Directional Control of Weight Forces in Rotating Bodies

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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 α_i, 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., $\alpha_i \propto \omega$, and $\vec{\alpha}_i$ has the *same direction* of $\vec{\omega}$ (See Fig. 1(b)), then we can write that

$$\vec{\alpha}_i = k\vec{\omega} \qquad (1)$$

where k is a constant to be determined. If α is expressed in $rad.yr^{-1}$, then k must be expressed in $s.yr^{-1}$ because ω is expressed in $rad.s^{-1}$. Note that, α, can be expressed in rad, in this case, k must be expressed in *seconds*.

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

$$\alpha_i \approx \alpha_e (r/R) \qquad (2)$$

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

$$\alpha_e \approx k\omega (R/r) \qquad (3)$$

The Gravity Probe B experiment measured the angle α_e, in the case of the Earth. The result is $\alpha_{e(\oplus)} = 0.041\ arc\ \sec ond = 1.97\times10^{-7} rad$ [6, 7]. Since Earth's angular velocity is $\omega_{\oplus} = 7.29\times10^{-5} rad.s^{-1}$, then Eq. (3), gives

$$k \approx \left(\alpha_{e(\oplus)}/\omega_{\oplus}\right)\left(r_{\oplus}/R_{\oplus}\right) = 2.7\times10^{-3}\left(r_{\oplus}/R_{\oplus}\right) \qquad (4)$$

Since the Earth's rotation affects the orbits of the satellites near the Earth, and as most these orbits are at altitudes close to $600km$ (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 $r_{\oplus} \cong 1{,}000km$ (See Fig.1 (b)), Substitution of this value and $R_{\oplus} \cong 6.3\times10^{3} km$, into Eq. (4), gives

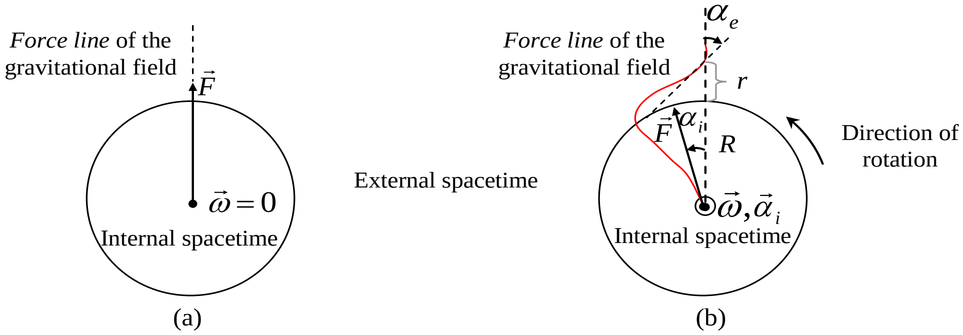


Fig. 1 – Schematic diagram of the angular displacement of a gravitational central force, $\vec{F}$, in a spherical rotating body, due to the bending of the force lines of the gravitational field of the body, consequence of the bending of the metric of the local spacetime produced by the rotation of the body.

$$k \approx 4 \times 10^{-4}\, s \tag{5}$$

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

$$\omega \approx \left(2{,}500 rad.s^{-1}\right)\alpha_i \approx \left(23{,}873 rpm\right)\alpha_i \tag{6}$$

This equation shows that, in order to obtain a significative value of α_i, in this case, the value of ω 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 α_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).

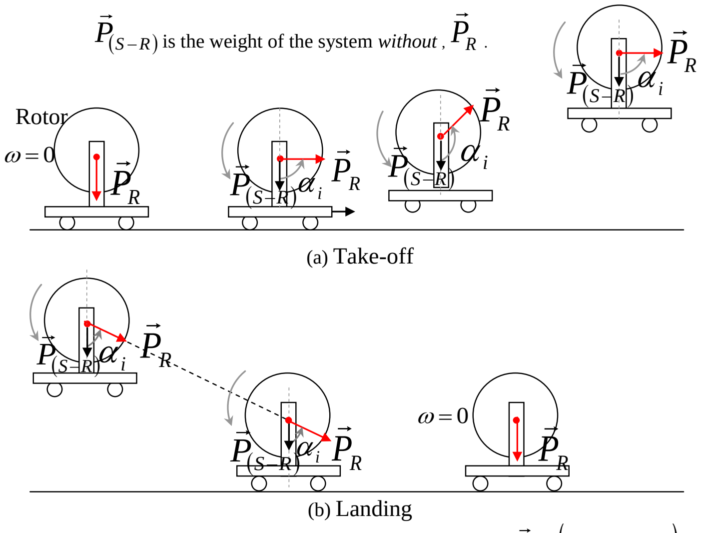


Fig 2 – Take-off and landing by means of the control of $\vec{P}_R$, $\left(P_R >> P_{(S-R)}\right)$.

It is important to note that, if there is a symmetric and homogeneous mass distribution around the rotor, with mass center coincident with the mass center of the rotor (for example in the case of a solid spherical rotor, spinning inside a hollow sphere), then, when $\vec{P}_R$ be displaced of an angle α_i (α_i is the angle given by Eq. (1) at the *first page* of this article), *also* the weight force, $\vec{P}_m$, of the mentioned mass around the rotor, will be displaced of the same angle α_i, together with $\vec{P}_R$. Thus, at the direction of $\vec{P}_R$, during its displacement (α_i), the resultant will be: $\vec{R} = \vec{P}_R + \vec{P}_m$ (See Fig. 3 (a)). Note that this increasing does not have influence on the *torque* of the motor connected to the rotor.

On the other hand, note that, the amount of mass around the rotor can be controlled by means of addition (or removal) of *superposed spherical shells* around the rotor (See Fig. 3 (b)). In this case, the weight force $\vec{P}_m$ increases progressively with the amount of spherical shells that are added around the rotor, and it will decrease with the removal of said spherical shells. Thus, by increasing the magnitude of $\vec{P}_m$ it is possible to increasing the magnitude of $\vec{R}$.

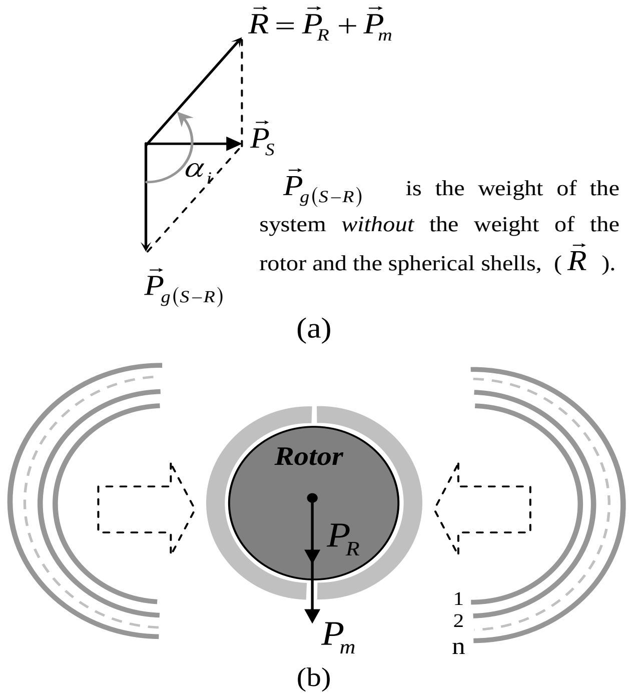


Fig. 3 – *The rotor inside spherical shells*. The weight force, P_m, increases with the increase of superposed spherical shells added around to the rotor (*without touching* the rotor).

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 α_i.

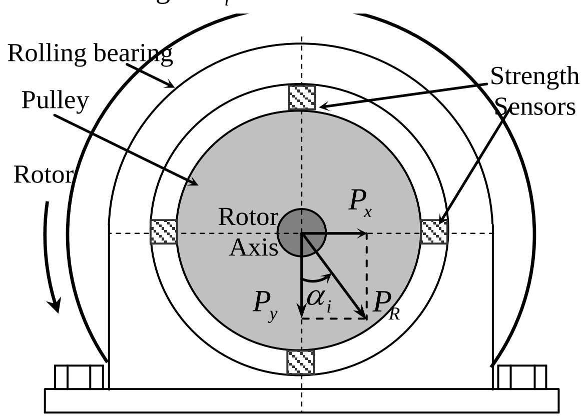


Fig.4 – The strength sensors will detect the forces produced by the *rotor* in the case of an angular displacement of its weight force.

The possibility of controlling the direction of weight forces, simply by controlling the angular velocity of the rotating body, can provides a new and powerful technology in order to move cars, ships, trains, etc., or to produce thrust to the flight of an 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 $\alpha_i = 180^0$. Thus, the weight $\vec{P}_m = m_{i0}\vec{g}$ (See Fig.5) will be displaced of the same angle α_i, together with the $\vec{P}_{Rs}$, $(nP_R << m_{i0}g)$.

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 $\vec{v}_1 = \vec{v}_0 + \sqrt{2\vec{g}h} \cong \sqrt{2\vec{g}h}$, where v_0 is the initial velocity. Then the velocity v is given by $\vec{v} = \vec{v}_1 + \sqrt{2\vec{g}h} \cong 2\sqrt{2\vec{g}h}$ (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

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

where ρ (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

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

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

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

For example, if $\eta = 0.9$; $\rho = 1{,}000\,kg/m^3$; $x = 0.15m$; $L = 1m$; $h = 0.5m$, then the power is: $P_{motor} = 1.6\times10^4 W \cong 21HP$. 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.

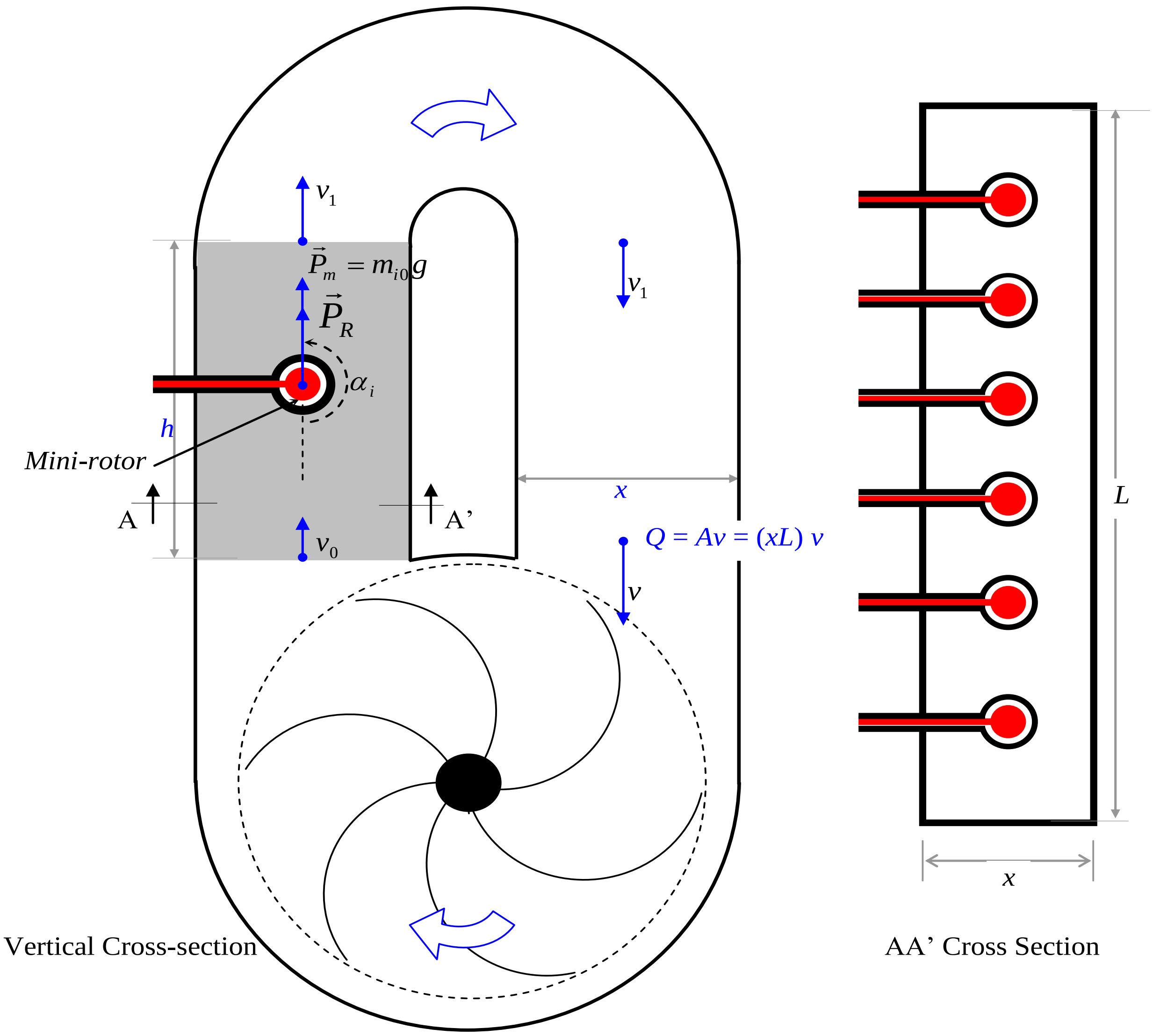
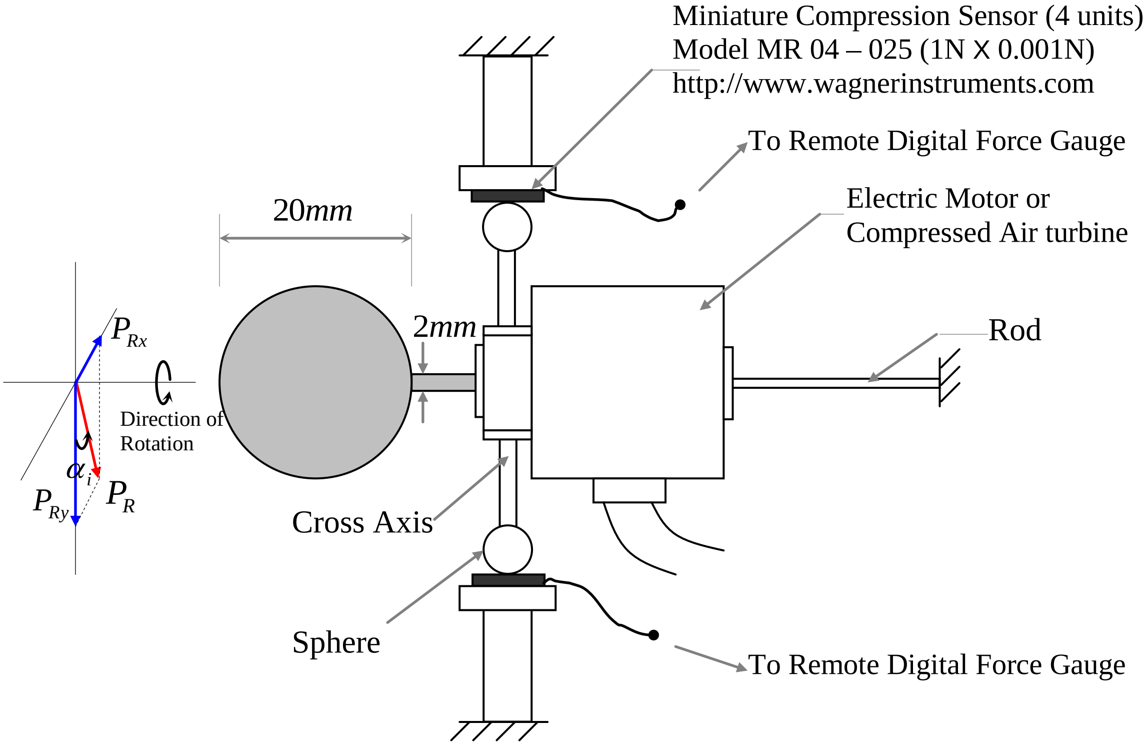
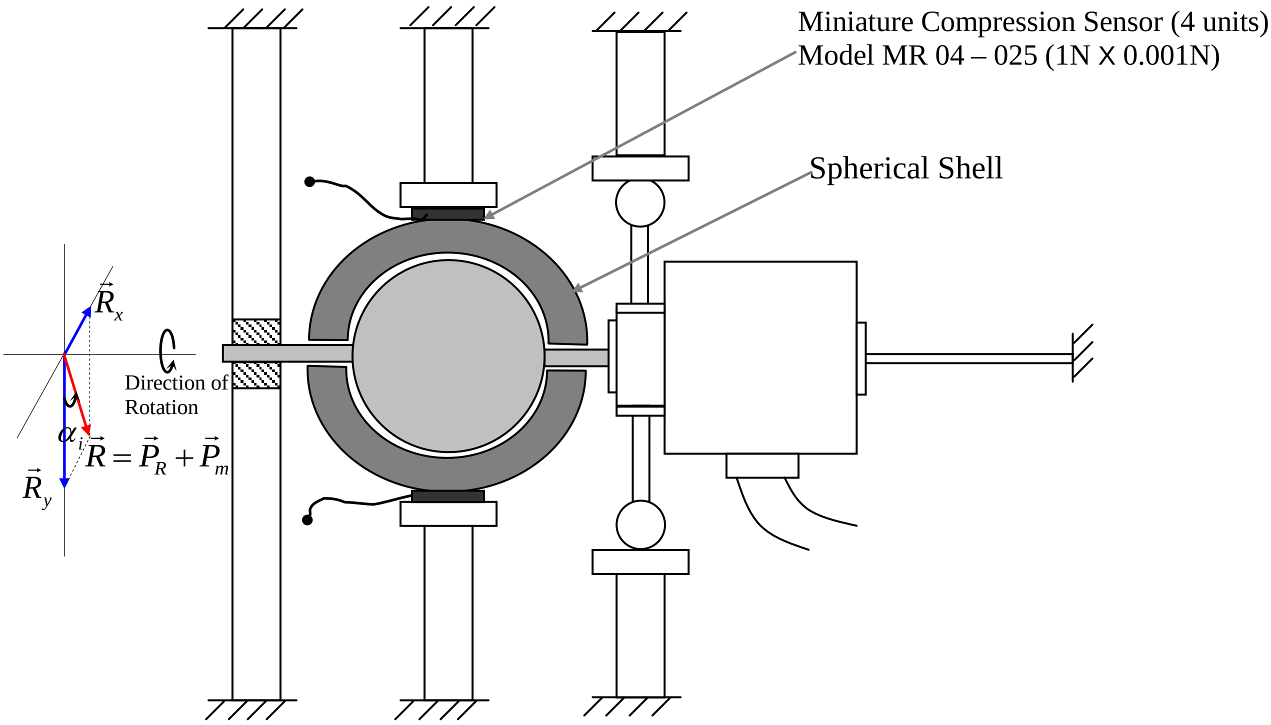


Fig.5 – Schematic Diagram of a Gravitational Motor using Mini-rotors.

Appendix: Experimental Set-Up to Check the Theoretical Predictions



(a)



(b)

Fig. 1A – It is shown in (a) an experimental arrangement to measure the magnitudes of the components $\vec{P}_{Rx}$ and $\vec{P}_{Ry}$ produced by the displacement of $\vec{P}_R$ (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 $\left(\vec{R} = \vec{P}_R + \vec{P}_m\right)$; $\vec{P}_m$ is the weight of the spherical shell.

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