Does a spinning mass have reduced inertia compared to the same mass in an unspun state?

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Abstract

Two experiments are proposed to determine if the *inertia* (not weight or mass) of a gyro is reduced when spinning compared to its stationary state. The experiments are simple enough to be done by STEM students at a high school or college level. This is an updated version of the first edition.

Reports of experiments

There have been reports of spinning masses experiencing a weight/mass/inertia reduction compared to the same mass in the unspinning state. Insights from non-local physics articles predict that the inertia should decrease even though the mass would remain constant.

References:
"Beyond Einstein: non-local physics, 5 th ed"
https://www.academia.edu/94182990/Beyond_Einstein_non_local_physics_5_th_ed

Specifically:
"Anomalous gravitational effects of rotation of spacecraft" (p. 61+)
"DePalma Spinning Ball Experiment" (p. 53+)
"DePalma Accutron Experiment" (p. 54+)
"Are gravitational mass and inertial mass equivalent?" (p. 56+)

Additionally, temporal acceleration (gravity) has effects that are different from spatial acceleration:

"Do temporally accelerated electric charges radiate?" (p. 31+)
https://en.wikipedia.org/wiki/Paradox_of_radiation_of_charged_particles_in_a_gravitational_field

Gravitational mass and inertial mass are currently thought to be equivalent. But this has led to some confusion:

"Anomalous weight reduction on a gyroscope's right rotations around the vertical axis on the Earth", Hideo Hayasaka and Sakae Takeuchi, Phys. Rev. Lett.63, 2701 – Published 18 December 1989;
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.63.2701

"ABSTRACT
Each weight change of three spinning mechanical gyroscopes whose rotor's masses are 140, 175, and 176 g has been measured in inertial rotations without systematic errors. The experiments show that the weight changes on rotations around the vertical axis are completely asymmetrical: The right rotations (spin vector pointing downwards) cause weight decrease of the order of milligrams (weight), proportional to the frequency of rotations at 3 000–13 000 rpm. However, the left rotations do not cause any change in weight."

You can find a review and critique at:

"Science: Does a spinning mass really lose weight?" Malcolm Maccallum (17 February 1990)
https://www.newscientist.com/article/mg12517042-700-science-does-a-spinning-mass-really-lose-weight/ (free registration is required to read the full article)

> "Most scientists are sceptical of the claims. They cannot explain the size of the observed weight loss by any of the corrections to Newton's theory of gravity that they normally apply. And there is no other physical effect that they know of that depends on the direction of spin of a gyroscope. . . .
>
> The real test of the experiment will of course come when other groups repeat it. The first such reports are now coming in. A team at the highly-respected joint Institute for Laboratory Astro physics and the National Institute of Standards and Technology at Boulder, Colorado, has repeated the experiment. Jim Faller and his colleagues report no anomalous reduction in the weight of their gyroscopes."

Note that these experiments measured *weight*, not *inertia*. Measurement of inertia would require that the spinning gyro be accelerated spatially, say in a straight line and under a constant force (or known impulse), and the values of linear acceleration of the spinning and non-spinning gyro be compared. From the standpoint of non-local physics, no weight or mass reduction would be expected, only an inertia reduction.

What is inertia?

For our purposes Inertia is the value of the object's acceleration in response to a unit of force. Hence, its dimensions would be a/F. This measurement requires accelerated *spatial movement*. It is not the same thing as a static weight measurement.

This definition has an obvious problem. If an object is easily accelerated by a unit of force, this definition would assign "high inertia" to the object. But this is just the opposite of the way we would like to think about this concept. Until a better term can be found, this article will use the term "alacrity*" instead of inertia. An object with high alacrity* means it can be easily moved or accelerated even though it could be a very massive object of great weight.

The space/time dimensions for mass are t^3/s^3 (Beyond Einstein: non-local physics, 5 th ed, p. 8). Ordinary spatial motion is s/t . The temporal motion of mass is NOT motion in space. Hence, we could think of it as "motionless motion". It still has "temporal momentum" and resists changes in motion, including, changes in spatial speed and spatial direction. This is what is normally called "inertia". Adding ordinary velocity (s/t) will add spatial momentum, and this also resists changes in spatial speed and spatial direction, except now the changes are visible spatial effects.

So what happens when the object is spatially spinning? This is a peculiar sort of motion. The spatial quantity "stays put" (as angular momentum) but the temporal quantity progresses normally. Any sort of spatial motion (linear, thermal, oscillatory, rotational, orbital, etc.) has an equivalent temporal component, and that temporal component is opposite in the space/time sense to the temporal character of mass. The effect is expected to be small, and distributed across three spatial dimensions, but should be measureable.

But . . . mass is "motionless motion." How can we measure a change in "motionless motion" when there does not seem to be any in the first place?

That is the question that his paper hopes to see answered.

Two laboratory experiments for students

The most obvious experiment to explore this possibility would be to mount an enclosed gyro on a small platform that can be shot down a horizontal "frictionless" linear, triangular cross section, air track by an impulse from a spring. Universities often have this equipment in their mechanical engineering departments. The speed over a portion of the track can easily be measured by an optical sensor connected to an oscilloscope. For the same impulse, the spinning gyro should move faster than the same gyro in the non-spinning state if there is indeed a reduction in inertia (or increase in alacrity*) . For a track that is not frictionless, the effect of braking forces can also be measured.

Another experiment of a different but still simple design would use a gyro on a pendulum. The apparatus is designed to move a spinning mass (a motor rotor with or without additional mass) back and forth on a pendulum. The spin axis of the rotor is perpendicular to the swing plane so there are no gyroscopic effects. The height of the motor changes slightly due to the arc of the pendulum, and the motor frame rotates slightly for the same reason, but these effects induce no gyroscopic action. Power to the motor will induce heating effects and convection currents in air, and while these would affect simple measurement of weight, they should not affect the measurement of inertia. The nominal swing of the pendulum is set to about 3 to 6 degrees either side of the center line. A video camera, graph paper, and a pointer measure any changes in the amplitude of the arc. An optical sensor at the bottom of the arc (maximum speed location) and a small tab (vane) attached to the bottom of the pendulum are used to measure the pendulum speed and decay rate of the oscillation. An oscilloscope or strip chart recorder captures the data.

Two configurations are used: one with the motor rotor spinning under constant DC power and the other with the rotor stationary (note that it is still free to rotate on its bearings). All rotating parts must be enclosed to reduce effects of air motion. At least 5 minutes should be allowed to pass between each run or a configuration change (if there is a change in inertia, the mass may require a few minutes to come back into equilibrium with the spatial gravitational reference system). The pendulum is set in motion by moving it aside to a fixed stop and then releasing it.

The objective is to determine if there is a measureable difference in the speed of the pendulum when the rotor is spinning or not spinning. Reduced inertia should have the effect of greater acceleration, and therefore initial pendulum speed. The same reasoning applies at the reversal of the arc. Reduced inertia should also have the effect of a quicker decay rate due to air resistance, and friction in the pendulum bearings. The crucial question is, How long does it take for the pendulum speed to decay down to, say, 63.2 per cent of its original value? The interval should be different for the spinning and not spinning configurations. And is there a mathematical relationship between inertia reduction and angular momentum? (this may be known, but it is not public knowledge)

There is not expected to be any initial difference in the heights of the arc. The initial arc height at the end of the swing should be the same as the arc height at the initial release point. This is simply the result of symmetry and conservation of momentum (high school physics). Note that the source of acceleration, g is the same for each half of the full arc.

The supposed increase in alacrity* of the pendulum with the spinning mass should decrease the period of the pendulum swing (i.e., it should swing faster). This seems to be a bit disconcerting. The period of a pendulum is dependent on the length of the pendulum (top pivot to center of mass) and the acceleration of gravity. It is not dependent on the amount of mass. However, the center of mass (and therefore pendulum length) may change as the system has a component of fixed mass/inertia (the pendulum itself) and another component of variable inertia (due to the spinning mass). This is unexplored territory, and it is not clear what will happen.

The Period of a simple pendulum for small angles (less than about 6 degrees from the vertical) is:

$$T_0 = 2\pi\sqrt{\frac{\ell}{g}}$$

For a real pendulum, the Period is:

$$T = 2\pi\sqrt{\frac{I}{mgL}}$$

where I is the moment of inertia. (For a simple pendulum, $I = mL^2$)
Ref: https://en.wikipedia.org/wiki/Pendulum_(mechanics)

Here, an ordinary pendulum is used; a parallel motion linkage is probably *not* required, provided that the spin axis is perpendicular to the swing plane. (See "Peaucellier–Lipkin linkage" at https://en.wikipedia.org/wiki/Peaucellier%E2%80%93Lipkin_linkage)

Practical effects

In our ordinary experience inertia reduction effects would not normally be noticed. Spin will affect the trajectories of bullets, artillery shells, and baseballs but these effects are simply blended into the overall observational behavior. Inertia reduction effects are not even suspected.

But the effect on spacecraft trajectories would be significant. This was suspected decades ago due to anomalous behaviors of various spacecraft, namely, Explorer 1, 3, 4, Luna 1, Pioneer 4, and Ranger 3. (See "Anomalous gravitational effects of rotation of spacecraft" in *Beyond Einstein*, 5th p. 61+) These spacecraft went way off target for unclear reasons. But a hint about the source of the problem became apparent with Ranger 4. Its solar panels failed to deploy, and its gyroscopic guidance system subsequently failed. Still, it became the first American spacecraft to impact the Moon, and even did so without a midcourse correction.

The spacecrafts with guidance problems were either spin stabilized, or had high speed gyros in the guidance system, or both. Eventually, corrections were made for the presence of rotating masses, and the baffling anomalies came under control.

It can be seen that the inertia reduction effect is not only of academic interest to physicists, but also to engineering practice, especially in aerospace.

Inertia reduction can apparently be done by indirect access to temporal motion via spatial rotational motion. The effect can have practical significance, but is not nearly sufficient to make something with the mass of an aircraft carrier act like a massless particle. However, direct access to the t^3/s^3 (mass) motion is probably possible via specific configurations of electric fields (t^1/s^1) , and magnetic fields (t^2/s^2). (Related: "Research needed on monopolar pulsed high voltage levitation")

Hints that this can be done have shown up in US Navy photos of UFOs (UAPs):

> Black Aces squadron commander David Fravor, the *Nimitz*-based fighter pilot who was sent to intercept one of the objects, likened its rapid side-to-side movements, later captured on infrared video, to that of a ping-pong ball.
> https://www.history.com/news/ufo-sightings-speed-appearance-movement

The full-length video of this event is apparently no longer available. But the flight behavior of an object rapidly jittering side to side like a ping-pong ball implies very low inertia, as do high speed 90 degree turns and extremely rapid acceleration. (This object was probably "showing off" or maneuvering to avoid a possible missile lock.)

Another problem concerns how an object engaged in temporal motion would manifest itself to a spatial reference system: are shape and size affected? Definable? Can multiple images of the same object appear in different places? . . . https://www.youtube.com/watch?v=6aJVYH2u4Jc

An opportunity for a student STEM experiment presents itself

The experimental setup first described seems to be the preferred one, provided the equipment is available. The results, whatever they are, should be straightforward and unadorned by complications. The setting is controlled and repeatable. The apparatus can be seen, touched, and modified. It is likely safer than tossing spinning metal balls in a room, or dropping gyros from a building.

The STEM student can investigate acceleration and impulse-momentum relations, as can dependence on rotational speed, rotational momentum, radius of gyration, moment of inertia, composition of rotors (metal vs non-metal), possible effect of Earth's magnetic field on a spinning conductor, two rotors mounted coaxially but spun in opposite directions, etc. The student will also be exposed to measurement issues such as repeatability, statistical significance, signal-to-noise ratio, etc.

Tapping into the enthusiasm and creativity of young students is badly needed because of issues presented by institutional lethargy. They also need to have their imagination fired up by an introduction to non-local physics.

If experiments like the above produce "unconventional results", they will be met with skepticism, particularly by people who have a "reputation" to defend. It is important that the experiments be carefully done, and carefully documented. Reproducibility will be crucial. Commercial, off-the-shelf parts are preferred where possible. Journal editors don't want to be accused of promoting "junk science", nor does the dean of a physics or mechanical engineering department. It is also important that a reasonable theoretical explanation be offered for the results.

Question for readers

The question for my readers here at academia.edu is:

> **"Can either of these experiments be expected to detect a reduction in *inertia* if such actually exists?" Or are there apparent flaws?**