

The Rattleback and the Magnus Force

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Abstract. The rattleback (Celtic stone) is the most mysterious phenomenon in classical mechanics. It freely undergoes a complete reversal of its angular momentum without the involvement of any apparent external torque. This mystery will now be investigated at the atomic and molecular level.

Introduction

I. A rattleback is a special kind of spinning top, usually semi-ellipsoidal in shape, which when placed on a horizontal surface and rocked, will begin to rotate in a preferred direction. See the Russian rattleback in this video, <https://www.youtube.com/watch?v=PydoEA5Jx5s>

If we rotate the rattleback contrary to this preferred direction, any slight rocking will escalate at the expense of the rotation. The rotation axis will then precess a full 180 degrees until the rattleback is rotating in its preferred direction. It seems that a reversal torque of some kind must be acting on the rattleback. Gravity acts vertically downwards and so this cannot be what is supplying the torque. Rolling friction is involved and it serves to dissipate the motion, but this is merely a resistive force which couldn't possibly cause a reversal torque. Static friction is also involved, and indeed without static friction a rattleback will not work. Static friction is necessary in order to avoid dissipation to dynamic (sliding) friction during the rocking stage of the motion, but static friction doesn't do any work and so it could not possibly be the cause of the reversal torque.

The Electric Sea

II. In *“The Rattleback and the Centrifugal Force”*, [1], it was argued that the reversal torque was due to the rattleback's asymmetrical shape about the rocking axis and the fact that this caused the inertial centrifugal force and the reactive centripetal force to be out of line with each other. Hence, the asymmetry resulted in a net transverse centrifugal torque. What wasn't

explained however was how to reconcile this centrifugal torque with the alignment of the molecules which make up the material of the rattleback. It is now suggested, that at a deeper level, this centrifugal torque is caused by an inertial equivalent of the *Magnus Effect* acting on the atomic or molecular scale.

In order for there to be a Magnus effect, we need to have a spinning object and a wind. In the case of a rattleback, this wind will arise from the all-pervading luminiferous medium which serves as the carrier of light waves and also as the cause of both electromagnetic and inertial phenomena. We will refer to the luminiferous medium as "*The Electric Sea*" and we will refer to any associated wind as "*The Inertial Wind*". The physical structure of the electric sea is such that when a body is in motion, an inertial wind passes through the interstitial spaces between its constituent atoms or molecules causing a physical interaction similar in nature to that which occurs when an electric current generates a magnetic field. It is proposed that the all-pervading electric sea is comprised of tiny dipolar aether vortices, densely packed and pressing against each other with centrifugal force while striving to dilate, [2], [3], [4], [5], [6]. These dipolar vortices in turn each comprise a mutually orbiting electron sink and a positron source. The pure aether itself is the fundamental electric fluid with which everything is made and must not be confused with the electric sea which is a sea of tiny aether vortices.

When the inertial wind blows through a moving body, a mutual interaction occurs such that the tiny aethereal vortices align along their mutual rotation axes forming concentric solenoidal rings of force around the moving body, in the likeness of a magnetic field. This is in essence a disc-like centrifugal pressure field at right-angles to the direction of motion, [7]. Meanwhile the constituent atoms or molecules of the moving body itself are caused to precess with their precession axes aligned along the direction of the body's motion.

So, we have now established the basis for the existence of an inertial equivalent of the Magnus effect. We have an all-pervading electric sea with which to provide the wind, and meanwhile the precessing atoms or molecules of a body in motion will serve as the spinning objects. We will treat the constituent atoms or molecules as though they are tiny gyroscopes, and the inertial wind will flow through the interstitial spaces between these tiny gyroscopes as like water flowing through the holes in a basket. Hence in the case of a rigid body in a state of simple rotation, there will be an inertial wind circulating within it, and the precession axes of the constituent atoms and molecules will be tracing out concentric circles parallel to the inertial wind. This is rather like an inertial equivalent of Ampère's circuital law.

The Inertial Magnus Effect

III. When a rigid body undergoes simple rotation, the radial centrifugal pressure is induced due to the interaction of the molecules with the inertial wind circulating inside the body. The subsequent tendency for radial expansion is in turn cancelled by a reactive centripetal force which is induced from the inter-molecular bonds [8], and if the rotation axis is symmetrical, the body will continue to rotate in the same plane.

In the case of a rattleback however, the key feature is the asymmetry about the rocking axis. This asymmetry results in a net axial centrifugal torque, transverse to the centre of rotation. This suggests that the asymmetrical interaction between the centrifugal force and the centripetal force has caused the precession axes of the constituent atoms or molecules to tilt, hence changing the angle of attack of the inertial wind so that it will have a differential effect on either side of each atom or molecule, such as to induce a force in the axial direction relative to the rocking motion. This would be similar in principle to the case of a spinning cricket ball moving through the air, where the mutual speed as between the wind and the edge of the spinning ball itself will be different on either side, hence causing a pressure differential, and hence a right-angle deflection. It is like a kind of Magnus effect on the molecular scale in connection with the inertial wind. James Clerk Maxwell uses a very similar principle in order to explain the force on an electric current in a magnetic field and also for convectively induced electromagnetic induction. See his physical explanations for the convective terms in equations (5) and (77) in his 1861 paper *“On Physical Lines of Force”*, [4].

It's quite probable that a similar inertial Magnus effect explains the Coriolis force that is induced by the forced precession of a spinning rigid body, [9]. But for this to be the case, the constituent atoms or molecules of the body along the axis of forced precession would first have to themselves be induced to precess on an axis at right angles to this axis, and parallel to the axis of rotation, in order for the Magnus effect to kick in and induce a precession on the large scale at right angles to the forced precession. Consider a spinning copper disc being subjected to a forced precession. On the perimeter at the two points of application of the external torque, the resulting forced precession will change the angle of attack of the inertial wind relative to the constituent copper atoms at those locations, and this will cause them to precess with their precession axes radially in the plane of the disc's rotation. As we move around the perimeter from these points of application towards the points of intersection of the large scale forced precession axis, ninety degrees away, then if the precession axes of the copper atoms, on the axis of forced precession on the large scale, have rotated ninety degrees in comparison to those atoms at the points of application of the external torque, and are now parallel with the rotation axis of the disc,

then they will be correctly orientated for the Magnus effect to kick in and induce a precession on the large scale at right angles to the forced precession.

Conclusion

IV. The asymmetry about the rocking axis of a rattleback means that the centrifugal force and the reactive centripetal force acting in each limb are not exactly aligned with each other, and hence the centripetal force only cancels the radial component of the centrifugal force. A residual transverse component of the centrifugal force remains in each limb, resulting in an axial torque which causes the rattleback to precess out of the rocking plane and into a horizontal motion in a preferred direction. At the atomic or molecular level, this transverse centrifugal torque can be explained in terms of the Magnus effect while the required wind is an inertial wind flowing through the interstitial spaces between the atoms or molecules of the rattleback. The substance of the inertial wind is the background luminiferous medium which pervades all of space. A similar explanation will likely explain nodal precession in eccentric planetary orbits where large parts of the orbital path will be in a direction such that the centrifugal force fields will be out of line with the gravitational field lines.

References

- [1] Tombe, F.D., *“The Rattleback and the Centrifugal Force”* (2010)
https://www.researchgate.net/publication/299287781_The_Rattleback_and_the_Centrifugal_Force
- [2] Whittaker, E.T., *“A History of the Theories of Aether and Electricity”*, Chapter 4, pages 100-102, (1910)
“All space, according to the younger Bernoulli, is permeated by a fluid aether, containing an immense number of excessively small whirlpools. The elasticity which the aether appears to possess, and in virtue of which it is able to transmit vibrations, is really due to the presence of these whirlpools; for, owing to centrifugal force, each whirlpool is continually striving to dilate, and so presses against the neighbouring whirlpools.”
- [3] Tombe, F.D., *“The Double Helix Theory of the Magnetic Field”* (2006)
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- [4] Clerk-Maxwell, J., *“On Physical Lines of Force”*, Philosophical Magazine, Volume XXI, Fourth Series, London, (1861)
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- [5] Lodge, Sir Oliver, *“Ether (in physics)”*, Encyclopaedia Britannica, Fourteenth Edition, Volume 8, Pages 751-755, (1937)
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In relation to the speed of light, “*The most probable surmise or guess at present is that **the ether is a perfectly incompressible continuous fluid, in a state of fine-grained vortex motion**, circulating with that same enormous speed. For it has been partly, though as yet incompletely, shown that such a vortex fluid would transmit waves of the same general nature as light waves— i.e., periodic disturbances across the line of propagation—and would transmit them at a rate of the same order of magnitude as the vortex or circulation speed*”

[6] O’Neill, John J., “**PRODIGAL GENIUS, Biography of Nikola Tesla**”, Long Island, New York, 15th July 1944, Fourth Part, paragraph 23, quoting Tesla from his 1907 paper “**Man’s Greatest Achievement**” which was published in 1930 in the Milwaukee Sentinel, “*Long ago he (mankind) recognized that all perceptible matter comes from a primary substance, of a tenuity beyond conception and filling all space - the Akasha or luminiferous ether - which is acted upon by the life-giving Prana or creative force, calling into existence, in never ending cycles, all things and phenomena. The primary substance, thrown into infinitesimal whirls of prodigious velocity, becomes gross matter; the force subsiding, the motion ceases and matter disappears, reverting to the primary substance*”.

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[8] Tombe, F.D., “**The Centrifugal Force Argument**” (2014)

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[9] Tombe, F.D., “**Magnetic Repulsion and the Gyroscopic Force**” (2015)

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