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Supernova Explosion in the Process of Stellar Evolution

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Abstract: Supernova explosion is a peculiar astronomical phenomenon, which has aroused great interest and extensive research by astronomers. At present, however, it is erroneously believed that the supernova explosion is a splendid funeral of a dying star. In fact, new astronomical observations and the author's theoretical studies have shown that in the process of a star's never-ending evolution, numerous supernova explosions may occur, and supernova explosion will run through many stages of stellar evolution. Whenever the atmosphere of the star becomes very dense and its surface is covered with a thick layer of material again, a thermonuclear reaction can be ignited again, causing a supernova explosion. Especially, when the star has undergone a number of supernovae explosions and its surface is covered with multiple layers of supernova explosion remnants, the core of the massive star may undergo sudden gravitational collapse, causing a violent supernova; when a star is impacted by a falling celestial body, it also produces violent supernova explosions.

Key words: Stellar evolution, galaxy, supernova explosions.

1. The Defect of the Theory of Star Death

Supernova explosion is the most peculiar phenomenon in the universe. When a supernova explosion happens, an unusual bright star suddenly appears in the sky. The light that it emits can even illuminate its entire galaxy, before slowly fading from sight over several weeks or months and then thoroughly disappearing. In addition, supernova explosions are rare phenomena in a small galaxy. Only three Milky Way naked-eye supernova events have been observed during the last thousand years. Since supernova explosion is a transient astronomical event, people know little about supernova. In 1987, a Canadian astronomer discovered a supernova named SN 1987A in the Large Magellanic Cloud, but no remnant was left after the explosion. Even with the help of the Hubble space telescope, no black hole or super-dense neutron star was discovered [1]. Similar cases are too numerous to enumerate, so people generally believe that a supernova is a transient astronomical event that occurs during the last stellar evolutionary stages of a star's life, either a massive star or a white dwarf, whose destruction is marked by one final, titanic explosion. As to the reason for supernova explosion, the existing theory is also imperfect. The current theoretical studies indicate that most supernovae are triggered by one of two basic mechanisms: the sudden re-ignition of nuclear fusion in a degenerate star or the sudden gravitational collapse of a massive star's core. In the first instance, a degenerate white dwarf may accumulate sufficient material from a binary companion, either through accretion or via a merger, to raise its core temperature enough to trigger runaway nuclear fusion, completely disrupting the star. In the second case, the core of a massive star may undergo sudden gravitational collapse, releasing gravitational potential energy as a supernova.

In fact, it is wrong to regard the supernova explosion as a brilliant "funeral" at the end of the stellar evolution. Because supernova explosions only throw out some of the surface material, most of the remaining matter will collapse into a neutron star or black hole. But such faded neutron star or black hole is still surrounded by a thick layer of atmosphere, making it difficult to detect. But, it is not completely destructed, most of the material thrown out will eventually return to the neutron star or black hole. As

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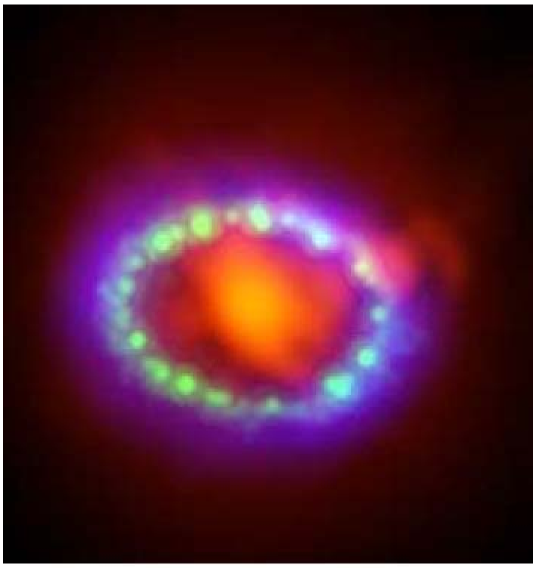

Fig. 1 SN iPTF14hls.

the neutron star or black hole revolves around its father star, it will continue to absorb the gas, dust and other interstellar matter near the orbit to increase its own mass and thicken its atmosphere. Whenever the atmosphere of the star becomes very dense and its surface is covered with a thick layer of material again, a thermonuclear reaction can be ignited again, causing a supernova explosion. Especially, when the star has undergone a number of supernovae explosions and its surface is covered with multiple layers of supernova explosion remnants, the core of the massive star may undergo sudden gravitational collapse, causing a violent supernova; when a star is impacted by a falling celestial body, it also produces a violent supernova explosions. Thus, we can see that in the process of a star's continuous evolution, numerous supernova explosions may occur, and supernova explosion will run through many stages of stellar evolution. For example, iPTF14hls is an unusual supernova star that has erupted continuously for the last three years (as of 2017) [2], and it had previously erupted in 1954. Obviously, this latest discovery poses a great challenge to the previous theory of star death.

In order to reveal the law of supernova explosion, it is necessary to analyze the antecedents and consequences of supernova explosion in detail and its connection with the various stages of the stellar evolution.

2. A New Theory of Stellar Evolution

2.1 The Formation and Evolution of Planetary Systems

According to the Solar System's formation law, a star can produce several planets around it, and each planet can also produce zero or several satellites around it, therefore forming a planetary system.

During the planets' revolution around its parent star, they unceasingly incorporate the nebula materials near the orbits to become larger and larger and may also generate new satellites. So except some small planets (like Mercury and Venus of the Solar System) near the parent star, other larger planets have their own thick atmospheres. During the normal rotation of a planet (such as Earth) around its parent star (such as the sun), the atmospheric pressure on the trailing hemisphere of the planet is higher than the other hemisphere, effectively increasing its speed, thus making the planet gradually move away from the parent-star along a spiral line [3]. In addition, with the parent star's shrinking from time to time and thus the speeding up of its rotation, the revolution speed of the planets will also increase correspondingly and thus the planets will move away from their parent star gradually.

As the planets gradually move away from their parent star, the gravitational attractions of the parent star to these planets also gradually become smaller, consequently these planets' self-rotation will gradually accelerate, making their satellites' revolution faster, eventually causing the satellites to move away from their planet. In addition, with the growth of the mass of a planet, the planet will shrinks from time to time, but conserving the angular momentum of the planet, so a decrease in the rotational inertia results in an increase in the rotation speed of the planet, and consequently also an increase in the revolution speed of the satellites, making the satellites move away from the planet [4].

2.2 The Formation and Evolution of Stars

(1) The birth of a star—new star

During the rotation of a planet around its parent star, it unceasingly absorbed the nebula materials near the orbits, making its mass increase gradually and its atmosphere becomes thicker and thicker. When a planet's mass becomes very large, its gas density and core temperature are high enough to initiate and maintain thermonuclear reactions, a new star is ready to be born. Because the mass of the star is much greater than that of the earth, the thickness and density of cloud around the star are much greater than the thickness and density of thunder storm around the earth, so when the star revolves around its progenitor and whirls on its axis fast, lots of cloud clumps would bump each other to cause frequent and immense electricity and thunder, which can easily ignite the combustion of the thick atmosphere and deep surface around the star, thus initiating and maintaining thermonuclear reactions on the star, a new star is born [5].

(2) Young star—main sequence star

After a star is born, it enters an evolutionary phase using hydrogen fusion as its major energy source. The outward expansion force of the gas inside the star and the inward contraction force induced by gravity are roughly balanced, making the star neither contract nor expand. So this is a relatively stable phase, the duration is about 90% of its whole life span, which is called the main sequence stage of a star, it is the prime of the star's life [5].

(3) Middle aged star—red giant star

During the rotation of a star around the center of a galaxy, it unceasingly absorbed gases, dust and other interstellar matter near the orbits, the trapped material is barely able to escape from the besiege of the dense atmosphere of the star. Many light elements are fused into heavy elements by the thermonuclear reactions of the star. So when a star evolves to the end of its main sequence stage, its mass increases greatly and can reach several times the mass of the sun. As the mass of star increases, its gravitational field increases, thus the atmosphere around the star also thickens significantly. Especially, as the helium ball gets bigger and bigger, the hydrogen combustion layer expands outward correspondingly, making the astral outer material expand due to heating, thus the star be transformed to a red giant star [6].

(4) Star in later years—white dwarf

When a star evolves to the end of its main sequence stage, its mass is much larger than that of the early days. The greater the mass of a star, the faster its energy is consumed, so it is increasingly difficult to capture external material to meet its energy consumption. Especially, old stars usually have complex sub-galaxies, including a series of satellites, planets and even young stars. These sub-galaxies move around the old star and compete for the resources originally belonging to the old star. When the hydrogen needed for the thermonuclear reactions in the core of the old star is insufficient, the thermonuclear reactions based on hydrogen fusion cannot proceed in the core of the old star. At this point the gravitational force is not balanced by the radiation pressure of the fusion, the core of the star will be compressed until the gravitational force is balanced with the core electron degeneracy pressure, then compression stops, forming a white dwarf [7]. As the old star shrinks into a dwarf, its rotation speed increases greatly as a result of conservation of angular momentum, which leads to an increase in the revolution speed of its lower stars, making its sub-galaxies move away from their parent star.

After the old star evolves into a white dwarf, the thermonuclear reaction on it is basically stopped, but its mass is much greater than that in the early days of the star, and the atmosphere around it will also resume gradually. During the contraction of an old star into a white dwarf, its rotation speed increases greatly. When a white dwarf revolves around its progenitor and whirls on its axis fast, lots of cloud clumps would bump each other to cause frequent and immense electricity, lighting the white dwarf. This is the reason for white dwarf white.

(5) Rise from the dead—supernova

During the movement of a galaxy, a white dwarf unceasingly incorporates the nebula materials near the orbits to increase its own mass and thicken its own atmosphere. When the atmosphere of the star becomes very dense and its surface is covered with a thick layer of material again, the conditions of a thermonuclear reaction are ripe again. Because the mass of such a star is much greater than that of the earth, the thickness and density of cloud around the star are much greater than the thickness and density of thunder storm around the earth, so when such a star revolves around its parent star and whirls on its axis fast, lots of cloud clumps would bump each other to cause frequent and immense electricity and heat, finally leading supernova explosion. However, such a supernova explosion will soon consume the accumulated atmosphere, and disperse part of the surface material at high speed, then make the remaining surface layer melt and contract into a thin onion-like shell. During the contraction of the supernova, its rotation speed increase greatly as a result of conservation of angular momentum, which leads to an increase in the revolution speed of its lower stars, making its sub-galaxies move away from their parent star along a spiral line.

In addition, when a star has undergone a number of supernovae explosions and its surface is covered with multiple layers of remnants, the core of the massive star may undergo sudden gravitational collapse, causing a violent supernova; when a star is impacted by a falling celestial body, it also produces violent supernova explosions [8, 9].

(6) Late stages of stellar evolution—neutron star

During the evolution of a white dwarf into a massive star, supernova explosions may occur multiple times. During each explosion, there is an accompanying collapse, causing the material at the core to compress more tightly. When the mass of the white dwarf increase beyond the Chandra limit, which is 1.4 times the mass of the sun, especially when its surface is covered with multiple layers of supernova explosion remnants or a huge celestial object hits it, a supernova explosion will occur immediately, and the gravitational attraction of the star core is strong enough to compress atomic nuclei and electrons into neutrons, transforming the white dwarf into a neutron star with a diameter of only a dozen kilometers and a density of one billion tons per cubic centimeter. As the star shrinks into a neutron star, its rotation speed increases greatly as a result of conservation of angular momentum, hence the newly formed neutron star rotates at up to several hundred times per second [10, 11]. The acceleration of the star's rotation will accelerate the revolution of its lower stars, making its sub-galaxies move away from their parent star.

(7) The endpoints of star evolution—black hole

During the evolution of a neutron star into a massive star, supernova explosions may occur multiple times. During each explosion, there is an accompanying collapse, causing the material at the core to compress more tightly. When the mass of the neutron star exceeds 3 times the mass of the sun, it will collapse into a black hole.

In fact, according to the galaxy formation theory described above, any galaxy is a hierarchical structure composed of many generations of stars and each generation consists of several brother stars. Such galaxy structure is not static, but in constant motion and change. A star of a later generation in a galaxy always revolves around its predecessors, i.e., a satellite moves around its parent planet, a planet moves around its parent star, and a star may further moves around its parent star, until all the daughter galaxies rotate around the center of the galaxy. During a star revolving around its parent star, it unceasingly incorporates the nebula materials near the orbits to become larger and larger, and as the parent star shrinks, it is moved away from the parent star. Especially, a planet may gradually move away from its parent star, even producing progeny galaxies. This means that a star of the *n*th ($n \geq 1$) generation might produce a sub-galaxy consisting of multiple generations of stars, making its spatial scale become overlong, so that when the sub-galaxy rotates around the star of the *n*th generation, its tail satellite may enter the gravitational field of the star of the (*n*-1)th generation, and finally be annexed by the later one, greatly increasing the mass and density of the later one, as is shown in Fig. 2.

Moreover, the impact of the sub-galaxy of the *n*th generation star on the (*n*-1)th generation star will produce tremendous energy, even start supernova explosion, to fuse the satellite with the (*n*-1)th generation star. Due to the strong gravitation of the center of the (*n*-1)th generation star, the newly added material shrinks immediately, but conserving the angular momentum of the (*n*-1)th generation star, so a decrease in the rotational inertia results in an increase in the rotation speed of the (*n*-1)th generation star, and consequently also an increase in the revolution speed of the *n*th generation star, making the *n*th generation star move away from the (*n*-1)th generation star, widening the distance between the two generation stars. Similar impacts may occur multiple times, finally allowing the passage of the sub-galaxy of the *n*th generation star.

Thus, we can see that in some old galaxies which have evolved over a long period of time, there are many high layer stars that have accumulated for a long time and encountered numerous impacts, eventually becoming black holes of great mass and density. Especially, the progenitor at the center of the galaxy has been the earliest and most frequently hit by other celestial objects, and has become a black hole with the largest mass and density. Some daughter stars under or beside the center of the galaxy may also have accumulated for a long time and encountered numerous impacts, eventually becoming massive black holes, but their mass and density are lower than that of their ancestor. Just because the mass of the black hole is very large and the gravitational force is very strong, any moving body entering the gravitational field of the black hole but having lower speed than light speed cannot escape the trap of the black hole. Also because the mass of the black hole is

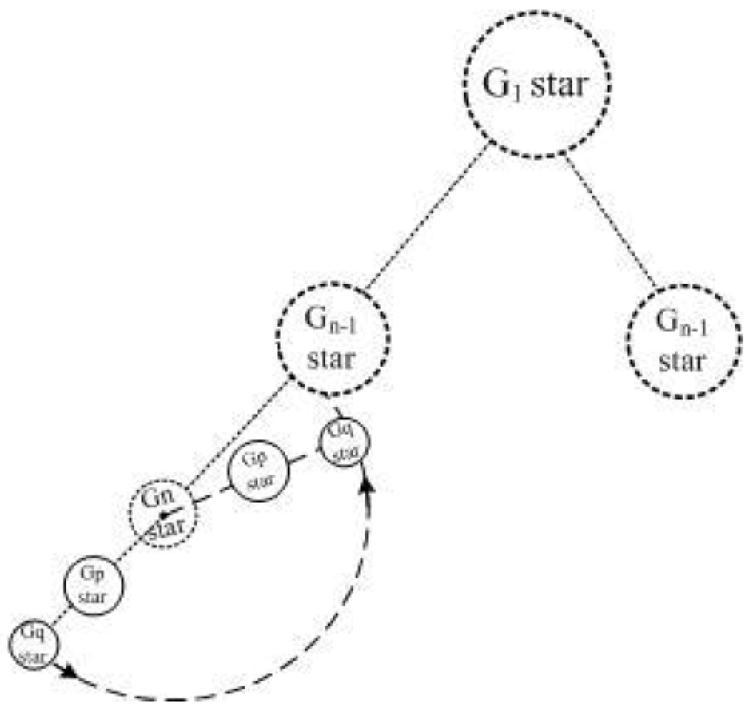

Fig. 2 An overlong sub-galaxy impacts on its parent star.

very large and the gravitational force is very strong, it can attract an extreme thick and dense atmosphere, so that the light emitted by objects smaller than black holes cannot penetrate so thick and dense an atmosphere, just as sunlight cannot penetrate thick clouds. Even if a luminous celestial body enters this area, since lots of its gaseous, liquid and solid materials may be swallowed by the black hole, making the object's resources are insufficient to maintain its luminous effect, causing the phenomenon of "light cannot escape a black hole" [4, 12].

(8) Stellar rebirth—quasar

According to the above theory of the formation of black holes, the mass of the black hole is gradually increased. When a black hole of small mass evolves into a super-massive black hole, its gravitational force acting on other objects will become extremely strong, therefore like the earth, it can attract atmospheric particles (such as molecules, atoms and dust particles) to form its own atmosphere. Because the mass of a supermassive black hole is much greater than that of the earth, the thickness and density of cloud around the supermassive black hole are much greater than the thickness and density of thunder storm around the earth, so the observers have found that star like objects have very dark nebula around them. When such a black hole revolves around its progenitor and whirls on its axis fast, lots of cloud clumps would bump each other to cause immense electricity and thunder, forming strong radio source and blast wave, so people on the earth can detect remote radio source and cosmic background radiation. In addition, these immense electricity also cause interlaced currents around the dense clouds, which then produce aurora like intense light around the quasar, so quasar is among the most luminous, powerful, and energetic objects known in the universe. Due to the dense hydrogen in the nebula around the quasar, a large number of hydrogen atoms emit light when excited by high-voltage electric fields, so the peculiar spectrum of hydrogen atoms can be observed on the earth through a spectroscope. Since a quasar usually revolves around its progenitor fast, the observed hydrogen atom spectrum has a high red-shift. Both the red-shift of quasars and the red-shift of other galaxies belong to cosmic red-shift. That is a quasar, which is essentially a supermassive black hole that is covered by an extreme thick and dense atmosphere and revolves around its progenitor and whirls on its axis fast. Since a supermassive black hole is usually a central star of a large galaxy, it normally has at least two spiral arms. So, when it revolves around its progenitor and whirls on its axis fast, it remotely looks like an active galactic nucleus [13-15].

Although a quasar consists of a supermassive black hole surrounded by an orbiting nebula, no quasar has been found in the range of tens of millions of light-years in the neighborhood of the Milky Way. This means that the mass of the largest black hole in the center of the galaxy is not enough to attract thick and dense clouds to generate a wide range of continuous violent thunderstorms. Hence, the mass of a black hole forming a quasar must be far greater than the mass of the largest black hole in the center of the Milky Way, so such a black hole should be at a higher layer in the super-cluster of galaxies than the black hole in the center of the Milky Way. Hence, it is far away from the Earth located at the bottom of the Milky way. In fact, they are usually billions of light years or tens of billions of light years away from Earth.

According to the formula calculating the distance between the central black hole of a galaxy and the central black hole of one of its sub-galaxy, and the ratio of the central black-hole mass to galaxy mass, we can easily calculate the ratio of the mass of a quasar billions of light years away from Earth to the total mass of the Milky Way. Since a normal galaxy is a hierarchical structure and astronomers have discovered that our galaxy is a suburb of a supercluster of 100,000 large galaxies that they have called Laniakea, we can assume that the Milky Way's central black hole has multiple ancestral black holes. Assume there is n black holes from the Milky way's central black hole to a quasar billions of light years away from Earth, numbered respectively as BH_1, BH_2,…, BH_n, and their correspondingly masses are M_1, M_2,…, Mn. Let the total mass of the Milky Way be m, then the mass of the Milky way's central black hole is $M_1 = 0.005m$ [16]. Just as the Milky Way has two spiral arms, a large galaxy normally has two spiral arms, so the total mass of the galaxy centers on BH_2 should be $2m$, the mass of BH_2 should be $M_2 = 0.005 \times (2m) = 2M_1$. Similarly, we have

$$M_3 = 2M_2 = 2^2 M_1,\ \ M_4 = 2^3 M_1, \cdots,\ \ M_n = 2^{n-1} M_1$$

Because the diameter of the Milky Way is 10^5 light-years, its radius is 5×10^4 light-years. In order to make the Milky Way revolving around its central black-hole BH_1 not collide with BH_2, the distance between BH_1 and BH_2 must be greater than 5×10^4 light-years, and this distance does not change for a certain period of time. So the distance between BH_1 and BH_2 is about 5×10^4 light-years. Similarly, the distance between BH_2 and BH_3 is about $2\times5\times10^4$ light-years, the distance between BH_3 and BH_4 is about $2^2\times5\times10^4$ light-years,…, the distance between BH_{n-1} and BH_n is about $2^{n-2}\times5\times10^4$ light-years. Since the earth is at the outskirt of the Milky Way, and it is billions of light years away from the quasar, hence:

$$5\times10^4 + 5\times10^4 + 2\times5\times10^4 + 2^2\times5\times10^4 + \cdots + 2^{n-2}\times5\times10^4 = 10^{10} \ \to 2^{n-1} = 2\times10^5$$

thus

$$M_n = 2^{n-1} M_1 = 2\times10^5 \times 0.005m = 1000m$$

i.e., the mass of the ancestral quasar billions of light years away from the earth is about 1,000 times the total mass of the entire Milky Way galaxy, so it is massive enough to attract extreme thick and dense cloud, when it revolves around its progenitor and whirls on its axis fast, a wide range of continuous violent thunderstorms can be produced, the energy released by the quasar would be 1,000 times more than the energy released by the entire Milky Way galaxy. Especially when such a quasar becomes a supernova, it can illuminate the whole galaxy.

3. Conclusions and Prospect

As a peculiar astronomical phenomenon, supernova explosion has aroused people's great interest and extensive research. However, since supernova explosion is a transient astronomical event, people knows little about supernova. At present, it is erroneously believed that the supernova explosion is a splendid funeral of a dying star. In fact, one need only to carefully analyze the causes and consequences of supernova explosion as well as its relations with various phases of stellar evolution, he can find that supernova explosion may occur many times in the process of a star's never-ending evolution, and supernova explosion will run through many stages of stellar evolution. Both the observation of supernova iPTF14hls and the author's theoretical study have confirmed this conclusion, so various supernova with different mass can be observed in the sky. When we study a supernovae, we cannot see it as an isolated and stationary star, instead we should see it as a member having close relation with galaxies.

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