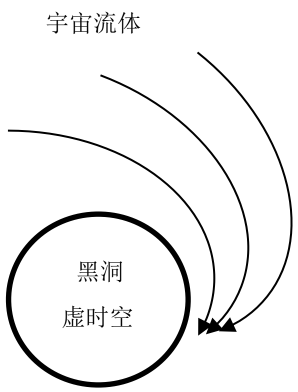

图 2 能量到质量的转换

对于没有黑洞存在的恒星系，比如太阳系，则行星始终围绕太阳运转。这是由于太阳内部的能量形成了一个如同大坝的形态，能够将能量阻挡在施瓦希半径之外，外部而不至于让物质快速流入虚时空。

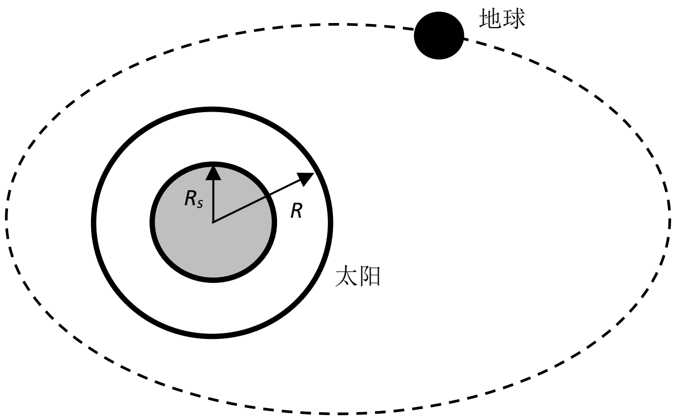

图 3 太阳的半径阻止了物质进入施瓦希半径

图 3 中 R 是太阳的半径，而 R_s 则是施瓦希半径。由于太阳的半径大于施瓦希半径，这样可以避免太阳坍塌成一个黑洞。因而外部其他行星将能够周而复始第围绕太阳运转。

然而图 3 显示的的情况并不意味着宇宙流体（行星物质）将永远能够以这种方式运转。毕竟太阳内部还在进行着能量消耗，恒星温度的变化意味着质量的变化，实时空的能量也仍然在不断转换成虚时空的能量（或者相反的过程，即质量不断转换成实时空的能量）。另外这些恒星系通常在一个更大的星系之中，比如银河系。而这些星系中央通常都会有一个大黑洞的存在。

因此由于虚时空和实时空之间的能量交换，直接导致了宇宙流体在一个时空的不断流动，既有流出到虚时空的流体，也有从虚时空流进实时空的流体。两个过程同时存在。

3 宇宙流体的蒸发

3.1 宇宙气体

构成气体的分子或者原子是可以自由移动的。一般来说，气体中的分子或者原子之间的相互作用力非常小。理想气体的分子或原子之间的相互作用力可以忽略。

构成宇宙气体的物质与地球大气构成的物质不相同。地球大气中主要包括各种分子和惰性气体原子。而宇宙气体则主要由各种基本粒子所组成。其中最基本的是电子、质子、光子和中微子。另外宇宙气体中还包含了各种复合粒子，比如各种重子、介子等。

在最极端的条件下，整个宇宙可能全部都是由这种宇宙气体组成。这时候对应了宇宙的一种非常高温的条件。

另一种很极端的条件，可能整个宇宙处于绝对零度的液体状态或者固体。

至于是否存在宇宙的固体状态，这值得进一步研究。因为如果整个宇宙处于固体状态，宇宙中的星系，相互之间将形成非常牢固的晶体结构。行星或者恒星要么被束缚在晶格之中，要么可以在晶格中自由移动。不过与固体离子之间相互作用不同，引力只有吸引力，没有排斥力。能否形成这种晶体结构可能需要更苛刻的条件。

如果宇宙处于不同的状态的概率都是相等的，则宇宙完全由宇宙气体组成的概率是非常小的。更多概率的情况则是宇宙处于常温或者比较低温（不到绝对零度）的液体状态。这就如同液态水，即便是没有到沸点，在水的表面仍然存在大量的水蒸气。

考虑到绝对温度不为零的宇宙液体将会蒸发出一定数量的宇宙气体，因此在现在的宇宙空间中将存在一定数量的自由的基本粒子和复合粒子。包括上面所提到的光子、中微子、电子和质子等不会产生衰变的粒子以及各种其他的轻子和重子等。

由于这些自然蒸发的气体具备与液体相同的温度，因此通过测量宇宙气体的温度可以获得现在我们所处的宇宙的温度。

3.2 微波背景辐射

微波是一种光子，因此如果我们现在的宇宙温度不是绝对零度，则宇宙液体将能够蒸发出大量的光子。这种光子就是以微波背景辐射的形式出现的。

当然宇宙液体蒸发出来的光子具有很宽的频谱。只是在不同的宇宙温度条件下，宇宙中光子的频谱分布是有很大的区别的。因此这里所说的微波背景辐射指的是一个平均的频率宽度。

宇宙大爆炸理论也预言存在微波背景辐射。尽管微波背景辐射就是在大爆炸理论的预言下发现的。然而近年来大量的实验证据却发现其中存在一些理论与观察数值不太一致的问题。比如如果大爆炸理论正确，则所测得的微波背景辐射应该具有一定的方向性。然而现在观测的结果却是微波背景辐射是各向同性的，就是说微波背景辐射非常均匀。另外按照宇宙大爆炸理论的预测，在宇宙某些位置应该存在微波背景辐射的阴影。然而实际的观察结果否认了这样的预测。

如果从微波背景辐射是宇宙液体蒸发出来的气体组成成份来看，就不存在这样的问题。就如同静止的液体表面蒸发出来的气体，在液体表面所处的二维平面位置不存在方向性一样，宇宙液体蒸发出来的气体也必然是非常均匀，在三维空间中各向同性的。

当然在宇宙不同的位置，这种微波背景辐射温度应该还是会有所区别，就如同在地球上的不同位置的海洋表面水蒸气的温度会有很大的不同一样。如果今后有更先进的技术能够帮助我们测量更加遥远的位置的微波背景辐射，则可能会发现不同的区域微波背景辐射的温度也许会有所区别。

3.3 宇宙射线的来源

高能粒子宇宙射线也是蒸发出来的宇宙气体构成之一。当然宇宙射线的来源也是困扰天体物理学家的一个问题。目前有比较确切证据证实的是一个高能中微子束的来源。尽管数量很少，统计效应不是很明显，但至少给我们提供了一个了解宇宙射线来源的比较好的方法。这也为了解高能粒子的来源提供了依据。液态模型与大爆炸模型不同的是，从液态模型来看，我们现在探测到的高能粒子就是探测器周围的宇宙液体自然蒸发出来的。当然这个"周围"既包括了附近的星系，也可能包括了几十亿光年之外的遥远星系。这似乎与水面蒸发出来的气体的温度分布有所不同，一般来说水平面蒸发的气体主要来自观测点附近的液体分子。然而注意到在宇宙尺度上，我们更适合使用四维闵科夫时空来处理问题，因此时间也是需要考虑的相互作用的一个重要维度。

液态宇宙模型预测的一个重要结论就是高能粒子的平均温度应该和微波背景辐射一致。既然宇宙射线和微波背景辐射都是宇宙气体的组成成分，因此宇宙射线的平均温度也应该与微波背景辐射的温度是完全相等的。目前测量的结果表明，地球周围宇宙射线平均能量密度大约为 $1 eV/cm^3$, 即大约 $1.6\times10^{-13} J/m^3$. 而微波背景辐射的平均能量密度大约为 $4.8\times10^{-14} J/m^3$. 可以看出二者在数量级上基本是一致的。

如果从以有的宇宙模型来看，这或许是一个巧合。然而从液态宇宙模型来看，这实际上并不是一个巧合。这进一步证实了微波背景辐射和宇宙射线共同构成了蒸发的宇宙气体状态。

当然与微波背景辐射一样，液态宇宙模型同样也可以预言宇宙射线的分布也是非常均匀、各向同性的。

4 流体中波的传递

4.1 三种流体的比较

流体反映了物质的集体运动。最直接的是水流，是水分子的集体运动。电流是电子的集体运动。宇宙流体反映了星体的集体运动。同时流体作为一种介质，也能够传递各种信息。探讨流体中的信息传递是很有趣的。在水中主要通过机械振动的声波来传递信息，在电流中通过电磁波来传递信息。这些信息传递的速度都比水分子或者是电子的流动速度快。

而在宇宙流体中，也应该存在独特的信息传递仿方式。考虑到宇宙流体的物质相互作用主要通过万有引力进行，那么很自然的推论就是可以采用引力波来进行信息的传递。目前已经有比较强有力的证据证实了引力波的存在。

但是比较遗憾的就是引力波的传递速度也是光速，这导致一个星系要与另一个星系进行信息交流需要非常长的时间。那么能否存在一种更加快速的信息传递方式？这是一个很有趣的问题。如果存在则有助于我们观测遥远星系的发展变化情况。下面我们可以对水流、电流和宇宙流体的一些性质进行比较。

表 1 三种流体的比较

类型	水流	电流	宇宙流体
尺度	宏观	微观	宇宙
物质相互作用	分子间相互作用	电子质子相互作用	万有引力
方式	空间	空间	时间空间
信息传递	声波	电磁波	引力波?
速度	音速	光速	光速?

从上面的对比中来看，现在还不太确定的是宇宙流体的信息传递方式和传播速度。按照爱因斯坦广义相对论来看，宇宙中的物质只存在万有引力相互作用，这样物质之间的相互作用就只有万有引力。而万有引力所产生的是引力波。引力波的速度是光速。如果这就是宇宙流体的信息传递方式，则宇宙流体中信息传递速度就会受到光速的极限。这也意味着，随着宇宙流体的不断扩散，各部分的信息交流会需要越来越长的时间。

4.2 引力波

通过广义相对论，爱因斯坦获得了引力波的方程。爱因斯坦方程的引力波是一个平面波解。不过可以稍微注意一下爱因斯坦引力波解的一些条件。

1、该解是一个弱场近似解。就是说要产生该引力波解，需要引力场比较弱。

2、该解是一个线性解。就是说需要将复杂的引力场方程做各种近似，然后获得线性方程。这样就可以获得一个类似于电磁波一样的平面波解。

3、该解的存在需要平坦空间。为了满足希尔伯特协变性的要求，需要假设空间是平坦的。

当然上面的三个假设实际上其本质就是弱场近似。这种弱场近似反映出质量对时空的扰动是比较小的。因此引力波的传播就是一个标准的平面波的传播。

虽然做了这么多限制，但是爱因斯坦引力波的平面波解是有非常广泛的应用价值的。原因在于离开了巨大质量的扰动之后，引力波将传播出去。从现有的资料来看，引力波的传播过程绝大部分时间都是在弱引力场中传播的。因此观察者测得的引力波就是一个非常严格的平面波。该平面波以光速运行。

质量的扰动都会产生引力波，只是质量大小不同，所产生的引力波的强度也会有很大的区别。对于一个螺旋星系来说，靠近中心位置巨大质量的运动必然产生大量引力波。这种引力波就如同水流中的漩涡产生的声波效应是一样的。相比较 LIGO 测量到的两个巨大黑洞的合并产生的引力波，巨型黑洞合并则可与大块物体扰动液体相比较，就如同大块石头投入水中产生的扰动。目前探测到的是非常集中的大质量物体扰动形成的波长较短的引力波。

而螺旋星系的引力波的波长更长，更普遍。类似于声波中的次声波。

4.3 波对流体的作用

借助声波对流体产生的作用，可以启发我们理解引力波对宇宙流体的作用。目前声波对流体的作用主要体现在以下几个方面。

1、声波传播导致水流密度产生变化

由于声波是纵波，因此声波的传播导致液体密度产生变化。

2、超声波导致液体分子产生极化效应。

很弱的声音并不会导致液体产生明显的变化。但如果是功率比较大的超声波，则可以对液体分子产生极化效应。这种极化效应可以明显改变液体的一些重要物理和化学特性。

不过上述作用都局限于比较强的声波。正如 4.2 节所指出的那样，引力波大部分传播的途径都是可以做很好的弱场近似的。因此能量很强的引力波在宇宙空间中相对来说还是比较少的。不过在一些比较特殊的条件下，这些强引力波对宇宙流体所产生的各种物理效应还是可以被探测到的。比如在 LIGO 实验装置中，通过一个人工建造的大质量物体就可以探测到两个黑洞撞击所产生的强引力波。

另外声波之所以能够被生物体感受到，主要原因是声波引起了耳膜的振动，这种振动通过神经网络系统能够转换成神经冲动的电信号。因此这里涉及到一个机械波到电磁波的转换问题。如果宇宙中存在实现这样的能量转换功能的物质，则引力波传播到这些物质的时候，就可能引起能量的转换。比如出现一些射线或者离子喷射的情况。如果这样的机制确实存在，那么现在我们所探测到的大量宇宙射线中，是否有部分宇宙射线是属于引力波与物质相互作用的产物？

4.4 宇宙流体中引力波传播特性

可以将水声学一些研究结论推广到引力波在宇宙流体中传播的一些重要特性。这些特性包括：

1、引力波传播距离

如同声波在海水中的传播一样，引力波在宇宙流体中的传播距离也可以传播的很远。整个液态宇宙构成了引力波传播的通道。

2、星系干扰

由于星系是一个质量快速流动的地区，会干扰引力波的传播。这种干扰可能引起引力波的衰减、反射、折射等现象出现。当然引力波能量的变化也会导致星系物质出现一些可以观察的变化。

3、能量的转换

在引力波与宇宙流体产生相互作用的过程中，会导致引力波的传播状态出现改变。同时，星系中的物质状态也会出现一些物理特性的改变。主要是这些物质吸收了引力波的能量之后，导致出现物质结构、状态等的改变以及基本粒子气体的蒸发等现象。部分引力波被星系物质吸收转换成其他形式的能量。

4、引力波的散射

遇到不同质量的星系，时空弯曲、膨胀或压缩等效应就可能造成引力波的散射。

5、其他引力和引力波的干扰

如同声波一样，其他强引力场、引力波也会干扰正在传递的引力波，并导致各种引力波噪声信号的出现。

6、宇宙的流体状态

宇宙中的物质虽然整体上呈现流体状态，但是不同的区域流体的流动方式是不一样的，这将导致引力波在传播的过程中，在不同的区域会出现传播速度、引力波的分布等的变化。

5 引力波引起宇宙气体的蒸发

上述各种引力波与宇宙液体的相互作用中，一个比较容易观察的现象可能和宇宙射线、光子辐射等因素有关。而宇宙射线、光子等则是宇宙气体的重要组成部分。因此当引力波与星系物质产生相互作用的时候，就有可能将能量传递给这些物质，从而提升这些流体状态的物质出现额外的气体蒸发现象。如果能够观察到这些额外的宇宙射线、光子辐射等现象，而又无法找到其他的一些可能引起原因（比如超新星爆发等），则其中很可能跟引力波的相互作用有关系。

这里参考的 Kokkotas 的推导[3]，简单估算一下引力波的频率与激发出来的宇宙射线之间的关系。按照爱因斯坦场方程的计算，引力波解在弱场近似的条件下，可以表示为

$$\tilde{h}^{\mu\nu} = A^{\mu\nu} e^{ik_\alpha x^\alpha}$$

可以看出这是一个平面波解。$\tilde{h}^{\mu\nu}$反映出引力的波动情况，对应了时空度规的变化。在实际应用的时候，主要就是确定其中的几个重要的参数。

其中$A^{\mu\nu}$是一个常数，反映出平面波的振幅。k_α是平面波的波矢，反映了平面波的动量或能量。按照希尔伯特规范条件，$A^{\mu\nu} k_\mu = 0$，即二者是正交的。

引力波的波速为光速。因此根据波矢的大小可以确定出引力波的频率和波长。

上述平面波解看起来很复杂，但实际上很多参数都为 0，因此是可以进行大幅度简化的。简化之后可以得到弱场近似条件下引力波有两个极化方向。分别用加号和乘号来表示，即 h_+ 和 $h_\times$.

引力波的传播过程将导致所经过的时空产生扭曲振荡。这种时空的扭曲振荡可以用来检测引力波的存在。比如通过迈克尔逊干涉仪，可以检测到一些比较大的物质的形状改变，从而证实引力波的存在。不过这种时空的扭曲振荡效应相对于人类的视野来说确实是太小了。因此目前地球上最精密的设备，比如 LIGO 只能检测波长比较短的引力波。这种引力波通常由黑洞或者中子星的振荡发射出来。

对于测量在宇宙中更广泛存在比较低频率的引力波而言，现有的设备和技术是难以完成的。

引力波要在宇宙星系物质中产生可以观察的效应，主要还是需要通过检测引力波巨大的能量被物质所吸收，并产生物质结构和状态的改变这一点来进行。虽然星系物质相对于人类来说是无比巨大。然而所幸的是，引力波对星系物质所产生的效应，或许在宏观上难以被观察，但在人类视角上，这些相对微观一些的现象却是很容易被人造设备所观察到的。

因此同 LIGO 等设备通过直接检测时空的弯曲来寻找引力波不同，观察星系物质受到引力波的影响，主要还是要注意引力波所传递的能量。

对于一个沿着 z 轴传播的引力波，其应力能量张量只有三个分量是不为零的。分别是：

$$t_{00}^{GW} = \frac{t_{zz}^{GW}}{c^2} = -\frac{t_{0z}^{GW}}{c} = \frac{1}{32\pi}\frac{c^2}{G}\omega^2(h_+^2 + h_\times^2)$$

其中 0 表示时间维度，z 表示 z 轴方向。GW 用来标记这是一个引力波张量。Kokkotas 给出了一个例子，对于一个距离地球 15Mpc, 即大约 5000 万光年，10 倍太阳质量超新星所形成的黑洞所产生的引力波，到达地球的能量通量计算公式为：

$$F = 3 \times 10^3 \times \left(\frac{f}{1kHz}\right)^2 \left(\frac{h}{10^{-22}}\right)^2 \frac{J}{m^2 \cdot s}$$

上述公式中，f 是引力波的频率，h 是引力波的无量纲波幅。

由于引力波的通量与源的距离平方成反比，因此通过这个公式我们可以估算不同的引力波源所产生的引力波到达太阳系的能量通量。

我们可以假设银河系中心存在一个巨大质量运动。按照 Mark J. Reid 的数据[4]，在距离银河系中心位置大约 100AU 的位置观察到了一颗恒星，其线速度达到$5 \times 10^6 m/s$. 这反映出在银河系中心可能会存在一个质量大约 10^6 太阳质量数量级质量的巨大黑洞。本文假设了绕黑洞外围的质量与该黑洞在数量级上相等。因此银河系中心 2 光年范围之内的星体质量大约是 10^6 倍的太阳质量。这样按照向心力与引力相等的要求有：

$$M\frac{r}{2}\omega^2 = G\frac{M^2}{\left(\frac{r}{2}\right)^2}$$

其中 M 为银河系中心黑洞或者外围绕黑洞运行的质量，r 为银河系核心的半径，ω为银河系核心质量旋转的角频率。G 为引力常数。

由于是做很粗略的估算，这里不考虑广义相对论效应，假设围绕银河系中心黑洞运行的平均质量所处的位置为核心半径的一半($r/2=10^{16}/2$)，然后考虑中心黑洞的质量（M）和黑洞外部绕行质量(M)的相互作用产生的万有引力。这样外部质量做圆周运动产生的向心力与万有引力相等，保持相对稳定的平衡状态。

这样可以计算出

$$\omega^2 = G\frac{8M}{r^3} \sim \frac{8 \times 6.67 \times 10^{-11} \times 10^6 \times 2 \times 10^{30}}{10^{48}} \approx 12 \times 10^{-22}$$

因此可以估算出银河系中心质量旋转产生的引力波的频率大约为

$$f \sim 2 \times 10^{-10} Hz$$

这些质量旋转比较典型的线速度大约为：

$$v = r\omega \sim 2 \times 10^5 m/s$$

考虑到波幅与距离成反比，能量通量与距离平方成反比。则与 Kokkotas 估算的参数进行对比，到达太阳系的引力波的波幅大约是：

$$h' = \frac{5000}{2.6} h = 2000h$$

然后再考虑银河系中心质量大约是 Kokkotas 估算使用的黑洞质量的 10^5 倍，距离是 Kokkotas 估算的 1/2000.

将这些数据代入能量通量计算公式，可以大致估算出银河系中心质量运动所产生的引力波到达太阳系的能量通量大约为：

$$F = 3 \times 10^3 \times \left(\frac{2 \times 10^{-10}}{1kHz}\right)^2 \left(\frac{2000h}{10^{-22}}\right)^2 \times 10^5 \times 2000^2 \frac{J}{m^2 \cdot s}$$

即：

$$F \sim 10^{-4} \frac{J}{m^2 \cdot s}$$

这是非常大的一个能量通量。考虑到太阳的光盘的截面积大约为$\pi \times 7^2 \times 10^{16} \sim 10^{18} m^2$. 这也意味着银河系中心发射出来的引力波辐射到太阳的能量每秒钟达到$10^{14} J$. 即达到太阳的引力波的功率达到了$10^8 MW$. 目前中国的三峡大坝发电功率大约为$2 \times 10^4 MW$. 即银河系中心辐射到太阳的引力波功率大约是三峡大坝发电站功率的一万倍。而 2017 年全球的发电量大约是$10^{10} MWh$, 相当于功率为$2.7 \times 10^6 MW$. 可以看出到达太阳的引力波功率是 2017 年全球用电量的大约 50 倍。

不过由于银河系中心质量所产生的引力波频率要低很多。只有$10^{-10} Hz$. 这也意味着该引力

的波长将会非常长。大约 10^{17}m，即大约 30 光年。这比目前太阳系已知的直径还要长。由于 $h \sim 10^{-22}$, 考虑到引力波的波幅与距离成反比，因此银河系中心质量产生的引力波到达太阳系的无量纲波幅大小大约是 $h' \sim 10^{-19}$. 利用公式 $\Delta l = lh$(其中 l 为太阳系的直径), 可以估算出这一波幅为 $\Delta l \sim 10^{-3}$m. 可以看出在一个宇宙尺度，这仍然是一个非常小的数值。因此要通过直接测量时空扭曲的幅度来检测银河系中心发射出来的引力波也是非常困难的。

然而我们可以注意到银河系中心发射过来的引力波能量通量是非常大的。这么大的能量如何遇到合适的质量，产生了共振效应，就可以被完全吸收，从而产生可以观察的物理现象。比如各种粒子辐射等。这里将这种基本粒子辐射看作是宇宙气体，对应了引力波引起的宇宙液体的蒸发现象。

另一个值得考虑的是利用爱因斯坦方程求解出来的引力波解释是在弱场近似条件下获得的。如果不是弱场近似，则银河系中心产生的引力波会远比平面波复杂。其中也会包含一些更高频率的谐波存在。如果存在这样的高频率谐波，且频率正好与一个恒星的谐振频率一致，则就很容易被该恒星吸收，产生更明显的可观察效应。

6 太阳黑子的周期变化与引力波

尽管已经计算出了引力波的能量通量，但是遗憾的是我们不知道有多少引力波能量能够被太阳或其他恒星吸收掉。当然虽然引力波能量不一定会被太阳全部吸收，但相信应该能够对太阳表面的等离子体流体产生扰动，进而引起太阳表面流体状态的改变。引力波存在固定的周期，因此如果存在银河系中的引力波能够对太阳产生作用，则由于引力波的周期性，这会导致太阳的某些活动产生一定的周期性变化。目前已知的太阳黑子变化周期大约是 11 年左右。而我们上面估算的银河系中心质量运动所产生的引力波波长大约为 30 光年的数量级，二者在数量级上基本上是一致的。在没有其他更好的可以用来解释太阳黑子周期活动规律的理论的时候，引力波所产生的作用是一个比较有启发性的解释。当然反过来我们也可以用太阳黑子变化的周期来更准确地获得银河系中心物质的一些重要参数。

目前已经有观察事实和研究结果表明，太阳黑子活动存在类似于地球潮汐以及海啸的现象。早在 2009 年，NASA 的 STEREO 飞船就已经观察到了太阳黑子爆发的这种海啸现象。一些作者也发现可以使用处理地球潮汐及海啸问题的一种浅水模型来进行分析【5】. 分析结果与观察结果比较接近。这在一定程度上证明了太阳表面等离子体流体力学的特性非常类似于地球上的海水。

这样对于太阳黑子活动我们就可以在很大程度上参考地球上海啸现象的原理，并用来分析引起太阳黑子海啸现象的原因。

地球上的海啸现象主要是由于地球地质活动和外力作用的结果。近几十年来地球上出现的非常大的海啸主要还是跟海底地震有关系。而早在大约一亿年前，则出现过小行星撞击地球引发的巨大海啸。

然而地球上的这些海啸现象都是没有什么规律的，因此也很难预测。与地球上海水引起的海啸不同，太阳黑子活动产生的类似海啸现象却是非常有规律的，通常以 11 年为一个周期反

复出现。这也说明完全依靠太阳内部结构的变化来说明太阳黑子活动情况是不太足够的。这就如同地球并不存在固定时间的周期性大地震来引发巨大海啸现象一样。引起太阳黑子剧烈活动的非常大可能性的因素应该来自外部。

另外在地球上存在规律性很强的潮汐现象，而地球上的潮汐现象跟月亮的绕地转动有密切关系。对于地球上的海水来说，月球的运动是一个外部因素。而月球的规则运动，引起了潮汐现象的规律性出现。太阳黑子等离子体气体除了能够爆发大的海啸现象之外，也同样存在类似于地球潮汐现象的更温和一些的波动。这些太阳黑子现象都是很有规律的，通常每 11 年出现一次。作为太阳这样巨大的燃烧的气体，其内部具有非常复杂的非线性结构，完全依靠太阳内部的结构无法导致出现这种周期性的太阳黑子爆发现象的出现。因此必定存在一些非常有规律的外部作用力引起太阳表面 magnetohydrodynamic（MHD）的波动和振荡。

然而一个问题在于，相对于月球和地球来说，太阳周围的行星相对于太阳实在是太远了，也太小了。这些行星对太阳表面等离子气体磁流动力学的影响应该是比较小的，更别说产生大面积的"海啸"现象。另一个问题是，这些行星绕太阳飞行的周期都达到一年以上，太阳的自转则只有几天时间。和月球绕地运行的方式区别非常明显。因此这些行星无法如同月球一样，引起太阳表面巨大的太阳黑子潮汐以及海啸现象。

如果太阳系内的因素无法导致出现周期性的太阳黑子爆发现象，我们就可以将范围拓展到整个银河系。从本文第五节的估算结果来看，银河系中心巨大质量的运动所产生的引力波的周期与太阳黑子爆发周期在数量级上是基本一致的。因此我们自然可以推测太阳黑子活动应该跟银河系中心发射过来的引力波有很大的关系。引力波作为一种波，存在波峰和波谷，还存在极化方向。这意味着能量在传递的过程中，在一个周期内就会出现能量的峰值和低谷的情况。当引力波能量峰值传递过来的时候，导致太阳表面磁流体动力学结构出现变化，进而引发太阳表面等离子体气体的扰动，导致出现太阳黑子爆发的现象。而当一个周期的能量峰值过去之后，这种扰动变小，太阳黑子爆发又开始趋于平静，等待下一个能量峰值的到来。

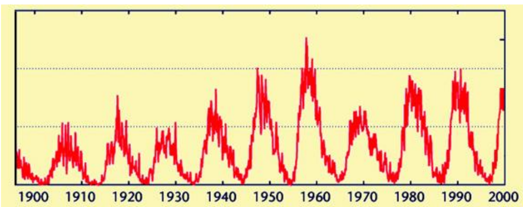

图 4 太阳黑子爆发的周期（来源：https://stereo.gsfc.nasa.gov）

图 4 显示了太阳黑子一百多年来爆发的周期性。从该图可以看出太阳黑子爆发除了 11 年为一个周期之外，似乎每 60 多年还存在一个幅度变化的更大的周期。这种周期性的形状非常类似于一个包含了多个谐波的振荡波。这种波形很难单纯从太阳内部流体力学结构的变化来进行解释。这是因为要产生固定的周期性振荡，一定要有边界约束条件的存在。比如地球上河流和海洋的边界等。然而在太阳上除了引力，我们还找不到可以约束 MHD 振荡波的边界条件存在。

7 总结

运用虚时空的假设，令我们现在的宇宙变成了一个开放的系统，这也为我们现在的宇宙物质和能量的流动提供了理论依据。这是因为如果是一个封闭的系统，则该系统最终会演化成熵最大的平衡态。在这种平衡态中，所有的物质流动也将停止。而在将宇宙作为一个开放系统来进行处理之后，我们就可以发现宇宙可以在气态和液态两种状态中来回转换，形成非常丰富的独特的宇宙流体动力学状态。通过本文的分析，我们发现宇宙的液态模型能够很好地说明微波背景辐射和宇宙射线的来源，与实际观察结果符合的非常好。

当物质和能量能够流动起来，就意味着能够形成丰富多样的流体动力学结构，并产生物质和波的相互作用。这就如同水和水中传递的声波相互作用一样。在宇宙中传递的是引力波。宇宙中引力波的传播存在很多类似声波和电磁波的特性。由于引力波的能量非常大，因此当引力波与星系物质相互作用的时候，将产生很多我们能够观察到的独特的现象。这些现象很难用现有的理论来进行解释。本文举出了一个太阳黑子爆发的周期性规律，就可能是由银河系中心发射过来的引力波所引起的。估算的结果表明，银河系中心质量所产生的引力波的周期与太阳黑子爆发周期在数量级上是一致的。由于目前还不清楚太阳黑子爆发为何会具备这样强烈的周期性，引力波引发太阳黑子爆发的解释是非常有启发性的。

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