

## THE ROLE OF DIAMAGNETISM OF ICE PARTICLES OF SATURN'S PROTOPLANETARY CLOUD TO THE RINGS ORIGIN. V. V. Tchernyi<sup>1</sup>, S. V. Kapranov<sup>2</sup>, A. Yu. Pospelov<sup>3</sup>, E. V. Chensky<sup>1</sup>, U. B. Milovanov<sup>1</sup>, <sup>1</sup>Modern Science Institute, SAIBR, Osennii Blvd., 20-2-702, Moscow, 121614 Russia, chernyv@bk.ru,

<sup>2</sup>A.O. Kovalevsky Institute of Biology of the Southern Seas, Russian Academy of Sciences, Moscow, 119991 Russia, sergey.v.kapranov@yandex.ru, <sup>3</sup>Independent Researcher, Los Angeles, USA, apospelov@hotmail.com

**Introduction:** The presence of Saturn's magnetic field and low temperatures of near the rings lead us to the idea of diamagnetism of the rings particles. Cassini found 93% of ice in the particles of rings. Knowledge about space ice is weak. We know 17 kind of ice on the Earth. Ice of XI kind has stable parameters at the temperature of the rings and it is diamagnetic [1]. The rings could have originated from ice particles moving along chaotic orbits around Saturn within protoplanetary cloud after the planet magnetic field was emerged. After the force of diamagnetic expulsion of ice particles appeared, all their chaotic orbits start to shift to the magnetic equator plane, where the minimum of magnetic energy of the particles is observed. Every particle on the magnetic equator comes to a stable position, and it prevents its horizontal and vertical shift. The particles are trapped in a three-dimensional magnetic well. The picture of the rings within magnetic equator plane resembles the picture of iron particles on a laboratory table around a magnet. The role of magnetic field unites both illustrations of these phenomena. Other effects of the rings origin are considered earlier may contribute some features to the final picture of the rings. The existing knowledge about rings origin is not denied, but complemented by the new one.

**The problem of the rings origin may be solved with diamagnetism of ice particles:** Questions about origin, evolution, and age of Saturn's rings are without answers, since Galilei has first seen them in 1610 [2]. The rings origin well-known explanation is based upon the gravitational defragmentation of a massive body was approached to Saturn [3]. This scenario is lacking how the sombrero disk of the rings is turned out so well constructed with separated particles and a thin structure. It does not explain either electromagnetic phenomena in the rings. Once compare the ratio of the thickness of the rings to their diameter with the ratio of the thickness of the paper sheet to its length, then the relative thickness of the disc of the rings is a thousand times less. It is a challenge that a thin film of ice particles of a huge diameter hangs in outer space. This is an emphasis on the important role of other interactions in the origin of rings, which have not been described yet. The theoretical concept is that after the emergence of the magnetic field of Saturn and the force of the diamagnetic expulsion for ice particles, all chaotic orbits of particles inside the protoplanetary cloud have begun to shift to the magnetic equator plane. As a result, all particles formed a system of rings. As a result, all par-

ticles formed a system of rings. The gravitational force in the particle's orbit is balanced with the centrifugal force and with the force of diamagnetic expulsion.

The problem to solve is how the interaction of Saturn's magnetic field with diamagnetic ice particles of the protoplanetary cloud of Saturn all orbits of ice particles can move in the magnetic equator plane and create a system of rings (please, see scenario of this transformation on Fig.1). All the ice particles should be trapped inside a three-dimensional magnetic well in Saturn's magnetic equator plane at the end of the movement.

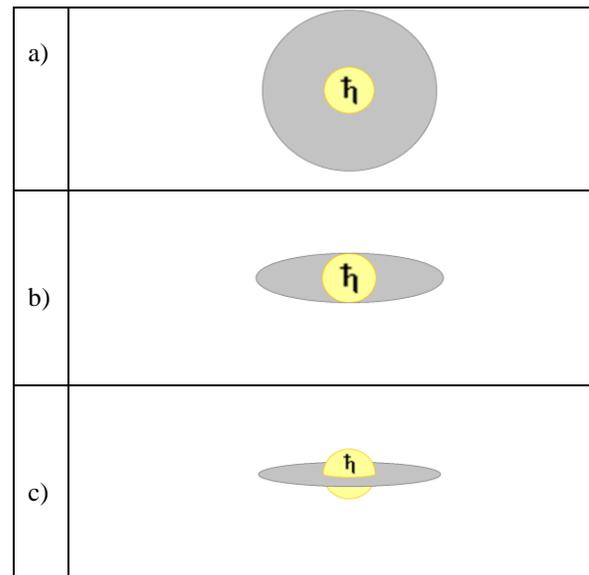


Fig. 1. Transformation of Saturn's protoplanetary cloud into a disk of rings next to the appearance of Saturn's magnetic field and interaction of it with the iced particles: from (a) >> (b) >> (c)

This process implementation uses the theory of V. Safronov "Evolution of the protoplanetary cloud and formation of Earth and planets", NASA, 1972. There is the process of Magnetic Anisotropic Accretion when magnetized diamagnetic particles under the action of Saturn's magnetic field within the protoplanetary cloud are collapsing into the disk of rings with separated particles in the magnetic equator plane [4]. Mathematical solution of the problem is based on the fundamental theory presented in the article of V. Tchernyi and S. Kapranov [6, 7].

At the beginning, the problem of a solitary magnetized

sphere located in an external magnetic field is solved. Next, a model of spatially separated densely packed particles of the rings of Saturn in the form of uniformly magnetized identical spheres in a disk-like structure was developed. As a result, the magnetization and magnetic moment of the disk-shaped structure exceeds similar values for a single sphere because of the coincidence of the magnetic moments of the dipoles with the field. The force of diamagnetic expulsion from the disk-shaped structure to the region of weak magnetic fields is stronger, and the potential barrier at the magnetic equator is larger.

The solution is that all particles end up moving into the magnetic equator of Saturn, which explains the significant flatness of the disk of the rings. The essential flatness and stability of the particles in the rings cannot be provided only by the accretion of ice particles in a spherically symmetric gravitational field. This problem has a solution with the axisymmetric magnetic field at the equator of which the magnetic energy of particles has a minimum value. At the same time, its influence increases with decreasing particle size. Solution for the azimuthal velocity of a particle shows the gravitational force in the orbit of the particle is balanced by both the centrifugal force and the force of diamagnetic expulsion.

The magnetic field in the plane of the disk of the rings is significantly inhomogeneous. Its lines tend to pass through the region with the highest magnetic permeability, and particles gather in areas with a low magnetic field density. The flow of magnetic flux density gradient repels particles from each other and it also clears gaps inside the ring system. This creates a rigid thin structure of separated rings.

The presented scenario of the origin of rings saying it is not only gravity that is responsible for the rings' origin. It means the existing gravity theory of the origin of the rings is not able to present a complete picture of the process.

The formation of the ring pattern is a result of the interaction of diamagnetic ice particles with the inhomogeneous magnetic field of Saturn. After the appearance of the magnetic field of Saturn collisions of the movement of a huge number of particles of the protoplanetary cloud will compensate for their azimuthal-orbital motion and all the orbits of the particles come to the magnetic equator plane. The particles are located in Kepler's orbits where is a balance of gravity force, centrifugal force, and force of diamagnetic expulsion.

The presence of spokes in the *B* ring is as follows: small particles come to Saturn's magnetic field anomalies and change their position, the observer sees this effect as a spokes.

**Conclusion:** The theory of the rings origin and particle stability is supported by the data of the Cassini mission to Saturn, it is proposed hereby. It considers that magnetism plays an important role in the origin, dynamics,

and evolution of Saturn's rings. [4-7].

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