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Formation and Evolution of Comets

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Abstract: Although people have studied comets for a long time and used spacecraft to detect comets in a short distance, the formation time and causes of comets are still unresolved. Therefore, according to the formation and evolution law of planets and the dynamic mechanism, the author thoroughly revealed the formation and evolution of comets: A powerful storm cyclone on Neptune, such as the Great Dark Spot, can involve a large number of clouds. These clouds are gradually cooled and compressed in the process of rapidly sinking along the spiral path, and then condense into huge water ice crystals at the bottom of the cyclone; When such a crystal falls into a deep hole filled with liquid hydrogen, it is easy to collide violently with the boulders in the hole, and instantly ignite the liquid hydrogen in the hole. Under the strong push of high-pressure gas, some fragments of the ice crystal can quickly reach a very high initial speed. Especially when the jet direction of the Great Dark Spot is consistent with the direction of Neptune's revolution speed, such fragments can quickly reach Neptune's escape speed of 23.56 km/s. Therefore, the fragments can break away from Neptune and enter an elliptical orbit around the sun, becoming a comet. Similarly, when the metal hydrogen at the bottom of a Great Red Spot on Jupiter explodes in a series, the fragments ejected from the Great Red Spot can reach the escape speed of Jupiter of 60 km/s, therefore, such fragments can break away from Jupiter and enter the elliptical orbit around the sun to become comets. Many of these comets can become asteroids in the asteroid belt, which is the formation principle of the asteroid belt.

Keywords: Neptune, Great Dark Spot, Jupiter, Great Red Spot, escape speed, comet.

1. Introduction

Comet is a rare and strange celestial body, which makes people curious with its indefinite period of motion, special orbit and strange shape. The ancients in the age of ignorance once believed that comets were the harbingers of natural and man-made disasters. But with the advent of the era of civilization, people more and more clearly realized that comets, like other celestial bodies, belong to the product of nature. Some scientists believe that comets are the products left over from the early formation of the solar system and are the most primitive objects in the solar system. However, the astronomical community can find 4 to 5 new comets every year, and the generation and evolution of comets have never stopped. It is still a mystery where comets came from and how they came into being. In 1950, the famous Dutch astronomer Oort, Jan Hendrik proposed a theory of comet origin [1]. He believed that there was a huge nebula cluster around the sun, also known as the comet bank, in which there were hundreds of millions of comets, all of which existed in solid form. Comets in the nebula cluster are pushed into the solar system due to the gravitational action of the surrounding stars. However, the study of comet orbit shows that any comet found today does not come from outside the solar system, so the comet origin hypothesis of Oort is not tenable.

In order to reveal the origin and evolution of comets, humans have also carried out a series of more in-depth research and exploration on comets. The morphological structure, brightness and spectrum of comets have been observed in visible light, radio, infrared, ultraviolet, X-ray and other wavebands. As of November 2014, 5253 comets have been found. Since the 1980s, some advanced countries in the world have also launched a series of space detectors to detect comets in space, and achieved fruitful results. The probe launched by NASA in September 1985 passed through the tail of Comet 21P/Jiacobini Zinner for the first time and sent back a lot of precious data. In 1986, the Vega probe launched by the former

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Soviet Union flew over Halley's Comet, and successfully sent back more than 700 photos and data on the gas and dust around the comet. In the same year, the Giotto detector launched by ESA successfully flew 596 kilometers away from Halley's Comet, becoming the closest detector to the comet. It took nearly 1500 photos and returned a large amount of data. Although the photo can show that the surface of Halley's Comet is like a rough peanut, this exploration is still only on the surface. What about the internal structure of the comet? How did it come into being? Still not sure. So in April 2007, NASA launched another deep impact spacecraft to hit Comet Temple I. It took about 6 months for the spacecraft to reach the rendezvous point with Tempel I after two orbit corrections and 429 million kilometers. After being ready, the impactor and flyer of Deep Impact successfully separated, and the intelligent program guided the impact, which successfully impacted Comet Tempel I. According to the data sent back by the flyer, it is calculated and analyzed that the impact made the comet eject about 5 million kg of water and 10-2.5 million kg of dust.

Through the exploration of comets by space probes, scientists have made people understand comets more clearly. But what they can conclude is that at the early stage of the formation of the solar system, dust and cloud gas condensed into comets. These comets either collided with the nascent sun, planets and satellites, or were thrown out of the solar system by the gravity of Jupiter, or were evaporated by solar radiation. Now they have disappeared around the eight planets. The comets observed today are likely to come from the Kuiper Belt or the Oort Cloud at the edge of the solar system.

The recent studies of Morbidelli *et al.* in 2015 [2] and Michael *et al.* in 2017 [3] also recognized that comets originated from the Kuiper Belt and the Oort Cloud, and they also found two other comet origins — the main asteroid belt and interstellar space. It can be seen that their research did not get rid of the shackles of previous thoughts, but only found two more comet origins. However, the asteroids in the asteroid belt are irregular and lack of vitality, which cannot provide enough power to make the planetesimal escape from the asteroid belt to become comets revolving around the sun; additionally, it is difficult for the planetesimals produced by one galaxy to obtain the third cosmic velocity to enter another galaxy, so these recent studies have failed to reveal the origin and evolution of comets.

It can be seen that the new conclusions still have great uncertainty about the formation time, causes and operation rules of comets, and even contain serious mistakes. In order to clarify the vague understanding of comets and reveal the nature of comets [4], we should reveal the formation and evolution of comets according to the general laws and dynamic mechanisms of planetary formation and evolution.

2. The Formation and Evolution of Comets

Since the study of comet orbit has shown that any comet found now does not come from outside the solar system, it must be the product of the sun or its planets, so there are only two possibilities as follows:

First, it is possible that the sun has produced comets. In this case, we can subdivide the following two cases to consider: (1) If the comet is a planetesimal emitted when the mass of the sun exceeds the mass of Jupiter, because the escape speed of Jupiter is about 60 km/s, which is far greater than the explosion speed of the metal hydrogen with the strongest explosive force of 24 km/s, it is difficult to obtain the boost force for launching the comet on this sun, that is, the probability of the sun ejecting the comet is very small under the circumstances. (2) If the comet is a planetesimal that shoots out when the mass of the sun does not exceed the mass of Jupiter, it is known that the orbital eccentricity of Jupiter satellites is less than the eccentricity of comet orbits. With the increase of the mass of the sun, the comet orbit would become more and more circular, that is, the

eccentricity of comet orbits will become smaller rather than stay at the original level, so the probability of the sun ejecting comets is also very small.

Another situation is that the planets of the solar system produce comets. This is more likely, because some planets in the solar system have huge mass and their rotation speed exceeds the sun's rotation speed, becoming more active planets in the solar system. For example, Neptune has 17 times the mass of the Earth, and its rotation speed is 0.7 km/s faster than that of the sun. Because Neptune has a huge mass and can absorb a large amount of hydrogen into its atmosphere, the main component of its atmosphere is hydrogen, and there is a large amount of liquid hydrogen on its ground surface [5]. Because Neptune is a planet with huge mass and extremely fast rotation speed, during the rapid rotation of such a giant planet, strong polar vortices can be generated. When Neptune's satellite is close to a polar vortex, it can tilt, stretch, shear or break the polar vortex, or even drag out some sub cyclones, spreading them to regions at different latitudes. For example, Neptune's Great Dark Spot is a powerful storm vortex, which can involve a large number of clouds. These clouds are gradually cooled and compressed in the process of rapid sinking along the spiral path, becoming thicker and heavier, and more and more massive. At the bottom of the vortex, it condenses into huge water ice crystals, which contain dust and water vapor. When such a water ice crystal falls into a deep hole filled with liquid hydrogen, it is easy to collide violently with the boulders in the hole, which instantly ignites the liquid hydrogen in the hole. Some fragments of the water ice crystal will soon reach an initial speed of 18.13 km/s under the strong push of high-pressure gas. Therefore, when the jet direction of the Great Dark Spot is consistent with the direction of Neptune's revolution speed (revolution speed 5.43 km/s), the debris ejected from the Great Dark Spot can reach Neptune's escape speed of 23.56 km/s, so the debris can break away from Neptune to enter the elliptical orbit around the sun, becoming a comet, as shown in Fig. 1. In fact, the elliptical orbit is also an orbit around Neptune at the beginning, therefore, the orbit of the comet is a long and flat elliptical orbit, in which the sun and Neptune look like the two focuses of the ellipse, as shown in Fig. 1.

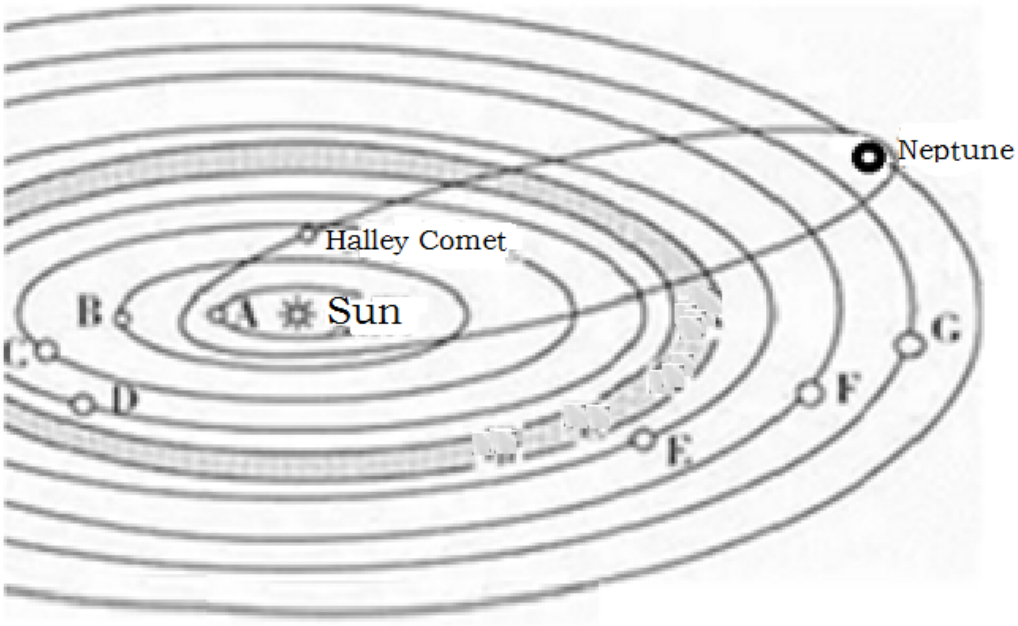

Fig. 1 Halley's Comet from Neptune

For another example, Jupiter is also a planet with huge mass and extremely fast rotation speed (12.66 km/s), during the rapid rotation of such a giant planet, strong polar atmospheric vortices will be generated at both poles. When Jupiter's satellite is close to a polar vortex, it can tilt, stretch, shear or break the polar vortex, or even drag out some sub cyclones, spreading them to regions at different latitudes. For example, Jupiter's Great Red Spot in the southern hemisphere is a strong storm cyclone [6-7]. As Jupiter's cyclone covers a vast atmospheric space, there are many clouds involved in the cyclone. The clouds are gradually compressed, becoming thicker and thicker, and their mass is larger and larger during the sinking process. When the clouds pass through a long spiral path, they are prone to severe friction and collision (but the temperature and pressure of Neptune's atmosphere are low, and the friction effect between the materials that form the storm cyclone is obviously weak), constantly producing violent thunderstorms, Thus, huge electric energy is released, so that the temperature of the surrounding air rapidly rises to tens of thousands of degrees, and the atmospheric pressure also rises to one million atmospheres. Therefore, many gaseous hydrogen in the cyclone changes into liquid metal hydrogen. This kind of liquid metal hydrogen is gradually cooled in the process of rapidly sinking along the spiral path, and condenses into huge metal hydrogen crystals at the bottom of the cyclone, of course, it also contains some impurities. When this metal hydrogen crystal collides, it will produce a violent explosion, and its explosion speed can reach 24 km/s. If a series of explosions occur, the fragments generated by the explosion can be shot out of the cyclone at a speed of 48 km/s. Therefore, when the jet direction of Jupiter's cyclone is consistent with the direction of Jupiter's revolution speed (whose magnitude is 13.06 km/s), the velocity of the fragments ejected from Jupiter's cyclone can reach 61.06 km/s, which exceeds the escape speed of Jupiter by 60 km/s. Therefore, the explosive fragments will be able to break away from the constraints of Jupiter and enter the orbit around the sun, becoming comets. Later, the asteroid became larger and larger by absorbing the interstellar matter near the orbit, and gradually reduced the eccentricity of its elliptical orbit under the perturbation of Jupiter's gravity, becoming an asteroid running in a nearly circular orbit. The orbits of these asteroids are relatively close, and together they form the asteroid belt between Mars and Jupiter.

Statistics show that the probability of comets hitting the Earth was very small, and they only passed the Earth six times every 240 million years [8]. Why are there so few comets passing over the Earth? In fact, one of the main reasons is that the asteroid belt between Mars and Jupiter is an absolute net [9]. When most comets pass through the asteroid belt to enter the solar system, they will collide with the asteroids in the asteroid belt and be captured. That is really a gospel of mankind!

3. Conclusion

Through scientists' remote observation of comets and spacecraft's close exploration of comets, humans have a clearer understanding of comets, but their conclusions about the formation time, causes and operation rules of comets are still uncertain, even contain serious mistakes. Therefore, the author thoroughly revealed the formation and evolution of comets according to the formation and evolution laws and dynamic mechanism of planets: the ice crystal fragments ejected by Neptune's Great Dark Spot cyclone can reach the escape speed of Neptune of 23.56 km/s under the strong push of a large amount of high-pressure gas of liquid hydrogen, so the fragments can break away from Neptune and enter the elliptical orbit around the sun to become comets. When the metal hydrogen at the bottom of the Great Red Spot on Jupiter explodes in a series, the fragments ejected from the Great Red Spot can reach the escape speed of Jupiter of 60 km/s, therefore, such fragments can

break away from Jupiter to enter the elliptical orbit around the sun to become comets. Many of these comets can become asteroids in the asteroid belt, which is the formation principle of the asteroid belt.

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