

Modeling of the Saturn's Rings Origin and Separation of their Particles

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Several theories that have been developed to date to explain the evolution and stability of Saturn's rings postulate that the orbits of the ring particles are close to the equatorial plane of the planet, but none of these approaches consistently explains this peculiarity [Porco, C. 2017, SciAm, 317, 78]. There are few known models of the origin of Saturn rings: a moon of the planet could have been disrupted by a passing celestial body; the rings could have been generated by the particles separated from moons of the outer planets by collision with comets or meteorites; the ring particles can be debris of a large comet tidally broken by the planet; the rings can be the relic of a protosatellite disk; the particles can be continuously forming as a result of volcanic activity on a moon of the Saturn. But none has provided a convincing explanation for rings observed peculiarities among Solar System bodies [Crida, A., Charnoz, S. 2010, Nature, 468, 903]. Cassini measured that the particles of rings mostly consists of water ice, 93% [Poulet, F., Cuzzi, J.N. 2002, Icarus, 160, 350] and 90 to 95% [Cuzzi, J.N., et al. 2010, Science, 327, 5972, 1470]. Also Cassini found the ratio of deuterium and hydrogen isotopes for the ice of Saturn's rings is the same as for the Earth's ice [R. Clark et al. 2019, Icarus, 321, 791]. This fact indicates the similarity of ice in the rings and Earth's ice. There are 20 known types of the Earth's ice. We can choose ice XI [Hemley, R.J. 2000, Annu. Rev. Phys. Chem., 51, 763], which is suitable for the environment of Saturn's rings. It has stable parameters below 73K and is diamagnetic [Tchernyi, V., Kapranov, S. 2021, RNAAS, 5, 255]. Taking into account these facts, we found a solution to the problem of the interaction of the gravitational field and the magnetic field of Saturn with the ice particles of the protoplanetary cloud [Cherny V., Kapranov S. 2020, APJ, 894, 1]. An interesting fact is taking into account the magnetic field of Saturn explains the transformation of a protoplanetary cloud into a disk of rings as well as it accounts for strong planar structure of rings located at the magnetic equator of Saturn which is almost coincide with geographical one. Then it became clear that Saturn can create rings from the ice particles of the protoplanetary cloud with its own magnetic field due to the action of an additional third force of diamagnetic expulsion and the mechanism of magnetic anisotropic accretion [Tchernyi, V., Kapranov, S. 2021, arxiv.org/abs/2104.03967]. An interesting fact is that under the influence of the planet, the particles of the rings remain separated, while the particles themselves try to stick together using their own gravity. In this presentation we discuss how Saturn's magnetic field can contribute to the separation of particles of the rings even under the influence of periodically changing gravity of Saturn.