Directional Control of Weight Forces in Rotating Bodies

Fran De Aquino
Professor Emeritus of Physics, Maranhao State University, UEMA.
Tutitor Researcher (R) of National Institute for Space Research, INPE
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The frame-dragging effect tells us that when a body rotates around itself the metric of spacetime around its surface is dragged. This occurs, for example, in the metric of the spacetime around the Earth surface, and produces the well-known phenomenon of shifting of the orbits of the satellites near the Earth. Such as the orbits of the satellites, the force lines of the gravitational field produced by rotating bodies are also affected by the frame-dragging effect. This means that the direction of a gravitational central force in a rotating body should be radially displaced, in respect to their initial position. In this work, we show that the radial displacement angle depends on the angular velocity of the rotating body, and that this fact point to the possibility of controlling the direction of these gravitational central forces, simply by controlling the angular velocity of the rotating body.

Keywords: Gravitation, Experimental studies of gravity, Lense-Thirring effect.

General relativity predicts that rotating objects should drag spacetime around themselves as they rotate. This effect on spacetime is known as frame-dragging. The first frame-dragging effect was discovered by the physicists J. Lense and H. Thirring, and is known as the Lense–Thirring effect [1, 2, 3]. This phenomenon tells us for example, that the Earth drags spacetime around itself as it rotates, and consequently shifting of the orbits of the satellites near the Earth. This fact led to the verification of the mentioned effect by means of satellites, and it was experimentally observed in 2004 by using the LAGEOS satellites [4].

The frame-dragging effect tells us that when a body rotates the metric of spacetime around its surface is dragged at the same direction of the rotation [5]. Due to this phenomenon the force lines of the gravitational field produced by a rotating body are also curved following the curvature of the metric of the local spacetime, similarly to the orbits of the satellites near the Earth.

The bend of the force lines allows us to infer that the direction of a gravitational central force, \( \vec{F} \), in a rotating body, should be displaced due to the curvature of the force lines. Thus, it is to be expected that the direction of the force \( \vec{F} \) describe an angular displacement \( \alpha \), in respect to its initial position (See Fig. 1(b)). Since the magnitude of this angle depends only of the magnitude of the angular velocity, i.e., \( \alpha \propto \omega \), and \( \vec{\alpha} \) has the same direction of \( \vec{\omega} \) (See Fig. 1(b)), then we can write that

\[ \vec{\alpha} = k \vec{\omega} \quad (1) \]

where \( k \) is a constant to be determined. If \( \alpha \) is expressed in \( rad \cdot yr^{-1} \), then \( k \) must be expressed in \( s \cdot yr^{-1} \) because \( \omega \) is expressed in \( rad \cdot s^{-1} \). Note that, \( \alpha \), can be expressed in \( rad \), in this case, \( k \) must be expressed in seconds.

Besides the internal angle \( \alpha_i \), there is also the external angle \( \alpha_e \) (produced by the bending of the internal metric of spacetime (See Fig. 1(b)). Since the arches, defined by \( s = \alpha R, s = \alpha r \), have the same order of magnitude, then, we can write that \( \alpha R \approx \alpha r \) or

\[ \alpha_e \approx \alpha_e (r/R) \quad (2) \]

Substitution of Eq. (1) into Eq. (2) gives

\[ \alpha_e \approx k \omega (R/r) \quad (3) \]

The Gravity Probe B experiment measured the angle \( \alpha_e \), in the case of the Earth. The result is \( \alpha_e (\odot) = 0.041 \text{ arc second} = 1.97 \times 10^{-7} \text{ rad} [6, 7] \). Since Earth’s angular velocity is \( \omega_\odot = 7.29 \times 10^{-5} \text{ rad} \cdot s^{-1} \), then Eq. (3), gives

\[ k \approx \left(\alpha_e (\odot) / \omega_\odot \right) \left( r_\odot / R_\odot \right) = 2.7 \times 10^{-3} \left( r_\odot / R_\odot \right) \quad (4) \]

Since the Earth’s rotation affects the orbits of the satellites near the Earth, and as most these orbits are at altitudes close to 600 km (Gravity Probe satellite was in a typical polar orbit of 642 km altitude [6]), then as \( r_\oplus \) must have a value greater than these values (but close of them), we can infer that \( r_\oplus \geq 1,000 \text{ km} \) (See Fig.1 (b)). Substitution of this value and \( R_\oplus \equiv 6.3 \times 10^3 \text{ km} \), into Eq. (4), gives

\[ \alpha \approx 2.7 \times 10^{-3} \left( r_\odot / R_\odot \right) \]

\[ \alpha \approx 2.7 \times 10^{-3} \left( 642 / 6.3 \times 10^3 \right) \approx 0.04 \text{ arc second} \]

\[ \alpha \approx 0.04 \text{ arc second} \]

Fig. 1 – Schematic diagram of the angular displacement of a gravitational central force, \( \vec{F} \), in a spherical rotating body, due to the bending of the force lines of the gravitational field of the body, consequence of the bending of the metric of the local spacetime produced by the rotation of the body.
\[ k \approx 4 \times 10^{-4} \, \text{s} \]  
(5)

Then, according to Eq. (1), we get \( \alpha_i \approx 4 \times 10^{-4} \, \omega \), whence we conclude that

\[ \omega \approx (2,500 \, \text{rad.s}^{-1}) \alpha_i \approx (23,873 \, \text{rpm}) \alpha_i \]  
(6)

This equation shows that, in order to obtain a significative value of \( \alpha_i \), in this case, the value of \( \omega \) must be very greater than 5,000 rpm.

If the gravitational force \( \vec{F} \) is the weight force, \( \vec{P}_R \), of the rotating body (Rotor), then it can be moved of an angle \( \alpha_i \) in order to produce horizontal displacement to move, for example, cars, ships, trains, etc., or it can be moved to produce an ascending displacement of the body (take-off) as shown in Fig. 2 (a), or in order to produce a descending displacement of the body (landing) as shown in Fig. 2 (b).

\[ \vec{P}_{R(S-R)} \] is the weight of the system without \( \vec{P}_R \).

\[ \vec{P}_{R(S-R)} = \vec{P}_R + \vec{P}_m \]

Fig. 2 – Take-off and landing by means of the control of \( \vec{P}_R \), \( \vec{P}_R \gg \vec{P}_{R(S-R)} \).

The possibility of controlling the direction of weight forces, simply by controlling the angular velocity of the rotating body, can provide a new and powerful technology in order to move cars, ships, trains, etc., or to produce thrust to the flight of an

with the removal of said spherical shells. Thus, by increasing the magnitude of \( \vec{P}_m \) it is possible to increasing the magnitude of \( \vec{R} \).

\[ \vec{R} = \vec{P}_R + \vec{P}_m \]

Fig. 3 – The rotor inside spherical shells. The weight force, \( \vec{P}_m \), increases with the increase of superposed spherical shells added around to the rotor (without touching the rotor).

The phenomenon here described can be easily checked by means of the experimental set-up shown in Fig. 4. By measuring the components \( \vec{P}_x \) and \( \vec{P}_y \) of the force \( \vec{P}_R \) of the rotor, it is possible to calculate the angle \( \alpha_i \).

Fig. 4 – The strength sensors will detect the forces produced by the rotor in the case of an angular displacement of its weight force.
aircraft, without use of any type of fuel. Also, it can be used in a motor (Gravitational Motor), which can transform gravitational energy directly into rotational energy (See Fig.5). Initially, the angular velocities of the mini-rotors are programmed to displace their weight forces, $\vec{P}_R$, of an angle $\alpha_i = 180^\circ$. Thus, the weight $P_m = m_{i0}g$ (See Fig.5) will be displaced of the same angle $\alpha_i$, together with the $\vec{P}_R$, $(\eta P_R \ll m_{i0}g)$.

Under these conditions, the gravity acceleration upon the liquid around the mini-rotors (See Fig.5) is $-\vec{g}$, then it acquires a velocity $v_1$ (in the opposite direction of $\vec{g}$), given by $\vec{v}_1 = \vec{v}_0 + \sqrt{2gh} \approx \sqrt{2gh}$, where $v_0$ is the initial velocity. Then the velocity $v$ is given by $\vec{v} = \vec{v}_1 + \sqrt{2gh} \approx 2\sqrt{2gh}$ (See Fig.5). Therefore, the liquid acquires a kinetic energy $K = \frac{1}{2}m_{i0}v^2$, where $m_{i0}$ is the inertial mass of the liquid. Thus, the power $P$ transported by the liquid is

$$P = \frac{K}{\Delta t} = \frac{1}{2} \left( \frac{m_{i0}}{\Delta t} \right) v^2 = \frac{1}{2} \rho Q v^2 \quad (7)$$

where $\rho \ (kg/m^3)$ is the density of the liquid and $Q \ (m^3/s)$ is the volumetric flow rate, which is expressed by $Q = Av$, where $A$ is the area of the cross-section, given by $A = xL$ (See Fig 5). Thus, Eq. (7) can be rewritten as follows

$$P = \frac{1}{2} \rho Q v^2 = \frac{1}{2} \rho A v^2 = 11.3\rho (xL) g^\frac{3}{2} h^\frac{3}{2} \quad (8)$$

The power of the Gravitational Motor, $P_{motor}$, depends on its performance i.e., $P_{motor} = \eta P$, where $\eta$ is the performance ratio. Thus, we can write that

$$P_{motor} = 11.3\eta \rho (xL) g^\frac{3}{2} h^\frac{3}{2} \quad (9)$$

For example, if $\eta = 0.9$; $\rho = 1,000 kg/m^3$; $x = 0.15m$; $L = 1m$; $h = 0.5m$, then the power is: $P_{motor} = 1.6 \times 10^4 W \approx 21 HP$. Note that, if an electrical generator is coupled to this motor, then it can produce sufficient electrical energy to supply, for example, the electrical consumption of a high-standard residence.

Fig.5 – Schematic Diagram of a Gravitational Motor using Mini-rotors.
Appendix: Experimental Set-Up to Check the Theoretical Predictions

Fig. 1A – It is shown in (a) an experimental arrangement to measure the magnitudes of the components $P_{Rx}$ and $P_{Ry}$ produced by the displacement of $P_R$ (weight of the rotating sphere). In (b) it is added a spherical shell around the rotating sphere (rotor), in order to measure the magnitudes of the components $R_x$ and $R_y$ produced by the displacement of $R = P_R + P_m$; $P_m$ is the weight of the spherical shell.
References


