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Possibility for the existence of anti-gravity: evidence from a free-fall experiment using a spinning gyro

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A free-fall experiment of a spinning gyro enclosed in a capsule has been conducted in order to investigate the effect of an object's spinning on the fall-acceleration. For 10 runs of the fall-acceleration measurements, in which each run consists of left, right and zero spinnings about the vertical axis, it has been shown that the mean value of the fall-accelerations of the right-spinning $<g(R)>$ is significantly smaller than $<g(L)>$ of the left-spinning at 18 000 rpm, with the latter being almost identical with $<g(0)>$ of zero spinning. The result suggests that the right-spinning generates anti-gravity and that the parity (the reflection symmetry) of gravity breaks down completely.

Keywords: anti-gravity; spinning gyro

Introduction

Hayasaka and Takeuchi [1] have previously reported that the right spinning (R-spinning) of a gyro (viewed from above) about a vertical axis induced a weight decrease proportional to the rotational velocity, whereas the left spinning (L-spinning) caused no weight change. These earlier measurements were made using both chemical and electronic balances. Subsequently, several authors have reported negative results [2-4] (i.e. no weight reduction of a right spinning gyro when measured by balances), and an affirmative result has been obtained by Kepner [5], who found that the fall-times of L- and R-spinning gyros were significantly different. (T. S. Kepner, personal communication. In 1969, he conducted an unpublished experiment in which fall-times of a spinning gyro of 7 cm diameter were measured repeatedly over a fall distance of 120 cm by using a time counter, and white light beam reflected by two mirrors.) From these reports, we have inferred that the gravitational field generated by an object's R-spinning may affect the action of a balance's control electronics. In fact, for the measurement reported by Hayasaka *et al.* [1], the control circuit of the electronic balance was located away from the balance body and connected to it with long lead wires. Furthermore, we have developed a topological gravity theory [5] which is able to explain our earlier result.

The theory suggests that the gravitational moments with time of a mass point rotating in the opposite directions along a loop (in the base space) are in an equivalent class with the de Rham cohomology group which is coupled to the invariant angular momentum on a mirror transformation. The de Rham cohomology effect (in general, the gauge effect of a groupoid of loop group) generates torsion fields of different strengths in both the rotations, and there is a possibility of the parity breaking of the gravitational force, and the generation of topologically repulsive force during an object's spinning.

Therefore, we have measured the fall-times of a spinning gyro enclosed in a capsule, and have found that the fall-acceleration $g(\mathrm{R})$ of R-spinning is, without exception, smaller than $g(\mathrm{L})$ on L-spinning at 18 000 rpm in a series of repeated experiments. The mean value $<g(\mathrm{R})>$ of R-spinning is significantly smaller than $<g(\mathrm{L})>$ of L-spinning, with the latter being almost identical with $<g(0)>$, the acceleration for zero spinning. This experiment has confirmed the result of our previous experiments. The present result suggests that R-spinning generates anti-gravity, and also that the parity (the reflection symmetry) of gravity breaks down completely.

Experimental Apparatus and Methods

A schematic diagram of our apparatus is shown in Fig. 1. It should be especially noted that parts **2**, **3**, **8**, **9** and **10** are important improvements that allow the gyro (part **6**) to be dropped exactly along the vertical axis through the centre of part **1**. A gyro of diameter 5.8 cm was used which is the same as that used in our previous experiment. The rotor mass of the gyro is 175 g and the inertia moment 969.47 g cm^2. When the edge of **11** crosses the laser beam at AA′, **18** opens, and then **19** and **20** operate. When the edge of **11** crosses the beams BB′ and CC′, **19** and **20** sequentially stop counting the time.

Fall-time measurements are based on the Newtonian formulation

$$h_1 = \frac{1}{2}gt_1^2 + v_0 t_1 \tag{1}$$

$$h_2 = \frac{1}{2}gt_2^2 + v_0 t_2 \tag{2}$$

$$h_3 = h_1 + \Delta h = \frac{1}{2}gt_3^2 + v_0 t_3 \tag{3}$$

where v_o is the velocity at the time when the edge of part **11** passes the beam AA′ . In this experiment, the fall-acceleration, g is given by

$$g = g_E + g_T + g_S(\xi, \nu) + g_H(\mathrm{d}) \tag{4}$$

Here, g is regarded as a time-independent quantity for the following reasons: g_E is the Earth's gravitational acceleration (= 980.0658 gal) at Sendai (latitude = 38.248 N, longitude = 140.847 E, height = 130.0 m). The change of the tidal force's acceleration g_T is within $\pm$ 100 μgal in every experiment from the calculated data, and then the effect of g_T on the fall-time of a spinning gyro can be neglected, as discussed in Equation 11. $g_S(\xi, \nu)$ is the upward acceleration which may be due to the topological effect [5] of a gyro's spinning, where ξ denotes the direction of spinning, and ν the number of spins. ν is considered constant because it hardly changes during the fall-time (about 0.53 s) from the calibration data. For $g_S(\xi, \nu)$, our previous result on the weight change of the spinning gyro suggests that the values of $g_S(\mathrm{L})$ and $g_S(\mathrm{R})$ at ν = 18 000 rpm may be approximately zero and -0.108 gal, respectively. $g_H(\mathrm{d})$ is the upward acceleration acting on **6**, **7** and **8**, due to both the residual magnetisms (1.3 G) on parts **1** and **8** at a distance d from the magnet. However, it has been shown from the calculation of the magnetic dipole–dipole interaction that $g_H(d)$ is much smaller than 40 μgal after the edge of part **11** has passed

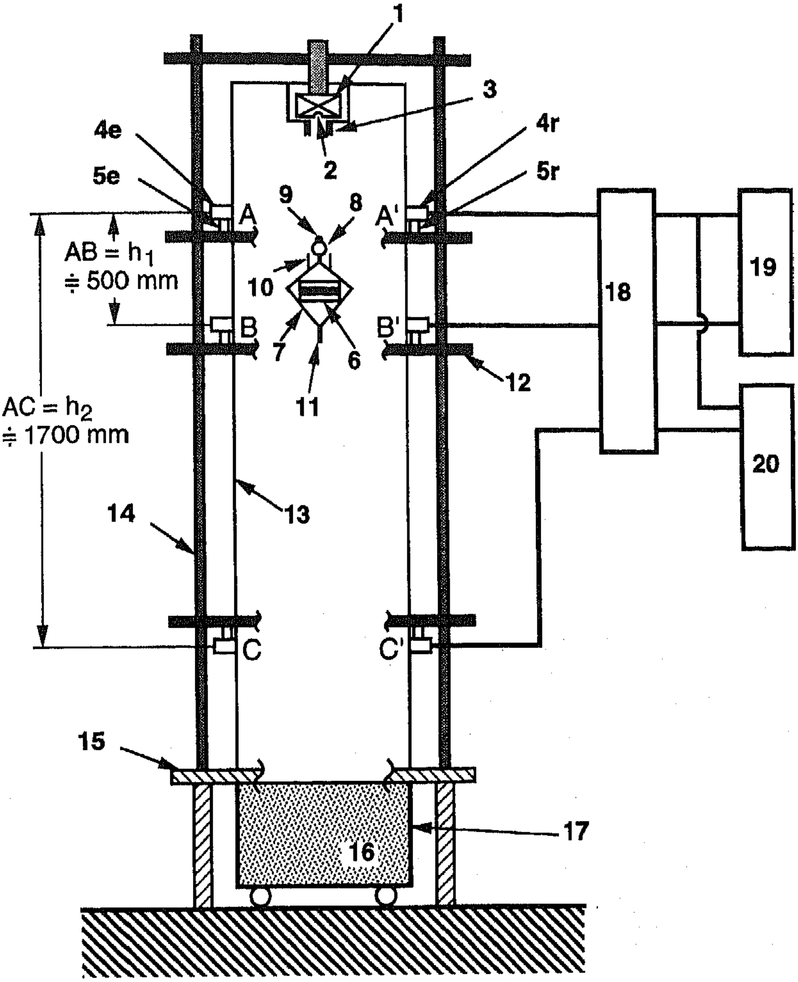

Fig. 1. Schematic diagram of the experimental apparatus for fall-time measurement of a spinning gyro. **1**, Electro-magnet having an electronic circuit for preventing the chattering caused by switch-off of a power supply. **2**, Small indent having the same radius as the ball-bearing **9**. **2** and **9** are used to fix part **7** at the centre of part **1**. **3**, Three mercury connectors into which **10** are inserted, where the inner surface of each copper cylinder is covered with the film of solder in order to increase the upward surface tension between copper and mercury. **4e**, Laser emitter. **4r**, Laser receiver. **5e**, Laser stage having micro-gauges in both the vertical and horizontal directions. **5r**, Laser stage having no micro-gauge. **6**, Gyroscope. **7**, Capsule including **6**. **8**, Spherical pure iron attached to **7**. **9**, The half of a bearing-ball (1.15 mm diameter) embedded at the top of **8**. **10**, Three electrodes used to supply electric power to **6**, and to prevent **7** from any inertial rotation associated with that of **6**. **11**, Guide rod of 4 mm diameter. **12**, Platform. **13**, Acrylic cylinder of 400 mm diameter. **14**, Four ceramic pillars made of SiC (thermal expansion coefficient = $2 \times 10^{-6}/°C$). **15**, Base platform. **16**, Shock absorber. **17**, Container having caster. **18**, Gate circuit. **19** and **20**, Frequency counters (time counters) with the accuracy of 0.1 μs. Each set composed of **4e**, **5e**, **4r** and **5r** is put on the respective platforms **12** which are set at the upper, middle and lower positions. A pair of two laser beams is crossed and focused on the vertical line through **2**. The two pairs are put respectively on the upper and lower positions, and only one beam is focused on the vertical line at the middle position. Each focus diameter is 0.1 mm.

point AA′, namely for $d \geq 20$ mm. Hence, $g_H(d)$ can be neglected. Thus, g in Equation 4 is reduced to a time-independent quantity

$$g = g_E + g_S(\xi, \nu) \tag{5}$$

The values of h_1 and h_2 are determined from fall-time measurements with a non-spinning gyro (0-spinning): first, t_1 and t_2 are measured for $g = g_E$, with h_1 and h_2 treated as unknown quantities because the pillars' lengths depend on room temperature. Next, t_3 is measured for $g = g_E$ and $h_3 = h_1 + \Delta h$, where $\Delta h = 3$ mm. From Equations 1, 2 and 3, h_1, h_2 and v_o are determined. By using these values of h_1 and h_2 , the fall-times on L- and R-spinning are measured at 18 000 rpm, and g in Equation 5 can be determined for both the spinning directions.

Results and discussion

The experiment was conducted between July and September, 1994. Each run consisted of fall-time measurements for 0-, L- and R-spinning. Measurements for 0-spinning were repeated twice to determine the values of h_1 and h_2. Each set of measurements was completed within 50 min, and the room temperature change was within ±0.2 °C. The experimental data, g(R), g(L) and g(R)−g(L) at ν = 18 000 rpm are shown in Table 1.

For each run, g(R) is significantly lower than g(L), without exception. For 10 runs, the mean values of g(L) and g(R) are respectively:

$$< g(\mathrm{L}) >= 980.0687 \pm 0.0663 \text{ gal} \tag{6}$$

$$< g(\mathrm{R}) >= 979.9266 \pm 0.0716 \text{ gal} \tag{7}$$

given as mean value ± 1 SD. The mean values of their differences with respect to $g(0)$ ($=g_E$=980.0658 gal) for all the runs are

$$< g(\mathrm{L}) - g(0) >=< g_S(\mathrm{L}) >= 0.0029 \pm 0.0663 \text{ gal} \tag{8}$$

$$< g(\mathrm{R}) - g(0) >=< g_S(\mathrm{R}) >= -0.1392 \pm 0.0716 \text{ gal} \tag{9}$$

Table 1. Summary of measured values of fall-acceleration for L- and R-spinning about the vertical axis at 18 000 rpm, and their differences.

Experiment date	g(L)(gal)	g(R)(gal)	g(R)−g(L)(gal)
27 July	980.0965	979.9153	−0.1812
27 July	979.9622	979.8324	−0.1298
28 July	979.9912	979.8702	−0.1210
8 August	980.0322	979.9356	−0.0966
9 August	980.0196	979.8185	−0.2011
10 August	980.1682	980.0159	−0.1523
11 August	980.1331	980.0166	−0.1165
12 August	980.1577	980.0259	−0.1318
9 September	980.0653	979.8926	−0.1727
28 September	980.0613	979.9432	−0.1181

and that for $g(\mathrm{R}) - g(\mathrm{L})$ is

$$< g(\mathrm{R}) - g(\mathrm{L}) >=< g_S(\mathrm{R}) - g_S(\mathrm{L}) >= -0.1421 \pm 0.0317 \text{ gal} \quad (10)$$

These results clearly support our previous measurements of weight change [1]. In fact, for R-spinning, the value of $< g(\mathrm{R}) - g(0) >$ in Equation 9 is close to the value of −0.108 gal which is expected from our previous experiment for the gyro of 5.8 cm diameter at 18 000 rpm, and Equation 8 corresponds to zero weight change for L-spinning, confirming the previous result. Discussion on the detailed statistical evaluation of the above results will be given later.

The results of these experiments are free from systematic errors. Our reasons are given below. In this paper, the problems of any supposed systematic errors discussed in our previous experiment have been overcome. We can discuss whether or not the results are caused by other systematic errors, from the viewpoint of Newtonian mechanics and electromagnetism. That is, we consider whether systematic errors could be due to the following.

(1) The biased decreases of the tidal force in only the repeated R-spinning. This is denied from the calculated data of the tidal force. It has been shown that there are both increases and decreases in the tidal force during the repeated measurements for R-spinning. Even if there were biased decreases, the variation in the tidal force can be neglected from a simple order of magnitude estimation. The fall-time from the tidal force variation is given approximately by

$$t = \sqrt{2h/(g - g_\mathrm{T})} \cong t_0(1 + (g_\mathrm{T}/2g)) = 0.58 + 2.9 \times 10^{-8} \text{ s} \quad (11)$$

where $g_\mathrm{T} = 100\ \mu$gal, $t_o = 0.58$ s, $g = 10^3$ gal, and $h = 170$ cm. On the other hand, the difference between both fall-times on L- and R-spinning is of the order of 10^{-5} s. Hence, the error of 2.9×10^{-8} s can be neglected.

(2) The difference between the interaction of the fall velocity $\vec{v}$ and L-spinning's angular frequency $\vec{\omega}$, and that of the $\vec{v}$ and R-spinning's $\vec{\omega}$. This is denied due to the following. The spinning gyro's fall-acceleration, $\dot{\vec{v}}$, is given by [6]

$$m\dot{\vec{v}} = m\vec{g}_\mathrm{E} + 2m\left[\vec{v} \times (\vec{\Omega} + \vec{\omega})\right], \quad (12)$$

where $\vec{\Omega}$ is the angular frequency of the Earth's spinning. It has been shown that the gyro was in the state of a sleeping top without nutation and precession during the fall-time measurements for L- and R-spinning, as discussed in detail below (4). This means that $\vec{\omega}$ is directed exactly along the vertical axis for both L- and R-spinning, and then the vertical component of $[\vec{v} \times \vec{\omega}]$, $[\vec{v} \times \vec{\omega}]_z$ is zero because the ω_x and ω_y are zero. Thus, the z component of fall-acceleration, $(\dot{\vec{v}})_z$ is independent of $\vec{\omega}$. Therefore, the direction of $\vec{v}$ deviates only slightly towards the east in the northern hemisphere, regardless of the spinning direction (the deviation is estimated to be the order of 10^{-3} cm for the fall-distance of 170 cm). The possibility of a gravitational repulsive force caused by the parallel spin–spin interaction of both the angular momenta of the Earth and a gyro is also denied, as discussed in our previous paper [1].

(3) The biased increase in the length of the support pillars caused by room temperature increase in only the R-spinning of each run. This is denied due to the randomness of the

room temperature change of only ±0.2 °C. If the room temperature T increases by $\Delta T = 0.2$ °C in each R-spinning, the fall-time is estimated from Equation 11

$$t = \sqrt{2(h + \Delta h)/g} \cong t_0(1 + \alpha \Delta T/2) = 0.58 + 1.2 \times 10^{-7} \text{ s} \tag{13}$$

where α is the thermal expansion coefficient of the support pillars (= 2×10^{-6}/°C). In contrast, the difference between both fall-times on L- and R-spinning is of the order of 10^{-5} s. Hence, the error of 1.2×10^{-7} s does not cause such a large difference. Even if there occur both the biased decrease of the tidal force, and the biased increase in the length of the support pillars in only the R-spinning of each run, the total error would be 1.49×10^{-7} s . Therefore, this error is not the cause of the difference of 10^{-5} s between both fall-times on L- and R-spinning.

(4) The problem of whether or not the laser beams are crossed correctly by the edge centre of the guide rod in all R-, L- and 0-spinning. Let us suppose that the problem is caused by the different deviations (or inclinations) of the gyro's attitude from the vertical axis in R- and L-spinning, where the different deviations are assumed to be caused by the different frictions of the rotor's bearing-balls in both spinnings. The supposition is denied from the following reasons. First, the vibration, and the dynamic balance prescribing the synthetic criterion of the gyro's stability are the same for both the spinning directions, as mentioned in the previous paper [1]. It means that there is no difference between both frictions in R- and L-spinning. Second, the supposition is also denied in that the gyro is in the state of a sleeping top having no nutation and no precession, as mentioned already. This is shown by the mechanical calculation for a fast spinning top [7]. In reality, when the gyro is spinning at 18 000 rpm (=300 rps), the gyro satisfies the condition of a sleeping top without nutation; that is, the angular frequency ω (= $2\pi \times 300$ rad s^{-1}) is more than 100 times larger than ω^* given by

$$\omega^* = (2Mgl/I_3)^{1/2} = 18.8 \text{ rad s}^{-1} \tag{14}$$

where M is the gyro-rotor's mass (175 g), g is the Earth's gravitational acceleration (980 cm s^{-2}), l is the distance between the rotor's mass centre and the lower fulcrum (1 cm), and I_3 is the vertical component of inertia moment (969.5 g cm^2). Here, the spinning gyro is suspended from the electromagnet, and is released from the magnet by its own weight, when the current to the magnet is cut off. Therefore, the spinning gyro in falling holds the state of a sleeping top without nutation. Furthermore, the spinning gyro has no precession, because the direction of $\vec{\omega}$ coincides with the rotor's inertial principal axis, the z axis.

From the above, the spinning gyro in falling has no nutation nor any precession. This means that the gyro's attitude does not fluctuate around the vertical axis in both R- and L-spinning, and then that the capsule's and the guide rod's axes are also held along the vertical axis. Third, the unquestionable evidence of the correct edge centre crossings have been confirmed by photographs flashed at 1/20 000 s, at the point where the flashes are coincident with the instantaneous times of cutting the beam CC′. The photographs were taken as follows: a silk thread was stretched and placed horizontally at 5 mm under the laser beams CC′, and a fine needle of 0.3 mm in diameter was suspended vertically from the thread just below the cross point of two laser beams. The edge centre crossings and the capsule's attitude were checked by using the needle as a reference line.

(5) The problem of lifting due to the air flow's circulation which is dragged by the capsule's inertial rotation associated only with R-spinning in each run. (Here, the lifting is based on the Kutta-Joukowski theorem [8] in fluid mechanics.) This is denied because of the lack of capsule rotation. In fact, only a small angular shift of the capsule around the vertical axis was observed within 10° in the clockwise direction at the beam CC$'$. This means that the circulation of air flow did not occur around the capsule and then that the lifting caused by air flow's circulation did not occur. Therefore, the decrease of the fall-acceleration in R-spinning is not due to the lifting. For L-spinning, there was also no rotation of the capsule, although small angle shift of the capsule was observed within 10° in the counter-clockwise direction. The circulation of air flow associated with the spinning gyro-rotor in the capsule, of course, does not cause the lifting of the capsule, because the air and the gyro are sealed rigorously in the capsule, then the effect of air circulation in the capsule converts only into the inner force. Furthermore, even if the turbulent flow occurs about the capsule's spherical iron **8** in Fig. 1, the turbulent flow does not cause the fluctuation of the capsule's attitude around the vertical axis, because the gyro's inertial moment I_3 ($=969.47$ g cm^2) is very large. It has been confirmed by the photographs mentioned in (4). From the above, the fall-accelerations of L- and R-spinning are not affected by these air flows.

(6) The difference between the interaction of the residual magnetism (1.3 G) of the magnet and the gyro-rotor (0.06 G) on L-spinning, and that for R-spinning (the direction of the residual magnetism for R-spinning is the inverse of that on L-spinning). This is denied, because the field of the magnet is axisymmetric about the vertical axis, and the field of the gyro-rotor is circular on the horizontal plane. Hence, both the magnetic interactions in R- and L-spinning do not cause forces along the vertical axis.

We now discuss whether or not our experimental data are significant in view of the statistics. Indeed, the experimental data are completely significant for the following. Here, it should be noticed that the rigorously statistical estimation must be not made directly for the sample ensemble (namely, the experimental data), but for the population which can be expected as an ensemble consisting of the data obtained from the infinitely repeated experiments. Therefore, we made the significant test for the population. Of course, the significant test is made by the usual method. Only the results from the significant test are shown in the following.

(1) Estimations of the population means μ_L and μ_R for the two sample ensembles $g(L)$ and $g(R)$, and of the respective 95% confidence intervals:

$$\mu_L = 980.0687 \pm 0.0499 \text{ gal} \tag{15}$$

$$\mu_R = 979.9266 \pm 0.0540 \text{ gal} \tag{16}$$

$$980.0188 \leq \mu_L \leq 980.1187 \text{ gal} \tag{17}$$

$$979.8726 \leq \mu_R \leq 979.9781 \text{gal} \tag{18}$$

The difference of μ_L and $g(0)$, and that of μ_R and $g(0)$ are respectively

$$\mu_L - g(0) = 0.0029 \pm 0.0499 \text{ gal} \tag{19}$$

$$\mu_R - g(0) = -0.1392 \pm 0.0540 \text{ gal} \tag{20}$$

The above estimations show that the respective 95% confidential intervals of μ_L and μ_R do not overlap each other. From this, it seems that there is a definite difference between μ_L and μ_R. This is also confirmed by the comparison of t_o (namely, Student's t) and t-distribution $t\ (\phi, \alpha)$, where ϕ is the degree of freedom, and α is the probability of both sides:

$$t_0 = 4.3691 \tag{21}$$

$$t(18,\ 0.05) = 2.1009 \tag{22}$$

The above shows $t_o > t\ (\phi, \alpha)$, so that the two population mean values μ_L and μ_R have a significant difference with a confidence of 95%.
(2) Estimations of the population mean value μ_{RL} which is evaluated from the sample ensemble consisting of 10 values, each of whose value is given by the difference (g(R)$-g$(L)) in an arbitrary run, and its 95% confidence interval;

$$\mu_{RL} = -0.1421 \pm 0.0239 \text{ gal} \tag{23}$$

$$-0.1660 \leq \mu_{RL} \leq -0.1182 \text{ gal} \tag{24}$$

The above confidence test shows that the absolute value 0.1421 gal of μ_{RL} is about six times that of the standard deviation 0.0239 gal, and the width of fluctuation of μ_{RL} is smaller than those of the estimated μ_R and μ_L. It means that a pair of g(R) and g(L) measured in the limited time (50 min) for any run, decreases the fluctuation of the population μ_{RL}. Such measurements confirm that this method is a correct one, which can remove the common causes of the respective fluctuations of the two sample ensembles for g(R) and g(L).

From the significant tests for the various populations, we conclude that our experimental data on R- and L- spinning have a completely significant difference with a confidence of 95%.

Conclusions

From the experimental results, the statistical significant tests, and the careful consideration of possible errors, we conclude that our previous result concerning weight change measurements is substantiated. The present results suggest that only R-spinning causes significant anti-gravity, and that the parity (the reflection symmetry) of gravity breaks down completely, in the same way as the weak interaction of elementary particles that selects the left-handedness.

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