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Formation and Change of Jupiter's Magnetic Field

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Abstract: The existing theory of planetary magnetic field holds that Jupiter has an internal magnetic field similar to the geomagnetic field, it is formed by the agitation of liquid metal hydrogen. But this hypothesis fails to explain many strange properties of Jupiter's magnetic field, especially that Jupiter's magnetic field is changing over time, which was discovered by NASA's Juno spacecraft. Hence, the hypothesis that Jupiter's magnetic field is internal magnetic field is incredible. Thus, the author analyzed the formation and evolution of Jupiter as well as its internal structure and external environment again, and has found the formation and change of Jupiter's magnetic field: During Jupiter's rapid rotation, a series of strong polar vortices are produced at the poles of Jupiter. These vortices contain a series of strong spiral currents, which can form a series of strong dipole magnetic fields. The superposition of these dipole magnetic fields form the original magnetic field of Jupiter. Since Jupiter has many massive moons, these satellites are constantly rotating around Jupiter, which has a huge impact on Jupiter's magnetic field. When a massive Jupiter satellite approaches a polar vortex, it can tilt, stretch, shear or break the polar vortex, even draw some sub cyclones out of the polar vortex, and some sub cyclones may turn into cyclones with opposite flow direction. Hence, the destruction of Jupiter's satellites will not only weaken the dipole magnetic field produced by the original cyclone, but also generate some reversed magnetic fields, which can counteract part of the original magnetic field. When this kind of Jupiter moons revolve enough times, the superposition of the generated magnetic fields of opposite direction will cancel out the original magnetic field, finally, making Jupiter's magnetic field reverse. Therefore, the north pole of Jupiter's magnetic field is near the geographical North Pole, and the south pole of Jupiter's magnetic field is near the geographical South Pole. Hence, the direction of Jupiter's magnetic field is opposite to that of Earth's magnetic field.

Keywords: Jupiter, Satellite, Magnetic Fields, Formation, Change

1. Introduction

The existing theory of planetary magnetic field holds that every planet in the solar system has an internal magnetic field similar to the geomagnetic field [1, 2]. However, Jupiter is made up of helium and hydrogen. Because the electric conductivity of these two elements is relatively weak, some theorists speculate that the tremendous pressure exerted by Jupiter's interior causes the formation of liquid metal hydrogen, which has the same conductivity as metal, therefore Jupiter's magnetic field is formed by the agitation of liquid metal hydrogen. But these theorists fail to explain many strange properties of Jupiter's magnetic field, especially that Jupiter's magnetic field is changing over time, which was discovered by NASA's Juno spacecraft [3]. Hence, the theory holding that Jupiter's magnetic field is internal magnetic field is incredible. Thus, the author analyzed the formation and evolution of Jupiter as well as its internal structure and external environment again, and has found the formation and change of Jupiter's magnetic field [4-6].

2. The Formation and Change of Jupiter's Magnetic Field

Jupiter is the most massive planet among the eight planets in the solar system, with a mass 2.5 times that of other planets, among the constituents, hydrogen accounts for 75% of the total mass and helium accounts for 25% of the total mass. In addition, it is the fifth farthest planet from the Sun. But according to the gravitation of the eight planets to the ejecta (such as gas molecules, dust or other substances) on the surface of the sun, as is shown in table 1,

Jupiter is the most attractive planet [7]. As a result, Jupiter is the planet that absorbs the most solar ejecta, becoming the largest gas giant. Jupiter has the deepest planetary atmosphere in the solar system, whose thickness is greater than 5000 km and basic atmospheric pressure is no less than 1M Pa.

Table 1. *Ratio of the main planets' gravity on objects on the Sun's surface.*

planet	mass	average distance from the sun	Ratio of planet's gravity relative to Mercury's gravity
Mercury	3.3022×10^{23} kg	57909050 km	1
Venus	4.8690×10^{24} kg	108209184 km	0.42228
Earth	5.9650×10^{24} kg	149597888 km	2.70684
Mars	6.4219×10^{23} kg	227925000 km	0.12554
Jupiter	1.9000×10^{27} kg	778547050 km	31.8327

Jupiter is also the fastest spinning planet, during its rotation, a series of polar vortices with a height of several thousand kilometers are formed. Since the clouds involved in a polar vortex are numerous and revolve rapidly, when they get to the bottom of the vortex, it is easy to have violent frictions and collisions among clouds, and constantly generating violent lightning and releasing huge electric energy, making the temperature of the surrounding air rise rapidly to tens of thousands of degrees and the atmospheric pressure also rise to more than 1MPa, so the gaseous hydrogen in the vortex changes into liquid metal hydrogen [8]. Since liquid metal hydrogen is a conductor with excellent conductivity, the vortex's lightning through rotating liquid metal hydrogen transforms into spiral electric current, as is shown in Figure 1 (captured by NASA's Hubble Space Telescope), which then produces a strong dipole magnetic field [9], as is shown in Figure 2.

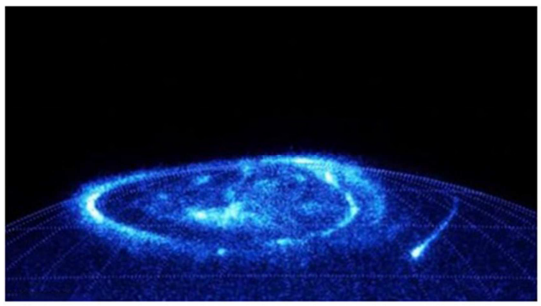

Figure 1. *The spiral current generated by Jupiter's arctic vortex.*

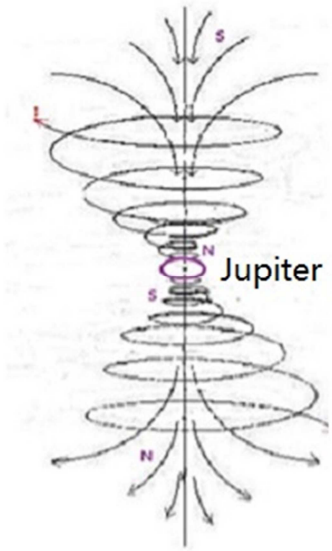

Figure 2. *Dipole magnetic fields of polar vortices.*

Because Jupiter's atmosphere is much thicker than Earth's, the polar vortices generated by Jupiter's atmosphere are more powerful and stable than those on Earth, therefore the dipole magnetic fields formed by Jupiter's polar vortices are much more stable than that by Earth's polar vortices. However, Jupiter's dipole magnetic fields are not unchangeable, but changes with the passage of time and the change of the environment [10]. Since Jupiter has many massive moons, these moons are constantly rotating around Jupiter, which has a huge impact on Jupiter's dipole magnetic fields. When a massive Jupiter moon approaches a polar vortex, it can tilt, stretch, shear or break the polar vortex, even draw some sub cyclones out of the polar vortex, and some sub cyclones may turn into cyclones with opposite flow direction, as shown in Figure 3. Hence, the destruction of Jupiter's moons will not only weaken the dipole magnetic field produced by the original polar vortex, but also generate some reversed magnetic fields, which can counteract part of the original dipole magnetic field. When this kind of Jupiter moons revolve enough times, the superposition of the generated dipole magnetic fields of opposite direction will cancel out the original dipole magnetic field, finally, making Jupiter's magnetic field reverse. Therefore, the north pole of Jupiter's magnetic field is near the geographical North Pole, and the south pole of Jupiter's magnetic field is near the geographical South Pole. Hence, the direction of Jupiter's magnetic field is opposite to that of Earth's magnetic field.

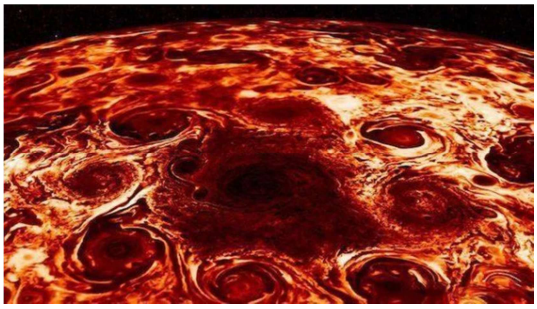

Figure 3. *Jupiter's Arctic polar vortex and its sub cyclones.*

Moreover, some sub cyclones will move under the gravitational pull of a Jupiter moon, even around the planet,

therefore, many strong elliptical cyclones can be seen in the atmosphere of Jupiter at different latitudes. For example, the Great Blue Spot and the Great Red Spot near the equator are large-scale cyclones [11], they can also produce dipole magnetic fields superimposed on the original magnetic field. So, Jupiter's magnetic field changes over time (called secular variation) [12]. But in the past scientists speculated that this change may be caused by the deep atmospheric wind of the planet. Obviously, it's illogical to associate wind with the hypothetical internal magnetic field, which hasn't revealed the root cause for the change of Jupiter's magnetic field. In fact, the magnetic field is generated by cyclones, and the wind is induced by moons. Without the gravity of a moon, there would be no wind. Because most of the massive moons orbit close to the equatorial plane of Jupiter, as is shown in Figure 4, the winds caused by the movement of Jupiter's moons are mostly east-west winds, rarely north-south winds [13, 14].

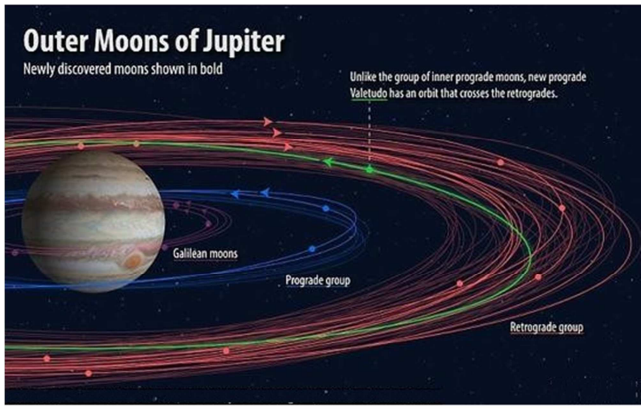

Figure 4. *Orbits of Jupiter's moons.*

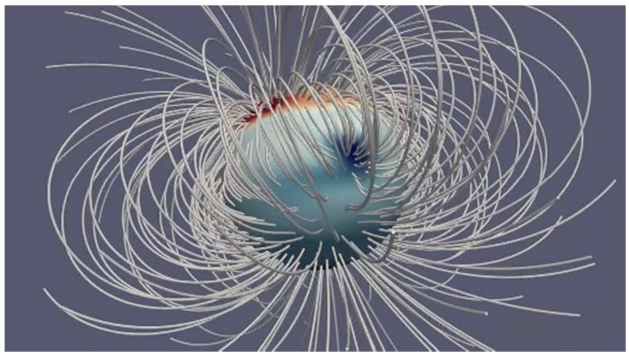

Figure 5. *Jupiter's magnetic field supposed to have two south poles.*

Although Jupiter's dipole magnetic field is very strong, it is very limited compared with the giant Jupiter. In fact, the dipole magnetic field produced by Jupiter's polar vortices is difficult to cover the whole planet. Especially Jupiter is a gas giant, its rapid rotation creates a huge centrifugal force, which makes Jupiter's poles relatively flat and equator heavily bulged out. Hence, most of the magnetic lines of the dipole magnetic field produced by the polar vortices pass through the bulging atmosphere near the equator. This makes it easy for some spacecrafts to detect that a part of the magnetic field line from Jupiter's Arctic magnetic field ends at the equator. In addition, the Great Blue Spot near the equator is also a large-scale cyclone, which can produce a strong dipole magnetic field whose north pole points to the ground and south pole points to the sky. This makes it easy for the spacecrafts to detect that Jupiter's dipole magnetic field has two south poles, one is near the Great Blue Spot near the equator, another is near the South Pole of Jupiter [15], as is shown in Figure 5.

3. Conclusion

The existing theories of the origin of planetary magnetic field are all based on the internal generator theory of geomagnetic field, which is still in doubt, therefore they are led astray, unable to explain the formation and change of Jupiter's magnetic field and other complicated magnetic fields. Thus, the author analyzed the formation and evolution of Jupiter as well as its internal structure and external environment again, and has found the formation and change of Jupiter's magnetic field. During Jupiter's rapid rotation, a series of strong polar vortices are produced at the poles of Jupiter. These vortices contain a series of strong spiral currents, which can form a series of strong dipole magnetic fields. The superposition of these dipole magnetic fields form the original magnetic field of Jupiter. As Jupiter's moons rotate around it, some of Jupiter's massive moons can induce some sub cyclones from the Jupiter's atmospheric vortices. These sub cyclones form powerful cyclones by absorbing dense clouds and generate some new magnetic fields, which are superimposed on the original magnetic field to form more complex magnetic field of Jupiter. So Jupiter's magnetic field changes with time and the external environment.

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