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New Electromagnetic Theory of the Origin of Saturn Rings From Superconducting Iced Particles of the Protoplanetary Cloud (The Unified Theory of the Planetary Rings Origin)

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Abstract

It is shown from electromagnetic consideration that the rings of Saturn may have a superconducting origin. The rings appear as a result of an interaction of the superconducting particles of the protoplanetary cloud with the nonuniform magnetic field of Saturn. As a result, superconducting particles are localized as a disk of rings in the magnetic equator plane, where the full energy of the particles has a minimum value. The gravitational resonances and other interactions also play an important role and they help bringing the order to the system of rings and gaps. Rings of Jupiter, Uranus and Neptune occurred the same way. Therefore, we propose a unified theory of the planetary rings origin.

Keywords: origin of Saturn (planetary) rings, space electromagnetism, space superconductivity

1. Introduction

Undoubtedly, the rings of Saturn is the most beautiful natural creation. Since their discovery in 1610 by G. Galileo of Italy they have been attracting scientists' attention and enjoyed great popularity. On February 15, 2014, humanity celebrates the 450th anniversary of Galileo's birth. The logotypes of the rings are widely used in business and advertisements. Thousands of articles have been written about them and tens of billions of dollars have been spent to study them. However, the issue of the origins of the rings of Saturn is still unsolved, and this is one of the main problems that hopefully should be resolved by the Cassini mission (2004-2018).

In 1859, the British physicist J. C. Maxwell, the founder of electromagnetism, proved that the rings consist of an infinite number of separate particles (see, e.g., Maxwell, 1859; Maxwell, Brush, Everitt, & Garber, 1983). Larger particles would be broken down into smaller. Maxwell considered the rings were to fall down on the planet with the passage of time, but surprisingly they still exist.

Despite the fact that humankind studies planets of the Solar system and the outer space, there are still very many riddles and unsolved problems. The mystery of the rings of Saturn is one of them (see, e.g., Alfven, 1981, 1983; Bliokh & Yaroshenko, 1991; Brahic, 1984; Goldstein & Morris, 1973; Gor'kavyi & Fridman, 1994; Greenberg & Brahic, 1984; Kaiser et al., 1981; Mendis et al., 1984; Rabinovich, 1996, 1999; Safronov, 1969; Shukla et al., 2003; Spilker, 1997; Yokota, 2001).

All admire this most beautiful phenomenon of the Solar system, yet its riddle has remained unsolved for four hundred years, and it thrills not just astronomers alone. All inhabitants of planet the Earth wish to know how the rings took shape and how Saturn became their Lord. The current Cassini Mission is trying to reveal the secrets of this phenomenon (see, e.g., Cuzzi et al., 2010; Dougherty, Esposito, & Krimigis, 2009; Lyra, 2013; Rowan et al., 2005).

2. The Way to the New Model of the Origin of Saturn Rings

The existing theory considers the origin of the rings as emerged from fragments of an asteroid that came close to the planet, and this was universally accepted before the flight of Cassini. Now it is crumbling away thanks to newly found phenomena in the rings. This is understandable as the old theory, in the absence of a digestible and physically comprehensible explanation, contains some mystical basis as is done in science fiction novels. Cassini has now discovered millions of large ice formations in the rings (they have been called moons) and new rings, -

but how to explain all these? One of the main puzzle is: why only planets - Jupiter, Saturn, Uranus and Neptune - located behind the asteroid belt with existence of the magnetic field and low temperature environment do have the rings system. It turns out one can do so, if one accepts our new theory of formation of the rings as is proposed by Pospelov and Tchernyi (1994, 2005, 2007), Tchernyi and Chensky (2005), and Tchernyi (2013), with taking into account of the superconductive nature of the rings particles.

Recently, a number of papers have been published on a new model of the origin of the Saturn rings that is based on the electromagnetic approach (see, e.g., Pospelov, Girich & Tchernyi, 2005, 2007, 2008, 2009, 2000; Tchernyi & Pospelov, 2005, 2007; Tchernyi & Chensky, 2005; Tchernyi, 2006, 2009, 2010, 2011, 2012, 2013). From experimental data there exists a possibility that the ring particles superconductive. After onset of the magnetic field of planet, the rings are formed as a result of interaction of the iced protoplanetary particles with the magnetic field. The Kepler's orbits of the particles would eventually localize within the magnetic equator plate, where the energy of the particles has a minimum value.

The rings are believed to have emerged and created from debris of an asteroid that approached Saturn and then was disintegrated by gravitational and centrifugal forces. Obviously this theory contains some mystical argument, although some succeeded to describe such approach by using a rich set of mathematical tools available. According to another opinion, the rings could emerge from particles of a protoplanetary cloud surrounding the planet. Or, the cloud consisting of the rings could be filled up by residue of destroyed celestial bodies approaching Saturn. Gravitational, magnetohydrodynamic and plasma effects near Saturn were thoroughly studied, but no explanation of the stable long-term existence of the rings and the fundamental properties of their particles was obtained. All these theories were of an uncoordinated nature. Up till now it remained unclear how the disk sombrero of Saturn consisting of rings and gaps could emerge from a protoplanetary cloud at the planet's equator.

At the same time electromagnetic interactions are known to be very important in the Solar system and particularly for Saturn. Alfven (1981, 1983) and other scientists pointed this out in their works.

Also the particles of the rings do not stick together. In 1994 Pospelov and Tchernyi, speaking at an international conference, put forward a hypothesis of possible superconductivity of the ice particles of the rings. This is principally possible, because they are warmed by the Sun weakly and have been retaining their temperature of about 70-100 K for a long time. Such assumption is also based on the fact that in laboratories they has been produced a wide spectrum of frozen multi-component substances possessing high-temperature superconductivity as was discovered in 1986 (Bednorz & Müller). Physicists in the Ural in Russia experimentally demonstrated in a laboratory in the same year that ice could possess superconductivity at both lower temperatures and high pressures (Babushkin et al., 1986). Ice is a complex formation, of course. A huge number of its modifications exist on Earth (Maeno, 2004). Yet, the knowledge about outer space ice is very limited. Superconductivity of C_{36} has been conjectured just recently (Côté et al., 1998). So, even 7% of a glassy carbon composition of Saturn rings may contribute to its superconductivity. In 2011 scientists lead by Deutscher demonstrated how the exceptional large scale superconductor disc frozen with liquid nitrogen is trapped in a surrounding magnetic field and can be made to hover over a magnet in any position with any movements.

In physical terms, the rings particle superconductivity means that the particles push the inner magnetic field out, while the magnetic field between the particles pushes them apart and they do not stick together. In 1933 Meissner and Ochsenfeld discovered the effect of a magnetic field being pushed out of a superconductor.

The specificity of the proposed theory that the rings of Saturn came into being due to the existence of superconductive properties of the ring particles lies in the fact that it does not reject previously obtained knowledge, but augments it with newly discovered physical effects. It then integrates this knowledge and allows one to get a physically real picture and to answer the question how did the rings emerge.

Besides, the gravitational, hydrodynamic and plasma interactions do not become subject to decomposition, but are just augmented with the properties of behavior of superconductive particles in the heterogeneous magnetic field of Saturn.

The scenario of the origination of the disk system of the rings of Saturn looks as follows. Before the planet acquires its magnetic field the particles move within the protoplanetary field around the planet at different orbits according to Kepler's laws, with the force of gravitation balanced by the centrifugal force. With the appearance of the planet's magnetic field the superconductivity of the particles starts "to work" and they interact with the magnetic field. As the electrodynamics analysis shows, the superconductive particles of the protoplanetary cloud display ideal magnetism and, obtaining an additional azimuth-orbital movement. As a result the orbits of the particles are drifting to the plane of the magnetic equator, forming disk sombrero. This takes place because in the

magnetic equator plane, which in Saturn practically coincides with the geographic equator, the particles possess the lowest magnetic energy. The huge magnetic moment of Saturn, that is 500 times greater than that of Earth, plays the major role here. Hence it follows that some time, perhaps a very long time as tens of thousands years, after the activation of the planet's magnetic field it was energy-wise beneficial to the orbits of the superconductive particles of the protoplanetary cloud to concentrate and drift to the magnetic equator plane.

The formation of the ring-like structure of the disk, resembling a gramophone record, occurs similar to iron particles creating the areas of thickening and rarefaction in the heterogeneous field of a magnet on laboratory table with the presence of the huge gravity force of the Earth. The magnetic field of Saturn in the ring disk plane is not homogeneous, as each superconductive particle ejects the magnetic field out of its volume, according to Meissner-Ochsenfeld effect.

The force lines of the magnetic field strive toward circuitry through the areas with the highest magnetic field. The compressions of the magnetic flow clear the gaps in the ring disk, disperse the superconductive particles and form separate structures that look like rings. The density of magnetic field in the ring will be lower than in the space of gaps surrounding it. The difference of the magnetic field densities on the borders of the rings cause magnetic pressure directed inside the ring and therefore the edges of the rings look sharp.

The formation of the specific picture of rings and gaps is affected by the influence of gravitational effects that are called orbital resonances, caused by the presence of Saturn's satellites (Gor'kavyi & Fridman, 1994), as well as due to big fragments and moons in the rings, that emerged as a result of collisions and sticking together before the appearance of the magnetic field of the planet.

The electromagnetic model of a possible role of the superconductivity of the ring particles in the formation of the system of the rings, proposed by Pospelov and Tchernyi in 1994, 1997, mathematically extended by Tchernyi and Chensky in 2005 and finalized by Tchernyi in 2013 surprisingly can explain many experimental data of land-based tests and NASA space probes Pioneer, Voyager 1 and 2 and Cassini-Huygens (Tchernyi & Chensky, 2005; Tchernyi, 2013).

Mathematic consideration of the origin of Saturn rings shows that if we will place the origin of the coordinates at the center of the planet and directing the z-axis along the magnetic moment of the planet (orthogonal to equator), the expression for magnetic energy then becomes:

$$U_H = R^3\mu^2(3\cos^2\theta+1)r^{-6}$$

Here θ - the angle between the vector r and the z-axis, R – the radius of the superconducting sphere located within the protoplanetary cloud, μ - the planetary magnetic moment. It can be seen from the expression that the magnetic energy of the superconducting particle has a minimum value when the radius-vector r (the position of the superconductive particle) is in a plane of the magnetic equator and is perpendicular to the z-axis ($\cos\boldsymbol{\theta} = 0$). Consider now only one particle. Evidently its azimuth-orbital direction trajectory (orbit) can only be disturbed by the magnetic field. However in case of a significant amount of particles forming the protoplanetary cloud, after a transient time, collisions between particles will compensate their azimuth-orbital movements, and as a result all orbits of the particles of the protoplanetary cloud should come together to the magnetic equator plane and create highly flattening disc around the planet. Within the disc of the rings all particles will become located on the Keplerian orbit where there is a balance of gravity, centrifugal and electromagnetic forces. At the same time orbital resonances (due to a gravity force) between satellites, moons and the ring particles would play an important role in forming a specific structure of the rings and gaps.

Tchernyi and Chensky (2005) estimated an interaction of two superconducting particles for two different cases. The first one is when two particles located in the same plane within the sombrero of the rings. It follows that both particles will repel each other and they will maintain a separate distance between them. This result has been confirmed by the data of Cassini mission: the particles are separated. The second situation is when two particles are located on the different planes but on the same axis. Now both particles could attract each other and they could even collide or stick together and form bigger clusters or lumps of ice. This process has an experimental conformation by the Cassini mission. From the data of the Cassini mission it follows that the particles within the thickness of the rings can collide or even stick together and create bigger clusters of ice. Then, in the following process, particles of 50 meters or more in diameter can be shattered into smaller pieces by a combined action of gravity and centrifugal force.

It also becomes clear (see, e.g., Pospelov, Girich, & Tchernyi, 2005, 2007, 2008, 2009, 2000; Tchernyi & Pospelov, 2005, 2007; Tchernyi & Chensky, 2005; Tchernyi, 2006, 2009, 2010, 2011, 2012, 2013) why the particles of the rings do not stick together, but sometimes the particles collide; why the rings exist only around

the planets behind the belt of asteroids where the temperature is favorable to the acquisition of superconductive properties by substances; why the reflection of circular polarization microwaves from the rings occurs as if from a superconductor that is a magnetic mirror; why there is a broad-band discrete non-polarized radio-emission in the range of 20.4 kHz through 40.2 MHz, which can be explained by non-stationary Josephson effect for superconductors; why an anomalous behavior of the dependence of the thermal emission of the rings in the range from 10 mcm through 1 cm is observed, which is also characteristic of superconductors; why there is an atmosphere of "unknown" origin near about the rings, which can be explained by diamagnetic expulsion of gas molecules due to the molecular magnetic moments induced in the superconductive particles; why waves of density and waves of bending exist in the rings, which can be explained as a generation of parametric oscillations by ponderomotive forces emerging in the situation the outer magnetic field directed in tangent toward the free surface of a group of the superconductive particles and across to the phase lines.

3. Conclusion

It is also clear also that the planets between the Sun and the belt of asteroids cannot have rings, because this space is well warmed by the Sun and the temperature destroys any superconductivity. Rings can exist only around magnetic field-possessing planets behind the belt of asteroids (Jupiter, Saturn, Uranus and Neptune), and appearance of the rings depends on the specifics of the substance of a protoplanetary cloud as well as physical and especially electromagnetic parameters of a planet.

Intriguing fact is that presented above scenario of the rings origin for the Saturn is applicable for the other planets: Jupiter, Uranus and Neptune, because the physical conditions of these planets in general look the same due to existence of the magnetic field and low temperature environment. As a result, we obtain a unified theory of the origin of the planetary rings.

A consequence of the proposed theory of the origins and formation of the rings of Saturn is the fact that some unified picture of electromagnetic interactions in the solar system takes shape, which makes it possible to confirm Alfven's opinion that the history of the origins of the Solar system at the earlier (cold) stage of its development might lie in the very process of origination and emergence of the rings of Saturn (Alfven H. 1981, 1983). It is obvious also that a new direction in science of astrophysics for the studies of superconductivity of the space matter behind the belt of asteroids and in the outer space has come into being (Tchernyi & Pospelov, 2005, 2007; Tchernyi & Kapranov, 2005; Tchernyi, 2013).

Further research will determine whether this new electromagnetic theory of the origin of Saturn rings from superconducting iced particles of the protoplanetary cloud is just a model or it will become real. It is important that the very idea of superconductivity of the particles of the rings looks new and attracts scientific interest. Also it is appropriate that this new theory of the origins of the rings of Saturn does not force other authors into abandoning the studies already conducted, but augments them and even unifies them, revealing a possible nature of the planetary rings' origins.

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