Anomalous Weight Reduction on a Gyroscope's Right Rotations around the Vertical Axis on the Earth

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The weight change of each of three spinning mechanical gyroscopes whose rotor's masses are 140, 175, and 176 g has been measured during inertial rotations, without systematic errors. The experiments show that the weight changes for rotations around the vertical axis are completely asymmetrical: The right rotations (spin vector pointing downward) cause weight decreases of the order of milligrams (weight), proportional to the frequency of rotation at 3000–13 000 rpm. However, the left rotations do not cause any change in weight.

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To confirm the reflection symmetry relating to the rotational motion of objects in the gravitational field of the Earth, the weight of each of three spinning mechanical gyroscopes has been measured during left (spin vector pointing upward) and right (spin vector pointing downward) inertial rotations around the vertical axis by means of a chemical balance. The experimental apparatus and method are as follows.

Each gyroscope is composed of the stator, rotor, and rigid frame. Rotors of 139.863, 174.882, and 175.504 g are used, and their diameters are 5.2, 5.8, and 5.8 cm, respectively. The materials of the rotors are brass, aluminum, and silicon-steel. The dynamic balance, which is the criterion of the maximum deviation of the center of a rotor's mass associated with rotations, and the fluctuation of the rotational frequency of each gyroscope are 0.3 mm/s and $\pm 0.2\%$, respectively, for both rotations. This means that the dynamic characteristic, i.e., the synthetic criterion of the stabilities of spinning and precession of each gyroscope, is the same for the two rotations. An oscillator capable of switching polarities and a voltage amplifier are used to change the frequency of rotation of the rotor and to supply the driving power to the gyroscope. The directions of the left and right rotations are determined by the polarity. A phototachometer is used to measure the frequency of rotation of the rotor. The chemical balance is made of nonmagnetic materials, and the measurable range is 0 to 500 g with an accuracy ± 0.3 mg. To exclude fluid effects of air on the rotating gyroscope, a vacuum container made of glass is used. An overview of the experimental apparatus is shown in Fig. 1.

The first experiment was carried out in the environment magnetic field of 0.35 G that is nearly totally due to the geomagnetism. The degree of vacuum in the container containing the gyroscope is kept between 1.3×10^{-2} and 1.3×10^{1} Pa. The electric power is supplied to the gyroscope through superfine wires. The rotational frequency of the rotor is brought to the desired value by increasing the supply voltage and the frequency of the oscillator under the same driving condition for all the measurements. After the desired value of the rotational frequency is attained, the electrical circuit is opened. Then the weight of the rotating gyroscope is measured under inertial rotation. The weight measurements are repeatedly carried out, 10 times, for a given frequency of rotation.

As shown in Fig. 2, the right rotations of each gyroscope always cause weight decreases of the order of milligrams, proportional to the frequency of rotation. The weight reduction occurs for both normal and reverse attitudes. Here, reverse attitude of a gyroscope means merely its upside-down attitude without change of the states of the other equipment and the environment considered. Right rotation means the spin vector pointing downward for both the normal and the upside-down attitudes. On the other hand, the left rotations of each gyroscope yield zero weight change for all frequencies of rotation and both attitudes, within the accuracy of the chemical balance. The weight changes for both rotations

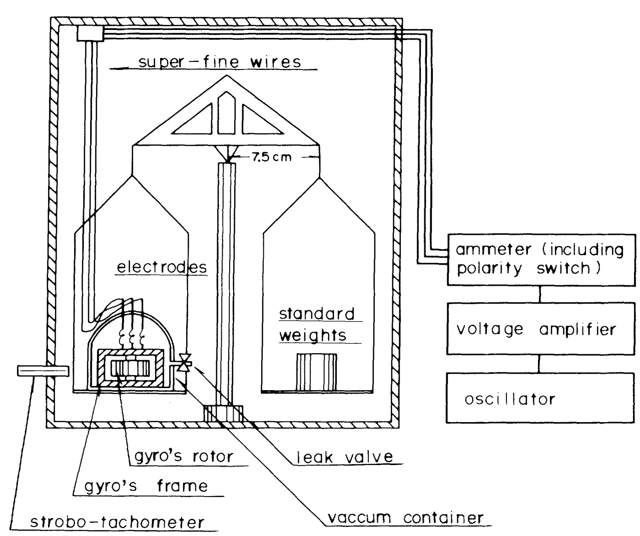

FIG. 1. Overview of the experimental apparatus including the chemical balance.

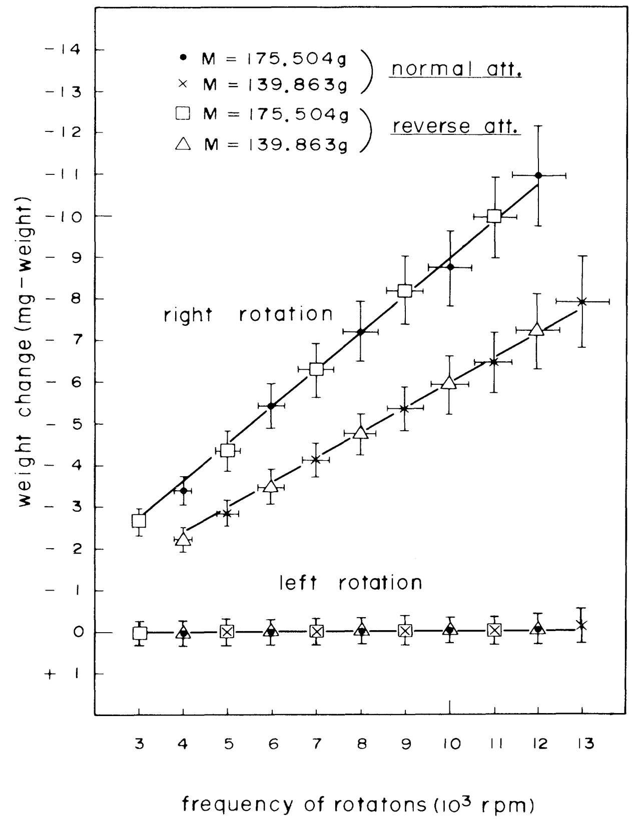

FIG. 2. Weight changes of gyroscopes for both left and right rotations around the vertical axis in the natural-environment magnetic field.

are independent of the placement of the balance's lever arm along the N-S or the E-W direction. Furthermore, the weight changes for both rotations are independent of the various ways of performing the experiment: The weight measurements are carried out after opening the electrical circuit while the rotation is speeding up, kept at constant speed, or slowing down, under the conditions of putting a polyurethane foam pad under the gyro to partially absorb the mechanical vibrations and of exchanging the positions of the gyro and the reference weights on the balance's pans. The experimental results do not change under these variations.

In Fig. 2, the data on the $M = 174.882$-g rotor are omitted because the weight changes are nearly the same as those for $M = 175.504$ g. The vertical error bars denote the fluctuation of weight changes, and the horizontal error bars denote the decreasing range of the frequency of rotation in one period of the movement of the direction needle of the chemical balance.

The experimental results show that the weight changes for rotations around the vertical axis are completely asymmetrical. Meanwhile, based on the conventional theory, the weight changes of a gyroscope under rotation should by symmetrical. Therefore, we have studied whether such an extraordinary phenomenon is due to systematic errors in our experimental equipment and method. Most dynamical problems can be solved in the framework of Newtonian mechanics, which is symmetrical under a mirror reflection, as concretely discussed later.

There might be a question of weak magnetic coupling between the environment magnetic field of 0.35 G and the weak residual magnetism of the gyroscope after the opening of the electrical circuit. However, the anomalous weight reductions for the right rotations are not due to magnetic coupling. First of all, this is supported by the experiments with an upside-down attitude for each gyroscope as follows: Let us suppose that magnetic couplings during the gyroscope's right rotations cause the weight reductions in the normal attitude. This assumption means that the coupling serves the upward force during the right rotation. Next, let only the attitude of the gyroscope reverse without changing the states of the other equipment and the environment magnetic field. If the above assumption is correct, the weight of the gyroscope will increase for the left rotation in the reverse attitude, because the force by magnetic coupling will operate down the gyroscope. However, the experimental results for the reverse attitude shown in Fig. 2 refute the correctness of the assumption.

Since the problem of magnetic coupling is important, this problem has been checked further by means of the following two methods. (i) It has been checked whether there is a difference between the residual magnetism of the left rotation and that of the right one in each gyroscope. The residual magnetisms for both rotations are measured in a magnetically shielded cylinder where the strength of the magnetic field is $\frac{1}{100}$ times the strength of the environment magnetic field. The residual magnetisms for the left and right rotations are identical at the same frequency of rotation, after cutting the same power supplies. For instance, the residual magnetism associated with both the left and right rotations of the 175.504-g rotor is 0.06 G at 15000 rpm. Of course, these results are independent of attitude. (ii) The weight changes for both rotations in each attitude of the 175.504-g rotor have been measured in a magnetically shielded room ($200 \times 200 \times 210$ cm^3) where the field strength is 3×10^{-4} to 3×10^{-3} G; that is, $\frac{1}{1000}$ to $\frac{1}{100}$ times the environment magnetic field mentioned previously. The weight changes for both rotations of the gyroscope in each attitude in this shielded room are entirely identical with those obtained in the environment magnetic field. The experimental results of these two methods definitely show that the anomalous weight reduction is independent of magnetic coupling.

Summarizing all the data obtained in the experiments, the weight decrease for right rotations around the vertical axis, $\Delta W_R(\omega)$, is approximately formulated, in units of dynes, as follows:

$$\Delta W_R(\omega) = -2\times 10^{-5} M r_{eq}\omega \text{ g cm s}^{-2},$$

where M is the mass of rotor (in g), ω is the angular frequency of rotation (in rad/s), and r_{eq} is the equivalent radius (in cm), defined as follows. A rotor is composed of various materials and domains, and hence r_{eq} is given by

$$Mr_{eq} = \int\int \rho(r,z) 2\pi r^2 dr\, dz ,$$

where $\rho(r,z)$ is the density of any material constituting the rotor, and r and z denote cylindrical coordinates. The values of r_{eq} for the three rotors of 139.863, 174.882, and 175.504 g are 1.85, 2.26, and 2.26 cm. On the other hand, the weight changes for left rotations in each attitude are zero within the accuracy of the chemical balance.

Here, it should be especially noted that the weight changes during inertial rotations of three rotors repeatedly measured using an electronic balance are nearly the same as those obtained with the chemical balance. The mechanism of the balance, the experimental method, and the results are as follows: The deviation of the vertical component in the bending of a horizontal metal trough system caused by a weight is compensated by electromagnetic force. The balance has no standard weight inside, and the measurable range is 0 to 300 g with an accuracy of ± 1 mg. The system of the balance and gyro closed in a vessel is rigorously held at a vacuum state using a rotary pump and a coarse control valve, and also a sorption pump and a fine-control valve. The latter pump and valve are set near the vessel. The weight measurements are carried out during the inertial rotations after opening the electric circuit of the gyroscope. The strength of the magnetic field is of the order of 1.7 G at the balance's pan. As examples, the mean values of weight reductions for right rotations of two rotors of 139.863 and 175.504 g at 1.33 Pa are 1.8, 2.4, 3.0, 3.6, 4.1, 4.6, 5.3, 5.8, 6.5, 7.1, and 7.7 mg for the former rotor, and 2.6, 3.6, 4.4, 5.3, 6.3, 7.2, 8.1, 9.1, 10.0, 10.9, and 11.9 mg for the latter, at 3×10^3, $4\times 10^3, \ldots, 13\times 10^3$ rpm. Meanwhile, the left rotations do not cause weight changes. The results are independent of attitude.

As shown in Fig. 2, the weight change of each rotating gyroscope is completely asymmetrical for inertial rotations around the vertical axis. In a common-sense view, anyone might consider that such a phenomenon is induced by systematic errors. However, the phenomenon is free from systematic errors; our reasoning is given below. The causes of systematic errors are as follows: (1) The different dynamic characteristics of the gyroscope for the two rotations. (2) The different electromagnetic couplings of the gyroscope for the two rotations. (3) The different fluid effects of air on the gyroscope for the two rotations. (4) The difference between the respective torques induced by the friction between the ball bearings and the shaft of the gyroscope for the two rotations. (5) The different environmental conditions for the repetitive experiments. (6) The difference in the forces of inertia for the two inertial rotations. (7) The difference between the two spin-spin couplings of the angular momenta of the Earth and the gyroscope for the two rotations.

For (1): The dynamic characteristic includes the effect of mechanical vibrations and, as mentioned previously, the dynamic characteristic of each mechanical gyroscope is the same for the two rotations. As one example, the overall effective values of the accelerations of mechanical vibrations (bandwidth, 0–2 kHz) for the two rotations of the 140-g rotor are $0.0995G$ and $0.0965G$ at 13000 rpm in the normal attitude, where G is 980 cm/s^2. The values in the reverse attitude are nearly the same. From the above, we conclude that there are no differences between the dynamic characteristics of each gyroscope for the two rotations or the two attitudes. For (2): The problem of magnetic couplings has been perfectly solved by the three kinds of experiments already mentioned. Further, as each weight measurement was carried out after opening the electric circuit, there is no electrical-current effect. Therefore, the gigantic weight reduction for the right rotation is independent of magnetic coupling and electrical-current effect. For (3): The weight reduction for the right rotation is not due to lift from the fluid effect of air within the vacuum container. The reasons are as follows: Under the standard atmosphere (1×10^5 Pa), both rotations of the 175-g rotor cause the same lift of about 260 mg at 12000 rpm. The lift power is proportional to the density of gas. As described previously, the gas pressure in the container is between 1.3×10^{-2} and 1.3×10^1 Pa. Further, the gyroscope and air are in a closed system. From the above, we find that the weight decrease for the right rotation is independent of the lift of air. For (4): Since the friction in a gyroscope is originally within the gyroscope system, this friction does not influence anything outside the system. Hence, the weight reduction is not due to the torque induced by the friction. For (5): A pair of weight measurements for both rotations at the same frequency of rotation are always completed within about 30 min under a constant temperature. It has been confirmed that there are no convection effects of the air surrounding the glass container for either rotation, although there are uniform temperature increases of less than 1 °C over the whole surface of the container due to the friction at the supports of the rotor's axis for both rotations. Further, there is reproducibility of the data obtained on different days. Hence, the changes of the environmental conditions of the Earth's tide, the fluctuations of the Earth's spinning, temperature, and magnetic fields can be neglected. For (6): The weight measurements have always been made for decreasing rotational frequency. In the view of Newtonian mechanics, generally there is an inertial force $M(\dot{\boldsymbol{\omega}}\times\mathbf{r})$, where M is the mass of a rotor, $\dot{\boldsymbol{\omega}}$ is the vector of the rate of change of the angular frequency ω, and $\mathbf{r}$ is the vector in the radial direction. However, since the gyro-rotor rotates on the horizontal plane in this experiment, the force does not occur in the vertical direction. Therefore, the anomalous weight reduction is not due to the inertial force. For (7): First, the weight reduction is not due to the Lense-Thirring precession,[1] or the geodetic or mass-current precessions.[2] Second, in the framework of Einstein-Cartan theory, there might exist the possibility of a gravitational repulsive force caused by the parallel spin-spin interaction of the angular momenta of the Earth and the gyroscope, as discussed by Kopczyński[3] and Trautman[4] for spinning dusts. If these theories are applied to our experiment, such an interaction causes only an extremely small effect. Hence, the gigantic weight reduction for the right rotation cannot be explained from the above theories, and then the weight reduction is independent of the Earth's spinning.

As discussed above, the experimental result cannot be explained by the usual theories.

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