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The Secret of Gravitational Wave in Galactic Environment

Cui-xiang Zhong

Department of Physics, Jiangxi Normal University, Nanchang 330000, China

Abstract: Einstein put forward the general theory of relativity in 1915 and predicted the existence of gravitational waves the following year. He pointed out that when two objects (such as planets or stars) revolve around each other, gravitational waves are generated because the accelerating moving objects disturb the surrounding space-time. However, due to the weak interaction between gravitational waves, Einstein predicted that human beings might not be able to detect gravitational waves. But, since the 1960s, scientists have been detecting gravitational waves. In 2015, LIGO (Laser Interferometer Gravitational-Wave Observatory) detected gravitational wave signals almost simultaneously with two detectors and officially announced this discovery in 2016, which directly verified Einstein's general theory of relativity's prediction about gravitational waves and made astronomy enter a new era of gravitational wave physics. In recent years, gravitational wave detection has entered the era of accurate detection from the era of discovery. For example, in early 202**5**, scientists carefully analyzed the clearest gravitational wave signal 250114 so far, and identified three independent "tones" in the "ringing stage" after the merger of black holes for the first time, which provided the first evidence for testing Einstein's theory in a strong gravitational field environment. However, the gravitational wave signal they obtained was not the result of the merger of black holes. To understand the essence of gravitational waves and its generation mechanism, we must first understand the formation and evolution process of galaxies.

Key words: Galactic environment, gravitational wave, gravitational wave signal, gravitational wave astrophysics.

1. Introduction

In 1915, Einstein proposed the theory of general relativity and in 1916 predicted the existence of gravitational waves. He pointed out that when two objects—such as planets or stars—orbit each other, their accelerated motion disturbs the surrounding space-time, creating "ripples"—gravitational waves. However, since these waves travel at the speed of light and gravitational interactions are extremely weak, Einstein himself once stated that humans might never be able to detect them. However, since the 1960s, scientists have been attempting to detect gravitational waves. In particular, after the upgrade of the U.S.-based LIGO (Laser Interferometer Gravitational-Wave Observatory) to Advanced LIGO in 2015, its detection sensitivity increased significantly, laying the foundation for the eventual successful detection of gravitational waves. On September 14, 2015, LIGO detected gravitational wave signals almost simultaneously with its two detectors located in Hanford, Washington (H1), and Livingston, Louisiana (L1). After several months of rigorous analysis and verification, the LIGO Collaboration officially announced this discovery on February 11, 2016. This breakthrough discovery directly verified Einstein's century-old prediction of the existence of gravitational waves in general relativity, and also confirmed the existence of black holes for the first time. It marks the beginning of the era of gravitational wave astronomy, opens a brand-new window for human beings to explore the universe, and makes astronomy enter a new era of gravitational wave astrophysics [1].

In recent years, gravitational wave detection has entered the era of accurate inspection from the era of

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Corresponding author: Cui-xiang Zhong, doctor, associate professor, research fields: astronomy. E-mail: cuixiang_zhong@163.com.

discovery. At the beginning of 202**5**, scientists carefully analyzed the clearest gravitational wave signal GW250114 so far, and identified three independent "tones" in the "ringing stage" after the merger of black holes for the first time. Their frequencies and decay times are perfectly consistent with the predictions of general relativity, providing unprecedented evidence for testing Einstein's theory in a strong gravitational field environment [2]. In fact, the gravitational wave signal they obtained is not the result of the merger of black holes. To understand the essence of gravitational waves and its generation mechanism, we must first understand the formation and evolution process of galaxies.

2. Formation and Evolution of Galaxies

2.1 The Formation and Evolution of Single Star

Since binary stars are composed of single stars, when studying the formation and evolution of binary stars, one should start with the study of the formation and evolution of single star.

It is well known that the formation of a star generally undergoes an evolution process from a satellite to a planet and then to a star. After a proto-star evolved from a very small satellite in both volume and mass into an earth-sized planet, it produced some of its moons, but it still revolved around its parent star, unceasingly accreted the nebula materials near the orbits to become larger and larger, and gradually moved away from its parent star with the frequent collisions of planetesimals or the accelerlating rotation of its parent star due to contraction. Afterwards it met a series of impacts from some other planets running into it from behind, making it become a Jupiter-sized planet much farther away from its parent [3]. Due to the large mass of this kind of giant, it can attract various gas molecules, forming a thick atmosphere. During its rotation, it generates powerful polar vortex. This polar vortex can continuously absorb hydrogen and other nebular matter from the surrounding space to the protostar, and can also eject some matter outward. During the process of a planet orbiting a protostar, the planet crossing the poles can pull a huge cloud over the top of the polar vortex. When this cloud is drawn into the polar vortex, it will be greatly compressed, but the angular momentum of the protostar remains unchanged. This will accelerate the rotation of the protostar, thereby gradually moving the planet away from the protostar.

The central depth of such polar vortices can reach over 100,000 kilometers, and their diameters can range from several thousand to tens of thousands of kilometers. As plasma clouds swept in by a vortex of the proto-star sink faster and colder, after a long spiral path, at the bottom of the vortex, the velocity of the airflow is tens of times faster than that of scale 12 typhoon, so the cloud clusters have already condensed into ice, and the temperature in the vortex is much lower than that around it; hence from the distant place, the vortex looks like a small sunspot.

Since the clouds involved in a vortex are continuous and rotate downward rapidly in a spiral manner, a series of thick spiral cloud belts can be formed. In this kind of plasma cloud belts, the negative ions that get electrons are heavier than the positive ions that lose electrons, and then move down to the lower part of the cloud or even down to the bottom of the vortex along the spiral cloud belt. The lighter positive ions are gradually carried up to the upper part of the cloud or even up to the top of the vortex along the spiral cloud belt by the updraft, thus forming a current from the bottom of the vortex to the top of the vortex in the spiral cloud belt, and also forming a powerful dipole magnetic field, as is shown in Fig. 1.

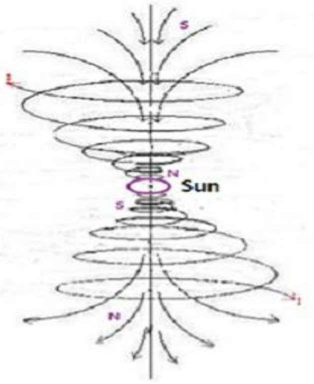

Fig. 1 Magnetic field of vortex.

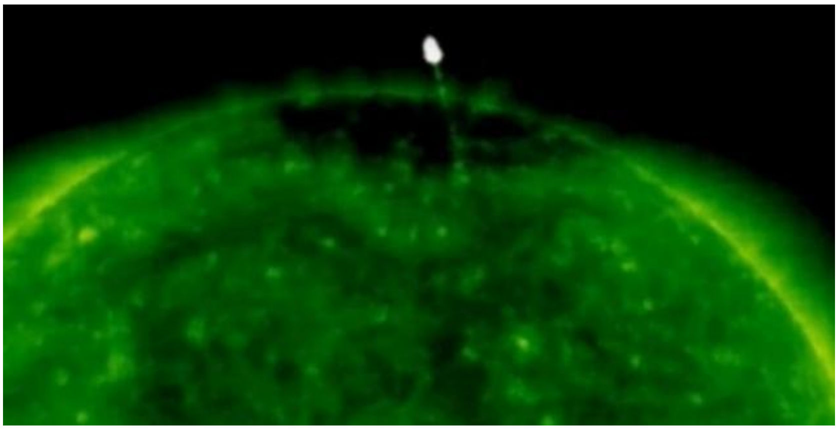

Fig. 2 An earth-sized object flew out of a sunspot region.

In addition, because the polar vortex of a star covers a vast and deep atmospheric space, they can draw in a large number of cloud masses. These cloud masses are gradually compressed during their sinking process, becoming increasingly thick and massive. As they travel along long spiral paths, they are prone to intense friction and collisions, frequently generating strong lightning, causing the surrounding air temperature to rapidly rise to tens of thousands of degrees and the atmospheric pressure to increase to millions of atmospheres. As a result, much of the gaseous hydrogen in the vortex transforms into liquid metallic hydrogen. This liquid metallic hydrogen and liquid hydrogen are mixed together and gradually cooled as they rapidly sink along a spiral path. By the time they reach the bottom of the vortex, they condense into a series of huge crystals, which contain solid metallic hydrogen and solid hydrogen. For instance, on May 23, 2019, astronomer Nassim Haramin discovered a white unidentified object flying out of the North Pole sunspot region of the Sun in the photos sent back by the SOHO (Solar and Heliospheric Observatory). This crystalline object was about the size of the Earth, as shown in Fig. 2.

It is known that the internal temperature of Jupiter reaches 30,000 degrees Celsius and the internal pressure is over 40 million atmospheres. However, the volume and mass of a brown dwarf about to become a star are comparable to those of the Sun, and its volume and mass are more than 1,000 times that of Jupiter. Therefore, the internal temperature of such a brown dwarf can reach 30 million degrees Celsius (>15 million degrees). The internal pressure should be above 40 billion atmospheres. When huge metallic hydrogen crystals collide in the atmospheric vortex of a brown dwarf, the nearby pressure can increase tenfold, exceeding 300 billion atmospheres. Therefore, it can ignite the thermonuclear reaction of hydrogen polymerization into helium in a sunspot cyclone and trigger a series of thermonuclear reactions beside the cyclone:

$${}^{2}_{1}\mathrm{H}+{}^{3}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He}+{}^{1}_{0}\mathrm{n}\ \mathbf{+17.6Mev}$$

When a thermonuclear reaction occurs, a large amount of energy is released in a short period of time, causing a violent explosion of metallic hydrogen and generating various electromagnetic radiations. The violent explosion of metallic hydrogen crystals can also produce burning debris shot in all directions, causing a rapidly intensifying bright spot to suddenly appear beside the sunspot. This is what is called a stellar flare. Therefore, flares indicate the outbreak of thermonuclear reactions in a star. The violent explosions that occur during this period may alter the structure of the sunspot cyclone or cause it to contract and decline.

In general, the formation and disappearance of a sunspot can only take a few days to a few months, and it can only attract a limited range of hydrogen gas; the hydrogen beyond this scope cannot be processed. So if there are no sunspot cyclones or no successor sunspot cyclones to take over its work, thermonuclear reactions on the star will stop. Fortunately, a star usually has multiple planets (such as Mercury, Venus, Earth, etc.) close to the star and orbiting at high speeds to pull nebular material to add thermonuclear fuel to these fading sunspot cyclones, so that the thermonuclear reactions in these sunspot cyclones can continue.

In addition, a giant planet like Jupiter exerts a greater universal gravitation on the polar cyclones of the Sun; when it approaches the cyclones at the Sun's poles, it can, through the effect of universal gravitation, cause the polar cyclones to tilt, stretch, shear or break, and even drag out some sub-cyclones, distributing them onto the surface of the Sun. When a sub-cyclone has absorbed sufficient airflow to become a long, large and heat-resistant cyclone, it will extend from the upper level to the lower level and become a mature and powerful sunspot, continuing the thermonuclear reaction of the preceding sunspot.

Table 1 shows the ratio of the gravitation of the major planets of the solar system on the objects on the surface of the sun as well as the revolution periods of these planets. It can be seen that Jupiter has the strongest gravitation on objects on the surface of the sun, while other planets have a much smaller gravitational pull on objects on the surface of the Sun.

Table 1 The ratio of the gravitation of the major planets of the solar system on the object on the surface of the sun as well as the revolution periods of these planets.

Planet	Mass	Average distance from the sun	Ratio of planet's gravitation relative to Mercury's gravitation	Revolution periods (Solar rotation period = 25.05 d)
Mercury	3.3022×10^{23} kg	57,909,050 km	1	87.9691 d
Venus	4.8690×10^{24} kg	108,209,184 km	0.42228	224.7 d
Earth	5.9650×10^{24} kg	149,597,888 km	2.70684	365.24 d
Mars	6.4219×10^{23} kg	227,925,000 km	0.12554	686.980 d
Jupiter	1.9000×10^{27} kg	778,547,050 km	31.8327	11.8618 yr
Saturn	5.6834×10^{26} kg	1,429,400,000 km	2.850523	29.5 yr
Uranus	8.6810×10^{25} kg	2,871,000,000 km	0.169529	84 yr
Neptune	1.024×10^{26} kg	4,504,000,000 km	0.512647	164.8 yr

Table 2 The ratio of the gravitational force exerted by Jupiter's moons on objects on Jupiter's surface to that exerted by Mercury on objects on the Sun's surface.

Moons of Jupiter	Distance to Jupiter	Quality	The ratio of gravity of Jupiter's satellites relative to that of Mercury
IO	422,000 km	8.94×10^{22} kg	5,096.61
Europa	671,000 km	4.80×10^{22} kg	1,082.68
Ganymede	1,070,000 km	1.48×10^{23} kg	1,314.48
Callisto	1,883,000 km	1.08×10^{23} kg	310.33
Amalthea	181,000 km	2.08×10^{18} kg	0.0645

Table 3 Shows the ratio of the gravitational force exerted by Jupiter's moons after moving 9.6 million kilometers outward from their current positions on objects on the surface of Jupiter to that exerted by Mercury on objects on the surface of the Sun.

Moons of Jupiter	Distance to Jupiter	Quality	The ratio of gravity of Jupitrer's satellites relative to that of Mercury
IO	10,020,000 km	1.788×10^{23} kg	3.129
Europa	10,271,000 km	9.60×10^{22} kg	9.247
Ganymede	10,670,000 km	4.44×10^{23} kg	39.6297
Callisto	11,483,000 km	3.24×10^{23} kg	24.9538
Amalthea	9,781,000 km	5.16×10^{18} kg	0.00055

In fact, we can even more clearly compare the effects of Jupiter and other planets on sunspots. We know that Jupiter's perihelion distance is $R_{\mathrm{n}} = 7.4052 \times 10^{8}\,km$, Jupiter's aphelion distance is $R_{\mathrm{f}} = 8.1662 \times 10^{8}\,km$, and Jupiter has a mass $M_{\mathrm{J}} = 1.900 \times 10^{27}\,kg$; therefore Jupiter at perihelion has a gravitational pull on an object of mass m on the Sun as $F_n = \mathrm{G}\dfrac{M_J m}{R_n^2}$, and Jupiter at aphelion has a gravitational pull on an object of mass m on the Sun as $F_f = \mathrm{G}\dfrac{M_J m}{R_f^2}$.

Assume that Mercury has a mass of $M_{\mathrm{w}}(M_{\mathrm{w}} = 3.3022 \times 10^{23}\,kg)$, Mercury's distance from the sun is $R_{\mathrm{w}}(=57910000\,km)$, and Mercury's gravitational pull on an object of mass m on the Sun is F_{w}, and then $F_{\mathrm{w}} = \mathrm{G}\dfrac{M_{\mathrm{w}} m}{R_{\mathrm{w}}^2}$; therefore

$$\frac{F_{\mathrm{n}}}{F_{\mathrm{w}}} = \frac{M_{\mathrm{J}}}{M_{\mathrm{w}}} \Box \frac{R_{\mathrm{w}}^2}{R_{\mathrm{n}}^2} \approx 35.19, \qquad \frac{F_{\mathrm{f}}}{F_{\mathrm{w}}} = \frac{M_{\mathrm{J}}}{M_{\mathrm{w}}} \Box \frac{R_{\mathrm{w}}^2}{R_{\mathrm{f}}^2} \approx 28.93$$

It can be seen that whether Jupiter is at perihelion or aphelion, it exerts a greater force on any object on the Sun (including polar cyclones) than other planets orbiting the Sun exert on that object, so Jupiter is the main planet that attracts solar polar cyclones and produces sunspots. This is true because sunspots have an activity cycle of about 11 years, which is about the same as Jupiter's orbital period around the sun. More detailed observations show that in each sunspot cycle, the number of spots starts in the year with the lowest number, increases in the following three to five years, reaches a peak, and then decreases to a minimum in the following five to seven years. It can be seen that when Jupiter is at perihelion, the most sunspots are generated, while at aphelion, the least sunspots are generated, and almost no sunspots are generated. Because planets other than Jupiter exert much less force on the solar polar cyclones than Jupiter at aphelion does on the solar polar cyclones, these planets cannot extract sunspots from the polar cyclones.

It can be seen that it is Jupiter that brings out the sunspots all over the Sun from the solar polar vortex. Then, Mercury, Venus and Earth, which are close to the Sun and orbit at a fast speed, pull nebulae material to the sunspot cyclones near the orbit, adding fuel to the thermonuclear reaction in the sunspot cyclones, so that the thermonuclear reaction in the sunspot cyclones can continue. This is the main sequence phase of a star, which lasts a long time [4].

However, the current perihelion distance of Jupiter is 741 million kilometers, and it is not yet a star. Some experts speculate that only when the mass of a giant star reaches 70 to 80 times that of Jupiter does it have sufficient gravity, pressure and temperature to cause fusion reactions between hydrogen elements and form a star. In fact, this speculation is not accurate. At a latitude of 20° in the southern hemisphere of Jupiter, there is a "Great Red Spot", which is a continuously rotating huge cyclone. Its internal temperature is hundreds of degrees Celsius higher than that of the surrounding atmosphere, indicating that nuclear fusion reactions have occurred inside the cyclone. However, due to being alone and weak, it failed to trigger a global thermonuclear reaction on Jupiter.

Why does such a huge Jupiter have only one heating cyclone? This is because Jupiter has over 60 moons, among which four have a significant gravitational pull on the cyclones on Jupiter, including IO, Europa, Ganymede and Callisto, as shown in Table 2 above. When a satellite drags out a sub-cyclone from Jupiter's polar cyclones, the other large satellites all exert significant gravitational forces on this sub-cyclone, thus easily tearing it apart. It can be seen that the probability of a Jupiter satellite dragging out a surviving sub-cyclone from Jupiter's polar cyclones is very small, and only one "Great Red Spot" sub-cyclone remains after 300 years.

For Jupiter to be covered by cyclones like the Great Red Spot, its large moons must be far enough away from the planet. For instance, when IO, Europa, Ganymede and Callisto move 9.6 million kilometers outward from their current positions, the gravitational forces they exert on objects on Jupiter's surface are shown in Table 3. Among them, the ratio of the gravitational pull of Ganymede on objects on the surface of Jupiter to that of Mercury on objects on the surface of the Sun is 39.6297. This indicates that Jupiter's gravitational pull on objects on the Sun's surface when Jupiter is at perihelion is less than Ganymede's gravitational pull on objects on Jupiter's surface. Thus, Ganymede can draw child cyclones from Jupiter's polar cyclones to the vicinity of Jupiter's equator, forming cyclones such as the "Great Red Spot". The ratio of the gravitational pull of IO, Europa and Callisto on objects on the surface of Jupiter to that of Mercury on objects on the surface of the Sun is less than 28.93, indicating that the gravitational pull of Jupiter on objects on the surface of the Sun when Jupiter is at its aphelion is greater than that of IO, Europa and Callisto on objects on the surface of Jupiter. Therefore, these Jupiter moons can only pull nebular matter to add fuel needed for thermonuclear reactions to the "Great Red Spot" cyclone near its orbit, making Jupiter a dwarf nova.

In fact, it won't be difficult for IO, Europa, Ganymede and Callisto to move 9.6 million kilometers outward from their current orbital positions. Given that the masses of two planets are m_1, m_2 ($m_1 > m_2$), and the distance between them is l; the formula for the centrifugal force of one planet orbiting the other is

$$F = G \cdot m_1 \cdot m_2 / l^2 \ (G = 6.674\times10^{-11}) \qquad (1)$$

According to the above formula, it can be proved that when Jupiter (with a mass of m_J) rotates around the Sun (with a mass of m_S), assuming the distance between Jupiter and the Sun is l_1 and the centrifugal force generated by the Sun's rotation on Jupiter is F_1, then the centrifugal force generated by the Sun's rotation per kilogram of mass on Jupiter is

$$F_1 / m_J = G \cdot m_S / l_1^2 = 1.989\times10^{30}\ G / l_1^2 = 1.3274586\times10^{20} / l_1^2 \qquad (2)$$

When a Jupiter satellite (with a mass of m_{JS}) orbits Jupiter again, assuming the distance between the Jupiter satellite and Jupiter is l_2 and the centrifugal force generated by Jupiter's rotation on the Jupiter satellite is F2, then the centrifugal force exerted by Jupiter's rotation per kilogram of mass on a Jupiter moon is

$$F_2 / m_{JS} = G \cdot m_J / l_2^2 = 1.8982\times10^{27}\ G / l_2^2 = 1.26685868\times10^{17} / l_2^2 \qquad (3)$$

According to Equation (2), the centrifugal force per kilogram of mass exerted by the Sun's rotation on Jupiter when it is at perihelion can be calculated:

$$F_1 / m_J = 1.3274586\times10^{20} / (7.41\times10^{8})^2 \approx 0.241176\times10^{3}\ \mathrm{N} \qquad (4)$$

According to Equation (3), it can be calculated that when the four moons of Jupiter move 9,600,000 km outward from their current positions, the centrifugal force per kilogram of mass on them generated by Jupiter's rotation is

$$F_{21} / m_{JS} = 1.26685868\times10^{17} / (10020000)^2 \approx 1.2618\times10^{3}\ \mathrm{N} > F_1 / m_J \qquad (5)$$

$$F_{22} / m_{JS} = 1.26685868\times10^{17} / (10271000)^2 \approx 1.2011\times10^{3}\ \mathrm{N} > F_1 / m_J \qquad (6)$$

$$F_{23} / m_{JS} = 1.26685868\times10^{17} / (10670000)^2 \approx 1.1127\times10^{3}\ \mathrm{N} > F_1 / m_J \qquad (7)$$

$$F_{24} / m_{JS} = 1.26685868\times10^{17} / (11483000)^2 \approx 0.9607\times10^{3}\ \mathrm{N} > F_1 / m_J \qquad (8)$$

It can be seen that during the 9,600,000 km outward movement of IO, Europa, Ganymede and Callisto from their current positions, the centrifugal force generated by Jupiter's rotation per kilogram of mass on each of them is greater than that generated by the Sun's rotation per kilogram of mass on Jupiter as it moves from its current perihelion to a more distant perihelion. So, without waiting for Jupiter to move 9,600,000 km from its current perihelion to a more distant perihelion, IO, Europa, Ganymede and Callisto would be able to move more than 9,600,000 km outward from their current orbital positions, thus transforming Jupiter into a new dwarf star with a surrounding area capable of initiating thermonuclear reactions.

2.2 The Formation and Evolution Law of General Binary Stars

There are a large number of binary stars in the universe's starry sky, but some stars have no companion stars yet. This is because these star systems are still very young. With the ongoing thermonuclear reactions on a star, star burst activities occur frequently. The star constantly ejects flare fragments and coronal matter into space. These ejected substances are absorbed by the planets and satellites in the star system. Therefore, there is a Jovian planet. It has the greatest attraction for the matter ejected by the star, thus becoming a bigger planet in the star system. It is precisely this Jovian planet that can exert a significant force on the star's polar vortices. When it approaches the star, it can pull out sunspot cyclones from the polar cyclones of the star through the effect of universal gravitation, distributing them onto the star. Then, these sunspot cyclones wait for the planets of the star to draw nebular matter to add fuel to their thermonuclear reactions, allowing their thermonuclear reactions to continue. As the huge cloud masses drew by the planets to the sunspot cyclones are greatly compressed, the rotational speed of the star keeps increasing. Under the effect of the centrifugal force generated by the star's rotation, the orbits of its planets expand outward, and especially the perihelion distance of the Jovian planet also increases. However, without waiting for the perihelion distance of Jovian planet to expand to the current aphelion distance, the satellites of the Jovian planet can move an appropriate distance, turning the Jovian planet into a new dwarf star around which thermonuclear reactions can be initiated. As the orbits of the planets expand outward, they bring less and less hydrogen to the sunspot cyclones.

As the perihelion distance of the Jovian planet increases, the number of sunspot cyclones it drags out from the polar cyclones of the star decreases; additionally, as the planetary orbits of the star expand outward, these planets bring less and less hydrogen to sunspot cyclones, making it increasingly difficult for the star to absorb sufficient hydrogen to maintain its thermonuclear reactions. In addition, when the Jovian planet becomes a new dwarf star, it needs to use sunspot cyclones to carry out thermonuclear reactions too and needs to seize hydrogen resources in the space where the solar system is located. When the star fails to absorb sufficient hydrogen to sustain the thermonuclear reactions within it, the balance between the radiation pressure of nuclear fusion and its own contracting gravitational force is disrupted. The helium nuclei inside the star contract and become hot, while the hydrogen shell expands outward and cools. As the helium core inside the star contracts, its rotation accelerates, and the hydrogen shell is forced to drift outward by centrifugal force, causing the star to expand into a red giant [5]. This stage may last for millions of years. The volume of a red giant can be several times or even hundreds of times that of the star. As the red giant expands, its rotation gradually slows down, causing the centrifugal force acting on the new dwarf star orbiting the red giant to gradually decrease. Thus, the new dwarf star gradually approaches the red giant again. When it enters the envelope of the red giant, because its mass is much smaller than that of the red giant, during its rotation around the core of the red giant, its outer hydrogen will be attracted to the outer hydrogen of the red giant, which will be integrated into their common cladding, thus making the common cladding thicker and larger.

In addition, as the star orbits its central black hole, when a binary star with a common envelope approaches this massive black hole, due to the excessive pull of tidal forces [6], the common envelope of the binary star will be torn apart. These torn envelopes by the black hole leave the binary star at a high speed, resulting in a loss of angular momentum. Eventually, the binary star with a common envelope contracts into a White Dwarf and a hot subdwarf, as shown in Fig. 3. As the White Dwarf further contracts, the hot subdwarf gradually moves away from the White Dwarf.

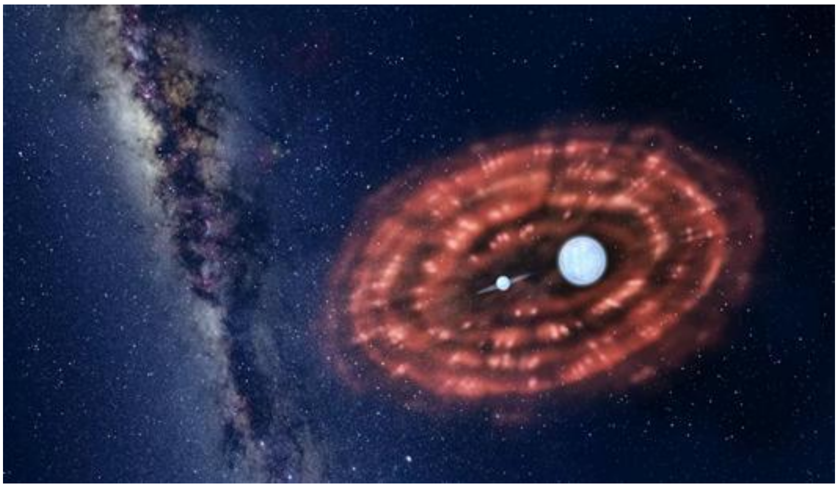

Fig. 3 The evolution process of the common-envelope of binary stars.

2.3 Several Other Forms of Stellar Evolution in Their Later Years

2.3.1 Black Dwarf

When a red giant star contracts into a White Dwarf and the hot subdwarf star formed by the contraction of a dwarf nova is also far enough from the White Dwarf, the hot subdwarf cannot spread a sunspot cyclone on the White Dwarf through the effect of universal gravitation. Beyond the poles of the White Dwarf, it cannot undergo the glowing and heating reactions of hydrogen fusion or helium fusion. Thus, it becomes a “black dwarf”. When the cyclones at both ends of the rotation axis of a “black dwarf” are not facing the Earth, people hardly see the light emitted by the black dwarf. However, since the black dwarf is still constantly rotating and the cyclones at both ends of its rotation axis will definitely emit light, a black dwarf that does not emit light absolutely does not exist.

2.3.2 Neutron Star

After a main sequence star evolves into a black dwarf, its mass increases significantly compared to the mass of the main sequence star, its atmosphere also thickens significantly, but its volume is greatly reduced, even smaller than the Moon, so its rotation speed is greatly accelerated, and the polar cyclones are greatly enhanced. It grows larger by constantly accreting nebular material near its orbit and satellites or planets in sub-galaxies that enter its gravitational horizon. In addition, as the black dwarf still has outer planets carrying sub-galaxies orbiting around it, during its rotation around its central axis, it continuously absorbs the clouds pulled by its sub-galaxies through its powerful polar cyclones. These clouds can be compressed into huge metallic hydrogen crystals at the bottom of the cyclones; when such huge metallic hydrogen crystals collide violently with the surface of a star, they not only directly exert tremendous pressure on the star’s surface but also cause a violent explosion, adding even greater pressure. This may even trigger thermonuclear reactions or supernova explosions, leading to the collapse of the star and causing significant changes in its material structure. In this case, not only the outer shell of the atom is crushed, but also the nucleus of the atom is crushed, and the protons and neutrons in the nucleus are forced out, and the protons and electrons are pushed together and combined to form neutrons. Eventually, all the neutrons are squeezed together to form a neutron star [7].

When the star shrinks into a neutron star, its size is greatly reduced and its rotation is greatly accelerated, which greatly enhances the dipole magnetic field generated by the cyclone at the poles of the neutron star, making people think that the neutron star is a very strong magnet. Neutron stars emit electromagnetic waves through the polar cyclones, but under the gravitational action of the outer planets of the neutron star and their child galaxies, the polar cyclones of the star will deviate from the star's spin axis and rotate along an elliptical trajectory during the star's rotation. Therefore, when a cyclone that emits electromagnetic waves is facing the Earth, the Earth people can receive electromagnetic waves; when the polar vortex of the star deviates from the Earth, the Earth does not receive electromagnetic waves. Therefore, the electromagnetic waves received by the Earth are intermittent, resulting in the "lighthouse effect", and thus neutron stars are called "cosmic lighthouses".

2.3.3 Black Hole and Quasar

During the evolution of a neutron star into a more massive giant, its polar cyclones continuously absorb nebular material near its orbit and the satellites or planets in its child galaxies that enter its gravitational horizon, increasing its mass; eventually it becomes a black hole or even a quasar [8-10].

2.4 Gravitational Waves in a Galaxy Environment

According to Newton's law of universal gravitation and Kepler's law of planetary motion, the orbits of celestial bodies are generally elliptical, and when two orbiting planets move along their respective elliptical orbits, the acceleration of their circular motion points to different centers, so it is impossible to linearly add the accelerations in these two different directions; the objects that produce gravitational wave must be other objects in the process of planetary motion.

2.4.1 Gravitational Waves during the Evolution of Binary Stars

According to the discussion in Section 2.2, the result of general binary evolution will produce a binary system with common cladding, including a white dwarf star contracted by a star and a thermal sub-dwarf star contracted by a companion star. Because the rotation speed of the white dwarf is significantly faster than that of the original star, the rotation speed of the thermal sub-dwarf is also significantly faster than that of the original companion star, and the mass of the white dwarf and the thermal sub-dwarf are still very large. For example, in February, 2024, the team of Professor Wang Xiaofeng from the Department of Physics of Tsinghua University first observed a binary system (code TMTS J0526) which is about 2,760 light years away from the Earth and rapidly orbits the period of revolution in 20.5 minutes. The mass of the white dwarf is about 0.74 times that of the sun, and that of the thermal sub-dwarf is about 0.33 times that of the sun [11]. Because there are some persistent interstellar substances (including many gases and dust) around white dwarfs and thermal sub-dwarfs during the evolution of binary stars, and the massive white dwarfs and thermal sub-dwarfs have strong attraction to these interstellar substances, with the rapid rotation of white dwarfs and thermal sub-dwarfs, strong polar atmospheric vortices will be formed at their poles, thus forming a strong dipole magnetic field at their poles, as shown in Fig. 4 below.

Due to the high-speed rotation of the thermal sub-dwarf around the white dwarf, the thermal sub-dwarf is sometimes below and sometimes above the white dwarf. When the thermal sub-dwarf is below the white dwarf, the polarity of the dipole magnetic field generated by the Antarctic cyclone of the white dwarf is opposite to that generated by the arctic cyclone of the thermal sub-dwarf. Therefore, when the Antarctic cyclone of the white dwarf approaches the arctic cyclone of the

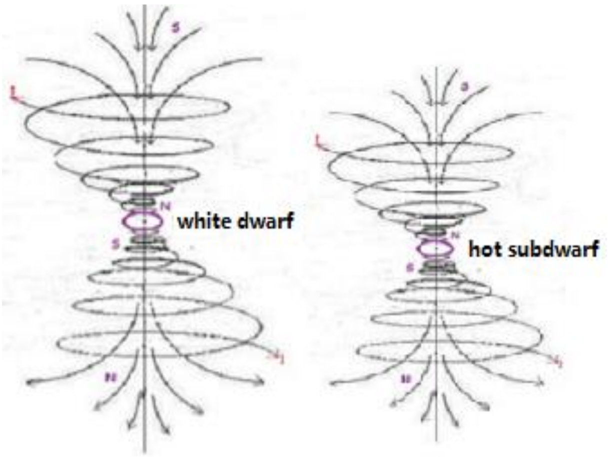

Fig. 4 Dipole magnetic fields generated by high-speed rotating white dwarfs and thermal sub-dwarfs.

thermal sub-dwarf, they will attract each other, so that both the Antarctic cyclone of the white dwarf and the arctic cyclone of the thermal sub-dwarf will be stretched, and the interstellar matter absorbed by the Antarctic cyclone of the white dwarf and the arctic cyclone of the thermal sub-dwarf will increase, thus making the Antarctic magnetic field of the white dwarf and the arctic magnetic field of the thermal sub-dwarf more attractive, which will produce gravitational waves. Similarly, when the thermal sub-dwarf is above the white dwarf and meanwhile the Antarctic cyclone of the thermal sub-dwarf approaches the arctic cyclone of the white dwarf, gravitational waves will also be produced.

2.4.2 Gravitational Waves Generated by the Rotation of White Dwarf around Neutron Star

According to the discussion in Section 2.3.2, white dwarfs can further evolve into neutron stars, and astronomical observations also show that white dwarf rotates around neutron star widely in cosmic galaxies. For example, there is a binary star system labeled 4U 1820-30 in the Milky Way [12], in which the rotation speed of a neutron star reaches 716 revolutions per second, and the other companion star is a white dwarf with a mass similar to that of the Earth, and the shortest orbital period of the white dwarf around the neutron star is 11 minutes.

Because the lower mass limit of neutron stars is 1.43 times the mass of the sun, and the mass of white dwarfs is between 0.12 and 1.44 times the mass of the sun, these massive neutron stars and white dwarfs have a strong attraction to the surrounding interstellar matter. With the rapid rotation of neutron star and white dwarf, powerful polar cyclones will be formed at their poles, thus forming a strong dipole magnetic field at their poles, as shown in Fig. 5 below. In addition, if a white dwarf revolves around a neutron star, then the neutron star has strong attraction to the white dwarf and the interstellar matter near the white dwarf, so the neutron star has a polar cyclone reaching the vicinity of white dwarf.

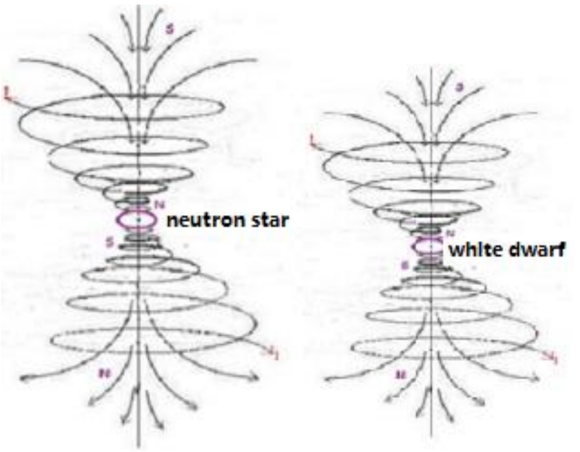

Fig. 5 Dipole magnetic fields generated by rapidly rotating neutron star and white dwarf.

Because a white dwarf revolves around a neutron star at high speed, it is sometimes under the neutron star and sometimes above it. When the white dwarf revolves below the neutron star, the dipole magnetic field generated by the Antarctic cyclone of the neutron star is opposite in polarity to that generated by the Arctic cyclone of the white dwarf. Therefore, when the neutron star’s Antarctic cyclone approaches the white dwarf’s Arctic cyclone, they will attract each other, so that the neutron star’s Antarctic cyclone and the white dwarf’s Arctic cyclone will be stretched, and the neutron star’s Antarctic cyclone and the white dwarf’s Arctic cyclone will suck in more interstellar matter, thus enhancing the attraction of the neutron star’s Antarctic magnetic field and the white dwarf’s Arctic magnetic field, and generating gravitational waves. Similarly, when the white dwarf revolves above the neutron star, the polarity of the dipole magnetic field generated by the white dwarf’s Antarctic cyclone is opposite to that generated by the neutron star’s Arctic cyclone. Therefore, when the white dwarf’s Antarctic cyclone approaches the neutron star’s Arctic cyclone, they will attract each other, so that the white dwarf’s Antarctic cyclone and the neutron star’s Arctic cyclone will be stretched, and the white dwarf’s Antarctic cyclone and the neutron star’s Arctic cyclone will absorb more interstellar matter, thus accelerating the attraction of the white dwarf’s Antarctic magnetic field and the neutron star's Arctic magnetic field, and generating gravitational waves.

When a white dwarf rotating around a neutron star evolves into another neutron star, then the system becomes a new one consisting of a neutron star rotates around another neutron star. According to the principle described in the above two sections, this new system can also produce gravitational waves. For example, a gravitational wave discovered by the LIGO project team is the result of two cyclones with different magnetism from a double neutron star about 130 million light-years away from the Earth.

2.4.3 Gravitational Waves Generated by the Rotation of a Black Hole around Another

There is also an example of a black hole spinning around another black hole in the vast cosmic sky. For example, in the center of the galaxy MCG-03-34-64, which is about 800 million light-years away from the Earth, astronomers discovered a double black hole system that is only 300 light-years away, and they rotate around each other at a very low speed (about 30,000 years) [13]. Because of their great mass, black holes have a strong attraction to the surrounding interstellar matter, so with the rapid rotation of double black holes, strong atmospheric vortices will be formed at their poles and strong dipole magnetic fields will be formed consequently at their poles, as shown in Fig. 6 below.

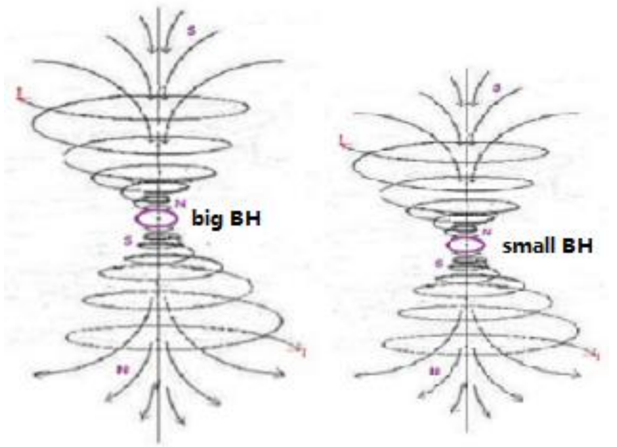

Fig. 6 The dipole magnetic field generated by a binary black hole system.

Because the small black hole revolves around the big black hole, the small black hole is sometimes under the big black hole and sometimes above the big black hole. When the small black hole orbits below the big black hole, the dipole magnetic field generated by the Antarctic cyclone of the big black hole is opposite to that generated by the Arctic cyclone of the small black hole, so when the Antarctic cyclone of the big black hole approaches the Arctic cyclone of the small black hole, they will attract each other. For example, the gravitational wave event GW231123 detected by LVK (LIGO-Virgo-KAGRA) on November 23rd, 2023, as shown in Fig. 7, is supposed to be caused by the merger of two primitive black holes whose mass is 100 times and 140 times that of the sun, but it is impossible for two black holes so far apart to merge for no reason. In fact, Fig. 7 shows the result that two cyclones with opposite magnetic fields of these two black holes approach each other due to mutual attraction. It is the attraction of two cyclones with opposite magnetism between these two black holes that makes them close together, thus stretching the Antarctic cyclone of the big black hole and the Arctic cyclone of the small black hole, and increasing the interstellar matter inhaled by the Antarctic cyclone of the big black hole and the Arctic cyclone of the small black hole, thus accelerating the attraction of the Antarctic magnetic field of the big black hole and the Arctic magnetic field of the small black hole, and thus generating gravitational waves. Similarly, when a small black hole orbits above a big black hole, the polarity of the dipole magnetic field generated by the Antarctic cyclone of the small black hole is opposite to that of the arctic cyclone of the big black hole. Therefore, when the Antarctic cyclone of the small black hole approaches the arctic cyclone of the big black hole, it will attract each other, so that the Antarctic cyclone of the small black hole and the arctic cyclone of the big black hole will be stretched, and the interstellar matter sucked by the Antarctic cyclone of the small black hole and the arctic cyclone of the big black hole will increase, thus accelerating the attraction of the Antarctic magnetic field of the small black hole and the arctic magnetic field of the big black hole, and thus generating gravitational waves.

In addition, because the gravity of the big black hole cyclone is greater than that of the small black hole cyclone, when the cyclones of the two black holes are close enough, the big black hole cyclone will instantly suck a section of the small black hole cyclone into the big black hole cyclone, and the material sucked into the big black hole will fall into the big black hole cyclone in a high-speed rotating way, so that observers on earth can only see that the big black hole cyclone is a high-speed rotating black hole, but can't see the broken small black hole cyclone for the time being, so observers on earth think that the two black holes have merged into one black hole.

In addition, due to the huge mass of the two black holes mentioned above, they have a strong attraction to the surrounding interstellar matter, so the bottom of the bipolar cyclone formed in the process of their rapid rotation is like a huge hard cone. When the material sucked by the big black hole cyclone from the small black hole cyclone falls into the big black hole cyclone at a high speed, it will turn faster and colder in the falling process, and when it reaches the bottom of the big black hole cyclone, it will be condensed into hard ice granules, when these hard ice granules hit the huge hard cone, there will be waves of "bells ringing".

2.4.4 Exploration of Gravitational Waves in Special Environment

In the cosmic galaxy, the speed of satellite rotating around the planet is usually very slow, and satellites can't generate polar cyclones, so there will be no gravitational waves caused by the attraction between the polar cyclones of satellites and the polar cyclones of planets.

In the cosmic galaxy, the angle between the orbital plane of a planet and the equatorial plane of a star is generally less than 45º, and the orbital radius of the planet around the star is usually more than several million kilometers, but the height of the polar cyclone of the planet is generally less than 100 kilometers, and the height of the polar cyclone of the star is generally less than 100,000 kilometers, so there is almost no gravitational wave caused by the mutual attraction between the polar cyclone of the planet and the polar cyclone of the star.

The situation that a black hole revolves around a quasar belongs to the situation that two black holes revolve around each other. Although the revolving period is very long, it will eventually produce gravitational waves, but the place where the gravitational waves are produced is too far away from the earth to be detected by human beings.

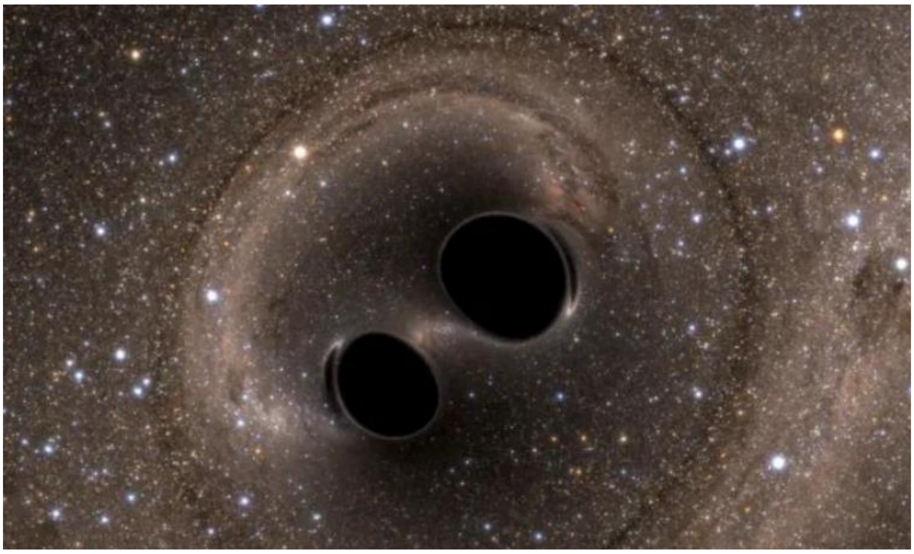

Fig. 7 Two black hole cyclones with opposite magnetism are close together due to mutual attraction.

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