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The observed symmetrical Supernovae remnants form overwhelming evidence for the Gravitomagnetic force

Analytical method – Applications on cosmic phenomena

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Abstract

Supernovae remnants are observed that are double-lobe shaped or double-ring shaped with a central ring. Gravitomagnetism fully explains this kind of explosions of fast spinning stars. We start with the Maxwell analogy for gravitation or the Heaviside field, and we develop the Gravitomagnetic model. The theory explains the deviation of supernova remnants' mass, and it defines the angle of the mass losses at latitudes of 0° and 35°16'.

Keywords. gravitation – star: rotary – supernova – relativity – gyrotation – gravitomagnetism
Methods : analytical
Photographs : ESA / NASA

1. Observation of symmetric Supernovae remnants.

Some observed supernovae have a strange shape. The most impressing ones are Eta Carinae and 1987a.
They have two lobes or two rings and a central ring, generated by an explosion. The lobes or rings have exploded symmetrically at both sides, and the central ring exploded at about the same moment.
In the center of the images, there is a fast spinning star that partially exploded. I will prove here that the origin of these shapes are due to gravitomagnetism.

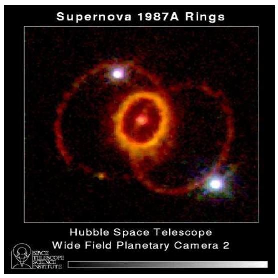


Fig. 1.1: 1987a supernova remnant
Image credits: NASA

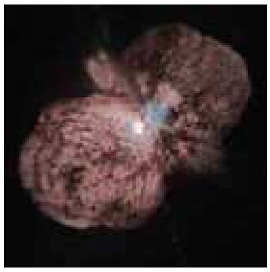


Fig. 1.2: Eta Carinae supernova remnant
Image credits: NASA

Important notice: In literature, the term "gravitomagnetism" is used for the complete set of gravity fields, but also for solely the magnetic part of the set of gravity fields. I prefer the term "gravitomagnetism" for the complete set of gravity fields, and "gyrotation" for the magnetic part of the gravity fields.

2. The Maxwell analogy for gravitation: a short history.

Several studies have been made formerly to find an analogy between the Maxwell formulas and the gravitation theory. Oliver Heaviside predicted the field in 1893. He suggested the existence of a field, as a result of the transversal time delay of gravitation waves. Further development was also made by several authors. L. Nielsen, 1972, deducted it independently using the Lorentz invariance. E. Negut, 1990 extended the Maxwell equations more generally and discovered the consequence of the flatness of the planetary orbits, Oleg Jefimenko, 2000, rediscovered it and deducted time retarded inductions, and M. Tajmar & C.de Matos, 2003, worked on the same subject.
This deduction follows from the gravitation law of Newton, taking into account the time delay caused by the limited speed of gravitation waves and therefore the transverse forces resulting from the relative velocity of masses. The laws can be expressed in the equations (2.1) to (2.5) below.

The formulas (2.1) to (2.5) form a coherent set of equations, similar to the Maxwell equations. Electrical charge is then substituted by mass, magnetic field by *gyrotation* (or "gravitomagnetism"), and the respective constants as well are substituted (the gravitation acceleration is written as $\boldsymbol{g}$, the so-called "gravitomagnetic field" as $\boldsymbol{\Omega}$, and the universal gravitation constant as $G^{-1} = 4\pi\,\zeta$, where G is the "universal" gravitation constant. We use sign $\Leftarrow$ instead of $=$ because the right hand of the equation induces the left hand. This sign $\Leftarrow$ will be used when we want to insist on the induction property in the equation. $\boldsymbol{F}$ is the induced force, $\boldsymbol{v}$ the velocity of mass m with density ρ.

$$\boldsymbol{F} \Leftarrow m\,(\boldsymbol{g} + \boldsymbol{v} \times \boldsymbol{\Omega}) \qquad (2.1)$$

$$\nabla \cdot \boldsymbol{g} \Leftarrow \rho / \zeta \qquad (2.2)$$

$$c^2\, \nabla \times \boldsymbol{\Omega} \Leftarrow \boldsymbol{j} / \zeta + \partial \boldsymbol{g} / \partial t \qquad (2.3)$$

where $\boldsymbol{j}$ is the flow of mass through a surface. The term $\partial \boldsymbol{g}/\partial t$ is added for the same reasons as Maxwell did: the compliance of the formula (2.3) with the equation

$$\text{div}\, \boldsymbol{j} \Leftarrow - \partial \rho / \partial t$$

It is also expected
$$\text{div}\, \boldsymbol{\Omega} \equiv \nabla .\, \boldsymbol{\Omega} = 0 \qquad (2.4)$$

and
$$\nabla \times \boldsymbol{g} \Leftarrow - \partial \boldsymbol{\Omega} / \partial t \qquad (2.5)$$

All applications of the electromagnetism can from then on be applied on *gravitomagnetism* with caution. Also it is possible to speak of gravitomagnetic waves, where

$$c^2 = 1 / (\zeta \tau) \qquad (2.6)$$

wherein $\tau = 4\pi G/c^2$.

3. How to find the value of the "gyrotation field"? Law of gravitational motion transfer.

In this theory the hypothesis is developed that the angular motion is transmitted by gravitation. In fact no object in space moves straight, and each motion can be seen as an angular motion.
Considering a rotary central mass m_1 spinning at a rotation velocity $\boldsymbol{\omega}$ and a mass m_2 in orbit, the *rotation transmitted by gravitation* (dimension [rad/s]) is named *gyrotation (or gravitomagnetism)* $\boldsymbol{\Omega}$. .

Equation (2.3) can also be written in the integral form as in (3.1), and interpreted as a flux theory. It expresses that the normal component of the rotation of $\boldsymbol{\Omega}$, integrated on a surface A, is directly proportional with the flow of mass through this surface.
For a spinning sphere, the vector $\boldsymbol{\Omega}$ is solely present in one direction, and $\nabla \times \boldsymbol{\Omega}$ expresses the distribution of $\boldsymbol{\Omega}$ on the surface A. Hence, one can write:

$$\iint_{\boldsymbol{A}} (\nabla \times \boldsymbol{\Omega})_n \, d\boldsymbol{A} \Leftarrow 4\pi G \dot{m} / c^2 \qquad (3.1)$$

In order to interpret this equation in a convenient way, the theorem of Stokes is used and applied to the gyrotation $\boldsymbol{\Omega}$. This theorem says that the loop integral of a vector equals the normal component of the differential operator of this vector.

$$\oint \boldsymbol{\Omega} .\, d\boldsymbol{l} = \iint_{\boldsymbol{A}} (\nabla \times \boldsymbol{\Omega})_n \, d\boldsymbol{A} \qquad (3.2)$$

Hence, the transfer law of gravitation rotation (*gyrotation*) results in:

$$\oint \boldsymbol{\Omega} .d\boldsymbol{l} \Leftarrow 4\pi G \dot{m} / c^2 \qquad (3.3)$$

This means that the movement of an object through another gravitation field causes a second field, called gyrotation. In other words, the (large) symmetric gravitation field can be disturbed by a (small) moving symmetric gravitation field, resulting in the polarisation of the symmetric transversal gravitation field into an asymmetric field, called gyrotation (analogy to magnetism). The gyrotation works perpendicularly onto other moving masses. By this, the polarised (= gravitomagnetic) field expresses that the gravitation field is partly made of a force field, which is perpendicular to the gravitation force field, but which annihilate itself if no polarisation has been induced.

4. Application 1: Gyrotation of a linearly moving mass in an external gravitational field.

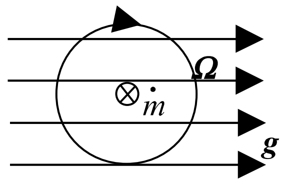
It is known from the analogy with magnetism that a moving mass in a gravitation reference frame will cause a circular gravitomagnetic field (fig. 4.1). Another mass which moves in this gravitomagnetic field will be deviated by a force, and this force works also the other way around, as shown in fig. 4.2.

The gravitomagnetic field, caused by the motion of m is given by (4.1) using (4.3). The equipotentials are circles:

$$2\pi R.\Omega_p \Leftarrow 4\pi G \dot{m} / c^2 \qquad (4.1)$$

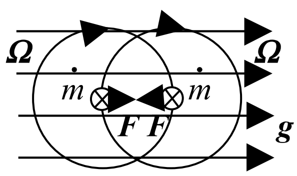
Perhaps the direction of the gravitation field is important. With electromagnetism in a wire, the direction of the (large) electric field is automatically the drawn one in fig 4.1., perpendicularly to the velocity of the electrons.

fig. 4.1



Creation of a gyrotation field about a mass flow.

fig. 4.2



Creation of gyrotation fields and Lorentz forces about two mass flows.

In this example, it is very clear how (absolute local) velocity has to be defined. It is compared with the steady gravitation field where the mass flow lays in. This application can also be extrapolated in the example below: the gyrotation of a rotating sphere.

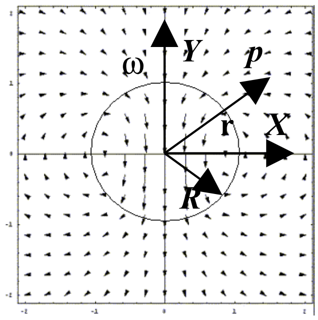
5. Application 2: Gyrotation of rotating bodies in a gravitational field.

Consider a rotating body like a sphere. We will calculate the gyrotation at a certain distance from it, and inside.
We consider the sphere being enveloped by a gravitation field, generated by the sphere itself, and at this condition, we can apply the analogy with the electric current in closed loop.

The approach for this calculation is similar to the one of the magnetic field generated by a magnetic dipole.

Each magnetic dipole, created by a closed loop of an infinitesimal rotating mass flow is integrated to the whole sphere. *(Reference: Richard Feynmann: Lectures on Physics)*

The results are given by equations inside the sphere and outside the sphere:



$$-\Omega_{int} \Leftarrow \frac{4\pi\, G\rho}{c^2}\left[\omega\left(\frac{2}{5}r^2-\frac{1}{3}R^2\right)-\frac{r(r\cdot\omega)}{5}\right] \tag{5.1}$$

$$-\Omega_{ext} \Leftarrow \frac{4\pi\, G\rho\, R^5}{5r^3c^2}\left(\frac{\omega}{3}-\frac{r(\omega\cdot r)}{5}\right) \tag{5.2}$$

(The dot represents a scalar product of vectors)

Fig. 5.2: (Reference: Eugen Negut, www.freephysics.org)
The drawing shows equipotentials of $-\Omega$.

For homogeny rigid masses we can replace the density by using $m = \pi R^3\rho\, 4/3$, and so we get (5.2) transformed as follows:

$$-\Omega_{ext} \Leftarrow \frac{G\, m\, R^2}{5r^3c^2}\left(\omega-\frac{3r(\omega\cdot r)}{r^2}\right) \tag{5.3}$$

When we use this way of thinking, we should keep in mind that the sphere is supposed to be immersed in a steady reference gravitation field, namely the gravitation field of the sphere itself .

6. Application 3: Unlimited maximum spin velocity of compact stars.

6.1. The compression acceleration by gyrotation at the sphere's surface.

When a supernova explodes, this happens partially and in specific zones. The purpose here is to find out why this happens so. Let us consider the fast rotary star, on which the forces on p are calculated (fig. 6.1). We don't want to polemic on the correct shape for the supernova, and suppose that it is still a homogeny sphere. If the mass distribution is different, we will approximate it by a sphere.
For each point p, the gyrotation can be found by putting $r = R$ in (5.2). And taken in account the velocity of p in this field, the point p will undergo a gravitomagnetic force which is pointing towards the centre of the sphere.

$$-\Omega_{R} \Leftarrow \frac{G\, m}{5Rc^2}\left(\omega-\frac{3R(\omega\cdot R)}{R^2}\right) \tag{6.1}$$

The gravitomagnetic accelerations are given by the following equations:

$$a_x \Leftarrow x\,\omega\,\boldsymbol{\Omega}_y = \omega R\cos\alpha\ \boldsymbol{\Omega}_y \quad \text{and} \quad a_y \Leftarrow x\,\omega\,\boldsymbol{\Omega}_x = \omega R\cos\alpha\,\boldsymbol{\Omega}_x \qquad (6.2)$$

To calculate the gravitation at point p, the sphere can be seen as a point mass. Taking in account the centrifugal force, the gyrotation and the gravitation, one can find the total acceleration at the surface of the sphere in terms of the latitude :

$$\boldsymbol{a}_{x\,tot} \Leftarrow \boldsymbol{R}\omega^2\cos\alpha\left(1-\frac{\boldsymbol{G}\,\boldsymbol{m}\left(1-3\sin^2\alpha\right)}{5\boldsymbol{R}\,c^2}\right)-\frac{\boldsymbol{G}\,\boldsymbol{m}\cos\alpha}{\boldsymbol{R}^2} \qquad (6.3)$$

$$-\boldsymbol{a}_{y\,tot} \Leftarrow 0+\frac{3\boldsymbol{G}\boldsymbol{m}\omega^2\cos^2\alpha\ \sin\alpha}{c^2}+\frac{\boldsymbol{G}\boldsymbol{m}\sin\alpha}{\boldsymbol{R}^2} \qquad (6.4)$$

The gravitomagnetic term is therefore a supplementary compression force that will stop the neutron star from exploding. For elevated values of ω^2, the last term of (6.3) is negligible, and will maintain below a critical value of R a global compression, regardless of ω. This limit is given by the Critical Compression Radius:

$$0 = 1-\frac{\boldsymbol{G}\,\boldsymbol{m}\left(1-3\sin^2\alpha\right)}{5\boldsymbol{R}\,c^2} \quad \text{or} \quad \boldsymbol{R} = \boldsymbol{R}_{C\alpha} < \boldsymbol{R}_C\,(1-3\sin^2\alpha) \qquad (6.4)$$

where R_C is called the Equatorial Critical Compression Radius for Spinning Spheres :

$$\boxed{\boldsymbol{R}_C = G\,m\,/\,5\,c^2} \qquad (6.5)$$

R_C is $1/10^{th}$ of the Schwarzschild radius R_S . This means that black holes can explode when they are fast spinning.
The fig. 6.2 shows the gyrotation and the centrifugal forces at the surface of a spherical star. The same deduction can be made for the lines of gyrotation inside the star. Fig. 6.3 shows the gravitomagnetic lines and forces at the inner side of the star. We see immediately that (6.5) has to be corrected : at the equator, the gravitomagnetic forces of the inner and the outer material are opposite. So, (6.5) is valid for $\alpha \neq 0$.

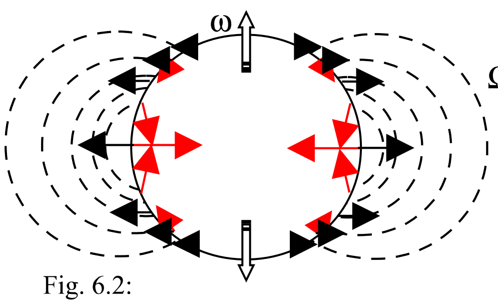


Fig. 6.2:

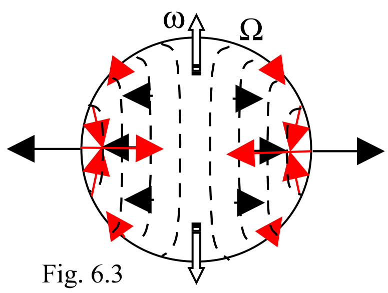


Fig. 6.3

The dotted lines are gyrotation equipotentials, the black arrows are centrifugal 'forces', the red arrows are gyrotation forces due to the spin. Remark that some forces point inward the sphere! These are compressing forces, whatever the spin rate is!

6.2. The symmetrical explosion of the lobes or rings.

From (6.4) also results that the fast rotating stars can partially explode: if $\alpha_C \geq \arcsin\,(3^{-1/2}\,(1-R/R_C)^{1/2})$ or if $\alpha \geq 35°16'$ the Critical Compression Radius becomes indeed zero. Contraction will indeed increase the spin and change the shape to a "tire" or toroid black hole, like some numeric calculations seem to indicate. (Ansorg et al., 2003, A&A, Astro-Ph.).
Hence, there are two symmetric lobes that depart from about $\alpha \geq 35°16'$ due to an explosion. However, for latitudes below $35°16'$, no explosion will ever occur at the exception of the equatorial explosion of next section)

6.3. The equatorial explosion.

Let us simplify the model for rigid and homogeny masses, and look inside the sphere at the accelerations. Using (5.1) and (6.2), and replacing ρ by $3\,m\,/(4\,p\,R^3)$ we find:

$$a_{x,\,tot} \Leftarrow r\ \omega^2 \cos\alpha \left\{ 1 - \frac{Gm}{5\ R^3\ c^2} \left[r^2 \left(6 - 3\ \sin^2\alpha\right) - 5\ R^2 \right] \right\} - \frac{Gm \cos\alpha}{R^2} \qquad (3.8)$$

$$-\ a_{y,tot} \Leftarrow\ 0 + \frac{3\ Gm\ \omega^2\ r^3\ \sin\alpha \cos^2\alpha}{5\ R^3\ c^2} + \frac{Gm \sin\alpha}{R^2} \qquad (3.9)$$

and we see immediately that the condition of section (6.2) has to be amended : at the equator, $\boldsymbol{\Omega}_{\mathbf{y,\,int}}$ becomes in fact zero at $r = (5/(6 - 3\ \sin^2\alpha_{Eq}))^{1/2} R$, which results in $r = 9/10^{th}\ R$ at $\alpha_{Eq,min} = 0°$, and at other values of α_{Eq} , the zero equipotential gradually evolves to $r = R$ at $\pm\alpha_{E,max} = 19°28'$.
Consequently, the centrifugal force will be able to act effectively around the equator area and provoke equatorial explosions of about $1/10^{th}$ of the star's radius.
These very important equatorial ring-shaped mass losses are even possible when $R_{\alpha=0} < Gm/5c^2$ and thus, even when there is a global compression at the equator area.

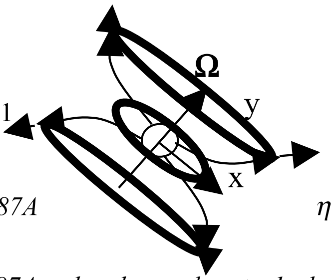
7. Discussion: origin of the shape of mass losses in supernovae.

When a rotary supernova ejects mass, the forces can be described. Due to (2.1) , at the equator the ejected mass is deviated in a prograde ring, which expansion slows down by gravitation and will in the end collapse when contraction starts again, but by maintaining the prograde rings as orbits.

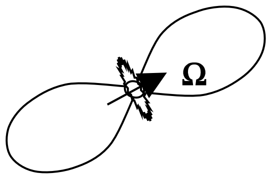
When the mass leave under angle, a prograde ring is obtained, parallel to the equator, but outside of the equator's plane. This ring expands in a spiral, away from the star, because of its initial velocity. The expansion slows down, and will get an angular collapse by the gyrotation working on the prograde motion.

The probable origin of the angle has been given in section 6: the zones of the sphere near the poles (35°16' to 144°44' and -35°16' to -144°44') are the "weakest". Indeed, these zones have a gyrotation pointing perpendicularly on the surface of the sphere, so that the gravitomagnetic acceleration points tangentially at this surface, so that no compensation with the centripetal force is possible. The zone near the equator (0°) has no gravitomagnetic force which could hold the mass together in compensation of the centripetal force.

Fig. 7.1



SN 1987A



η Carinae

SN 1987A: a local mass loss took place on the equator and probably close to the 35° 16' angle. The zone 35°16' to 144°44' exploded possibly much earlier, and became a toroid-like shaped rotary star.
η Carinae : mass loss by complete shells, probably above the 35° 16' latitude, forming two lobes with a central ring.

In the case of SN 1987A, the central spinning star probably was already become a torus instead of a full sphere. Therefore, instead of lobes, only rings can further explode from the star, which are situated around the 35° 16' latitude.

The observation complies perfectly with this theoretical deduction. The supernovae explode into symmetric lobes, with a central disc. Observation will have to verify that these lobes start nearly at a latitude of 35°.

8. Conclusions.

The double-lobe shaped or double-ring shaped supernovae remnants with a central ring that are observed are perfectly explained, in detail, by gyrotation. I defined *gyrotation* as the transmitted angular movement by gravitation in motion. It forms a whole with Newtonian gravitation, in the shape of a vector field wave theory, that becomes extremely simple by its close similarity to the electromagnetism.
Supernovae remnants are predicted to explode at latitudes between 0° and up to 19°28' , which corresponds to the equatorial explosion, and at latitudes above about 35°16' , which form two symmetrical lobes that leave the fast spinning star while spiraling outward, away from the poles.
A deeper analysis (see my paper "On the geometry of rotary stars and black holes"), not in the scope of this paper, shows that the latitude of 35°16' is a limit situation, depending from the spin rate. At low spin rates and with low cohesion forces, the sphere can explode everywhere. But the faster the spin rate, when the matter has got high cohesion forces acting on it, the higher the compression forces are, the closer to the latitude of 35°16' the

explosion will occur. This means that only highly compacted stars such as white dwarfs are qualified to become supernovae.
An advantage of the present theory is also that it is Euclidian, and that predictions are easily deductible from laws that analogous to those of Maxwell.

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