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On the dynamics of Saturn's spirally wound F-ring edge.

Described by using
the Maxwell Analogy for gravitation.

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Abstract

The F-ring of Saturn shows a spirally wound edge. I have deduced its qualitative behaviour in section 2.4 of "*New Evidence for the Dual Vector Field Theory for Gravitation (Cassini-Huygens Mission)*" . These spirals form regular buds with an amplitude and a wavelength. The aim of this paper is to show the relationship between the physical dimensions of the buds and the orbital velocity of the F-ring's edge.

Keywords: Saturn – gravitation – gyrotation – F-ring.
Method: Analytical.

1. The Maxwell Analogy for gravitation: equations and symbols.

For the basics of the theory, I refer to : "*A coherent double vector field theory for Gravitation*". The most relevant parts are summarized hereafter.
The laws can be expressed in equations (1.1) up to (1.6) below.
The electric charge is then substituted by mass, the magnetic field by *gyrotation*, and the respective constants are also substituted. The gravitation acceleration is written as $\boldsymbol{g}$, the so-called *gyrotation field* as $\boldsymbol{\Omega}$, and the universal gravitation constant out of $G^{-1} = 4\pi\,\zeta$, where G is the universal gravitation constant. We use sign $\Leftarrow$ instead of = because the right-hand side of the equations causes the left-hand side. This sign $\Leftarrow$ will be used when we want insist on the induction property in the equation. F is the resulting force, v the relative velocity of the mass m with density ρ in the gravitational field. And $\boldsymbol{j}$ is the mass flow through a fictitious surface.

$$\boldsymbol{F} \Leftarrow m\,(\,\boldsymbol{g} + \boldsymbol{v} \times \boldsymbol{\Omega}\,) \qquad (1.1)$$

$$\nabla \,.\, \boldsymbol{g} \Leftarrow \rho \,/\, \zeta \qquad (1.2)$$

$$c^2\, \nabla \times \boldsymbol{\Omega} \Leftarrow \boldsymbol{j} \,/\, \zeta + \partial \boldsymbol{g} \,/ \partial t \qquad (1.3)$$

$$div\, \boldsymbol{j} \Leftarrow -\, \partial\rho \,/\, \partial t \qquad (1.4)$$

$$div\; \boldsymbol{\Omega} \equiv \nabla .\, \boldsymbol{\Omega} = 0 \qquad (1.5)$$

$$\nabla \times \boldsymbol{g} \Leftarrow -\, \partial \boldsymbol{\Omega} \,/\, \partial t \qquad (1.6)$$

It is possible to speak of gyrogravitation waves with transmission speed c.

$$c^2 = 1 \,/\, (\,\zeta\, \tau\,) \qquad (1.7) \qquad \text{wherein} \qquad \tau = 4\pi\, G/c^2.$$

2. The F-ring.

2.1 Visual properties of the F-ring.

The F-ring is much larger in shape then the many other thin rings. The inside structure is also finer and foggy. It is made of gasses, which are shaped as spirally wound, regular buds.

A recent photograph by the Cassini-Huygens Mission shows them clearly.
Let us call the wavelength L and the radius of the tiny ring r_F (see fig. 2.1).

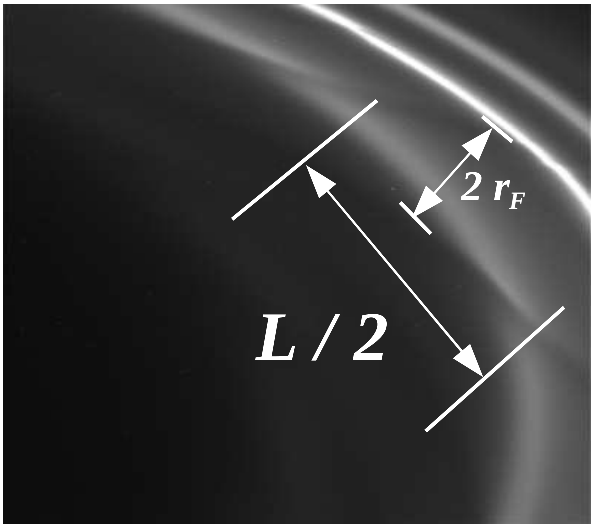

Fig. 2.1 a. F-ring : detail *(ESA / NASA)*

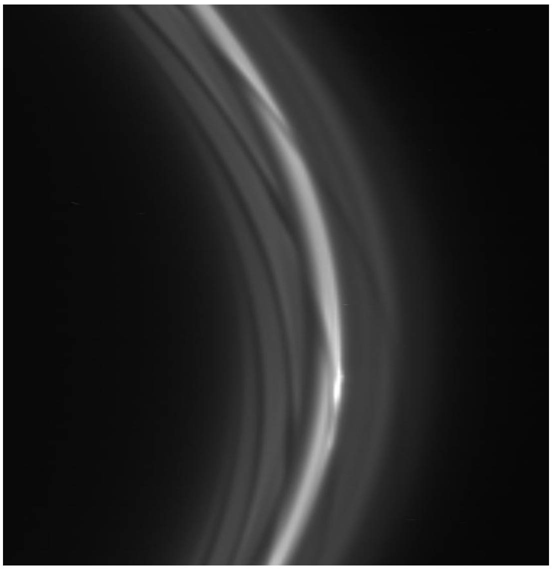

Fig. 2.1 b. F-ring : detail *(ESA / NASA)*

2.2 Defining the gyrotation field of Saturn and the swiveling of the global ring.

Consider a rotating sphere, enveloped by its gravitation field, and at this condition, we can apply the analogy with the electric current in closed loop, integrated over the sphere. *(Reference: Richard Feynmann: Lecture on Physics)*

The result for the equatorial gyrotation Ω at a distance r from the centre of the sphere with radius R is given by the equation (see "*A coherent dual vector field theory for gravitation*" equation (4.3) where $\omega \bullet r = 0$) :

$$\Omega = \frac{G\, m\, R^2}{5\, r^3\, c^2}\,\omega \qquad (2.1)$$

where ω is the angular rotation velocity of Saturn, R its radius and r the orbital radius of the F-ring. This gyrotation field points exacty opposite to the rotation vector of Saturn.

This gyrotation field generates a force on the moving particles in the F-ring.

In my paper "*Cassini-Huygens Mission: New evidence for the Gravitational Theory with Dual Vector Field*" , section 2.4 , is explained how we come to small successive rings. In the beginning, there was a cloud around Saturn, which rotated around the planet. These individual orbits swivelled all to the equator, due to Saturn's gyrotation field, and they formed a huge, flat disk.

Just for information, note that in "*Swivelling Time of Spherical Galaxies Towards Disk Galaxies*" I explained the proces of swiveling, and I calculated the swiveling time for a disk galaxy. Adapted for the Saturn's disk, this gives:

$$T = \frac{c}{\omega R}\sqrt{\frac{r^3}{G\,m}} \qquad (2.2)$$

The swiveling time T is fully related to Saturn's dynamics and the position of the cloud's particle. The equation (2.2) is an average for the totality of the particles laying at a distance r from Saturn's centre. At a time T, half of the particles have reached equator for the first time. They will then perform an extinguishing harmonic motion around the equator. After a time of $2T$, all the particles at the distance r have reached the equator for the first time.

2.3 The creation of spirals in the gas ring.

The original global disk has a global gyrotation field which collide with the circumferential path of the section's surface. For the detailed explanation, see "*New Evidence for the Dual Vector Field Theory for Gravitation (Cassini-Huygens Mission)*" at section 2. The most relevant parts are summarized hereafter.
Moons (larger objects) captured some matter of this ring inside its orbit, creating gaps.

At first, the rings at the edges, near the gaps were split off from the global ring. These outer tiny rings are larger, because the global gyrotation field is then the largest. With each split-off, this global gyrotation field becomes smaller.

The orbital velocity of the ring generates a circumferential gyrotation field as well, as shown in fig. 2.2.

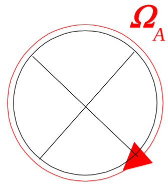

Fig. 2.2

The spirally wound waves in the F-ring are generated by the following effect. At the upper side of the equator, the gyrotation field has a small equatorial component, pointing outwards from Saturn's origin, as shown, exaggerated, in fig. 2.3.a and 2.3.b. Each particle of the ring has (almost) the same orbital velocity: the edge that is closer to Saturn, lays in a zone of higher orbital velocity, and the other edge, away from Saturn, lays in a zone of lower orbital velocity.
But the gas particles are in constant motion. A random gas velocity v, pointed as shown in the fig. 2.3.a and 2.3.b will be deviated as shown. The analogous happens with the fig. 2.3.c and 2.3.d.

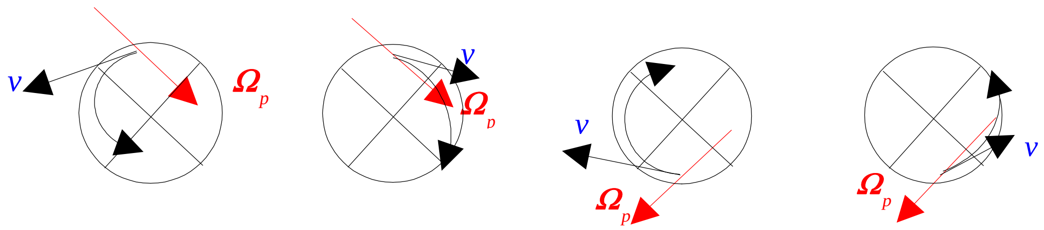

Fig. 2.3.a Fig. 2.3.b Fig. 2.3.c Fig. 2.3.d

Remark that when random gas velocity v is pointed towards Saturn, the orbital velocity will increase since it comes into a higher orbit, such as shown in fig. 2.2.a and 2.2.c. The orbital velocities decrease in fig. 2.2.b and 2.2.d , resulting in a smaller deviation.
Thus, random gas velocities pointed towards Saturn slow down the ring's orbital speed, random gas velocities pointed away from Saturn increase the ring's orbital speed.

The result is that we get two large spirally wound motions in fig. 2.2.b and 2.2.d , and two more internal spirally wound motions in fig. 2.2.a and 2.2.c. The spirals get a contrary motion two by two.
Due to these motions, four outcomes remain possible :

1) The four motions are totally symmetric, causing a turbulence in the gas ring.
2) & 3) One of the motions, right or left spiral is dominant because of an original asymmetry in the ring.
4) A double ring is created : one is a left spiral at the northern side, and one is a right spiral at the southern side. The both ring's equatorial zone is a common region.

We expect that 1) is the starting situation, and that one of the other situations is following after that. For gas rings, the latter outcome should be more likely.

2.4 Further qualitative dynamics' study of the double twisted F-ring

Let us study the global motion of the gasses in the F-ring more in detail. In fig. 2.4 , the F-ring is shown as the section of a tore, with different orbital radii r_i.

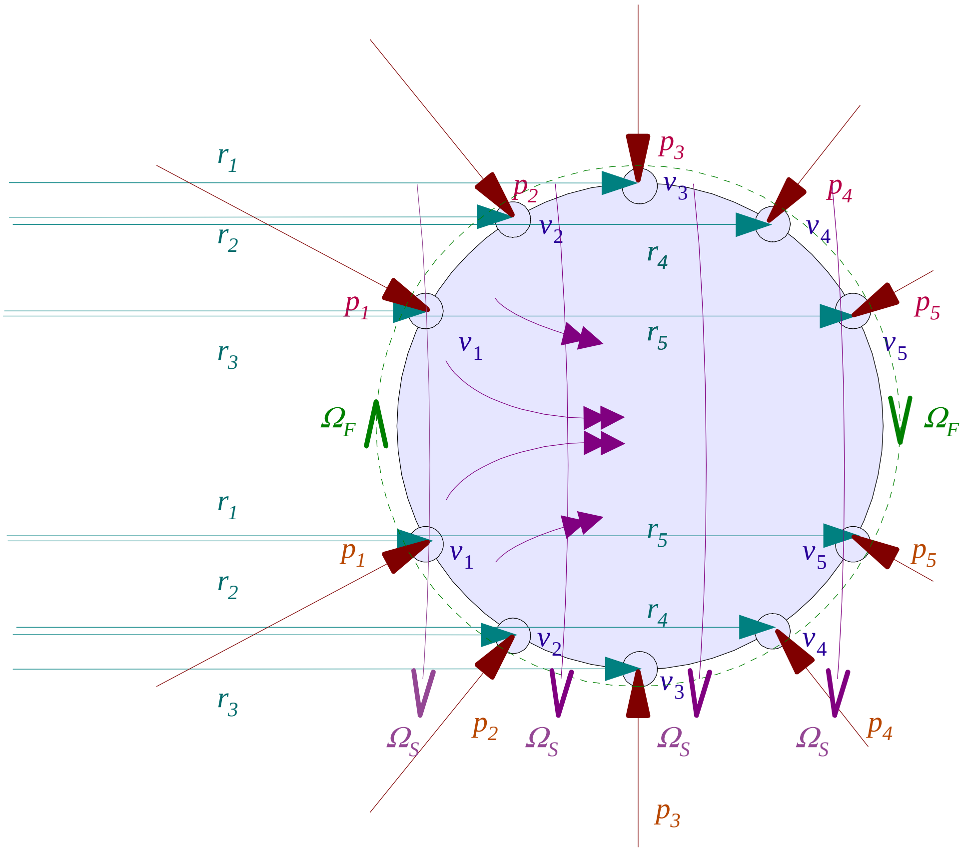

Fig. 2.4 : section of the F-ring, schematic view. The orbital radii , orbital velocities' gradient, gyrotations, the pressure gradient and the global motion inside the cloud are shown.

A section is shown with velocities v_i , perpendicular to the paper and pointing away from the reader. Due to the finite size of the section, the orbital velocities follow the rule:

$$v_i = \sqrt{\frac{G\,m}{r_i}} \qquad (2.3) \qquad \text{and} \qquad v_1 > v_2 > v_3 > v_4 > v_5 \qquad \text{because} \qquad r_1 < r_2 < r_3 < r_4 < r_5$$

Saturn's gyrotation Ω_S will induce an acceleration to the left for the whole section, and tend to extend the left side of the section to the left, where the velocities are higher. This will flatten the tore.

Due to the orbital velocity of the F-ring, a circular (rather elliptical) gyrotation Ω_F is created as well. Using (1.1) , where the gravitational term, which is pointing to the section's centre can be omitted, it is clear that for the corresponding pressures, we get :

$$p_1 > p_2 > p_3 > p_4 > p_5$$

since a_i are the corresponding accelerations according (1.1) : $$\boldsymbol{a_i} = \boldsymbol{v_i} \times \boldsymbol{\Omega_F} \qquad (2.4)$$

In superposition of the effect, shown in fig. 2.3 , we get another effect: the left pressures will induce a motion as shown in fig. 2.4 by the double arrows.
This motion is an acceleration which can be deduced from (2.4). Therefore we need the value of the orbital velocity which follows from (2.3), and the gyrotation Ω_F .
In "*A coherent double vector field theory for Gravitation*" , section 13, it follows that :

$$2\pi \boldsymbol{r_F} \boldsymbol{\Omega_F} = \frac{4\pi G}{c^2} \underline{\boldsymbol{m}}_F \boldsymbol{v_i} \qquad (2.5) \qquad \text{or} \qquad \boldsymbol{\Omega_F} = \frac{2\pi\rho G \boldsymbol{r_F} \boldsymbol{v_i}}{c^2} \qquad (2.6)$$

where v_F can be v_1 for example. The acceleration becomes: $$\boxed{\boldsymbol{a_{F,\Omega}} = 2\pi\rho G \boldsymbol{r_F} \frac{\boldsymbol{v_1^2}}{c^2}} \qquad (2.7)$$

Indeed, the value of the gyrotation Ω_F slightly varies from place to place, depending from the choice of v_i . At the left side of fig. 2.4 it is larger than at the right side.
In (2.7) , ρ is the density of the cloud, supposed to be homogene for simplicity, which depends also from its temperature. This parameter is not within the scope of this paper.
Although this acceleration might appear very small, the actual velocity of the double spiral became very significant after many years. It is acceptable to assume that at this moment, the maximum possible dynamics have been reached in order to maintain the spirally wound cloud together by their own gravitation forces.
In the section hereafter, we try to find the relationship between the buds' shape and the velocities in the F-ring.

2.5 Relationship between the buds shape and the velocities in the F-ring.

The acceleration of (2.7) will result in a double spiral, one in the northern part, one in the southern, with mutually inversed rotations. At the surface of the cloud, a finite curved velocity will be reached, creating so a centripetal force, which will be in balance with the gravitational force.
Let us call $v_{F,\Omega}$ the elliptical velocity of the spiral motion, in the plane of the section in fig. 2.4 , which has been created by (2.7). For a specific point P at the extremity of the cloud, this velocity must be in balance as follows:

$$G \int \mathrm{d} \frac{\boldsymbol{m_F}}{\boldsymbol{r_F^2}} = \frac{\boldsymbol{v_{F,\Omega}^2}}{\boldsymbol{r_F}} \qquad (2.8)$$

The left hand is the integration of the gravitation field of a infinite plain cylinder for a point P at its surface. Since this integral is hard to find, I will use an artifact.

The infinite plain cylinder can be approached by a succession of spheres, while guarantying the same volume and thus masses. Since the gravitation field of a sphere is easy to find (point mass equivalence), the result is then easy to find and fairly correct.

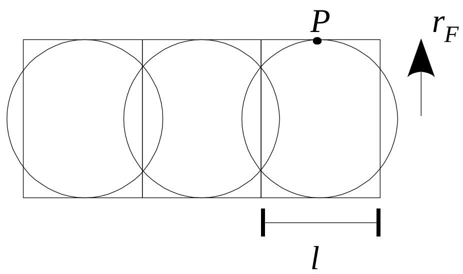

Fig. 2.5 : approximation of a long cylinder by spheres.

To guaranty a same volume, it is needed that : $$\frac{4}{3} r_F = l \qquad (2.9)$$

It can be found, that using the artifact of fig. 2.5 , the following integral is found for the left hand of (2.8).

$$G \int \mathrm{d} \frac{m_F}{r_F^2} = \frac{4}{3} \pi G \rho r_F \left(1 + 2 \sum_{i=1}^{\infty} \frac{1}{\left(1 + \left(i \frac{4}{3} \right)^2 \right)^{3/2}} \right) \qquad (2.10)$$

The series converge very quickly, so that the equivalence of the tore and the infinite plain cylinder becomes acceptable.
Solving the figures part, and using the right hand of (2.8) , this gives :

$$\boxed{v_{F,\Omega} = 2{,}57\, r_F \sqrt{G \rho}} \qquad (2.11)$$

This is the maximum value of the elliptical velocity of the double spiral motion in the section of fig. 2.4.

There is also another phenomena to consider. The time t , needed for a particle to describe a full spiral cycle, must be equal to the time needed (by the same particle) to fulfill a complete orbital wavelength L (see fig 2.1).

Hence, $t = \frac{2 \pi r_F}{v_{F,\Omega}} = \frac{L}{v_{t,\Omega}}$ or, with (2.11) : $$\boxed{v_{t,\Omega} = 0{,}41\, L \sqrt{G \rho}} \qquad (2.12)$$

The parameter $v_{t,\Omega}$ is the orbital velocity of the double spiral motion, with exception of the dragging orbital velocity.
Indeed, it is possible that the whole spiral F-ring is not only screwing through the vacuum, but is also partially dragged as a whole and that $v_{t,\Omega}$ is only a part of the total average orbital velocity (v_3 for example).

$$\boxed{v_{drag} = v_3 - v_{t,\Omega}} \qquad (2.13)$$

The dragging effect can be observed, and both (2.11) and (2.12) can be verified if the density of the F-ring is known.

2.6 Creation of an elliptic halo's at the inner edge of the F-ring.

Although we came to the equations (2.11) , (2.12) and (2.13) as a steady state, indeed these velocities are still under the influence of equation (2.7). Some particles will be lifted farther away from the F-ring, and because of the increase of r_F and the decrease of ρ , the acceleration $a_{F,\Omega}$ will decrease quickly as well. It is then probable that a double halo would be created at the left side of the F-ring in fig. 2.4 (inner edge of the ring) which is a cloud that continuously is pumping gasses from the right side to the left side, and filling the gap next to (left from) the F-ring. At the equator, the gasses have no specific rotation velocity and can thus be attracted again by the F-ring.
There exists a phenomena that avoids the adoption of these gasses by the next tiny ring at the left of the F-ring, which will be explained in a later paper.

3. Discussion and conclusion.

Deduced from the qualitative gyrotation analysis, we come to a double spirally wound F-ring, one in the northern part, one in the southern part, with mutually inversed rotations.
The equations (2.11) , (2.12) and (2.13) describe the relationship between the double spiral dynamics and the buds' geometry of the F-ring. Some of these parameters are public yet, but some parameters should be known somewhere at NASA/ESA.
Remark that these equations are independent from Saturn's parameters, because we calculated the equilibrium at the edge of the F-ring's cloud itself, assuming a maximal possible elliptical velocity $v_{F,\Omega}$. Thus, these equations are purely classical physics.
When all the parameters of (2.11) , (2.12) and (2.13) are known, we have again an indirect proof (to my frustration) of the Gyrogravitation Theory (= the Maxwell Analogy for Gravitation) which has been suggested by Heaviside at the end of the 19th century. Indeed, gravitation only cannot fully explain the double spirally wound parts of the F-ring.
In this paper, the most important equation, which is fully related to the gyrotation fields, is given by (2.7). However, it will probably be hard to detect this property visually because the initial dynamics has evolved to the actual steady state dynamics, which doesn't show this acceleration any more.

4. References and interesting literature.

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