

The Centrifugal Force and the Coriolis Force

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Abstract. In 1835, French scientist Gaspard-Gustave de Coriolis wrote a paper in which he mathematically derived equations of motion for rotating coordinate systems [1]. In this paper he drew attention to two categories of supplementary forces. Coriolis referred to these forces in the plural. The forces in the first category were the ordinary centrifugal forces, while the forces in the second category were described as being equal to twice the product of the angular velocity of the mobile plane, taken with respect to the relative momentum as projected unto that plane. By analogy with the mathematical formula for the ordinary centrifugal forces, Coriolis called this second category of supplementary forces '*The compound centrifugal forces*'. This paper aims to establish the fundamental physical cause behind centrifugal force as well as its connection with the medium for the propagation of light.

Centrifugal Force

I. The modern teaching is that *centrifugal force* doesn't exist. It is said to be merely a fictitious force (or an inertial force) that can only be observed from a rotating frame of reference. This misinformed notion initially stems from the fact that centrifugal force is commonly associated with a body that is undergoing circular motion, where it is then demonstrated that the only force acting is an inward *centripetal force* which deflects the body from its otherwise straight line inertial path. The argument is further bolstered by the observation that if the centripetal force is removed from the system, the body will fly away from the circle at a tangent and not radially outwards. This extended argument is however only a half-truth. The body does indeed fly off at a tangent, but at the same time it also flies radially outwards from the polar origin, and it's the outward radial motion that is significant in situations such as when centrifugal potential energy is utilized for the purposes of casting a mooring line from a ship to the anchor point ashore.

In a Keplerian planetary orbit, whether the orbit is elliptical, circular, parabolic, hyperbolic, or even so eccentric that it is in effect a fly-by straight line path, Leibniz showed that the centrifugal force obeys the inverse cube law, but nowadays it is frowned upon to use the name '*centrifugal force*' in connection with the outward acting term in the radial planetary orbital equation,

unless we consider the situation in conjunction with a co-rotating frame of reference. In the inertial frame of reference, the outward inverse cube law term is palmed off as being merely the effects of inertia. In such orbits, the inward acting centripetal force is caused by gravity and it exists in its own right irrespective of matters relating to the inertial centrifugal force. The inertial centrifugal force does not form an action-reaction pair with the gravitational centripetal force, neither are the two equal in magnitude in general, being equal only in the particular case of a circular orbit.

The attempts by modern physicists to deny centrifugal force by using word-play do however run into considerable difficulty when one considers contact situations where the inward acting centripetal force only comes into existence in the first place because of the inertial centrifugal force. We observe this when a body is moving in a circle due to being connected to a string that is tethered to a fixed pivot, or due to it pressing against a surface and causing a normal reaction, such as in the case of a wall of death rider. In such case scenarios, the body will in the first instant exert a very real centrifugal force on the string or on the surface.

If, as they insist, the inertial centrifugal force is merely a fictitious force that can only be observed in a rotating frame of reference, then these contact situations cause a major dilemma, in that a merely fictitious force is clearly having a very real physical effect. In fact, in the case of a conical pendulum, the inertial centrifugal force can even cause the bob to rise upwards against the force of gravity, but as is often the case when people believe passionately in two self contradictory positions, they nevertheless attempt to justify the situation with what is invariably a totally irrational response.

A typical response to this particular dilemma is to segregate centrifugal force into two completely unrelated topics, one to emphasize that centrifugal force is a fictitious effect that is only observable from a rotating frame of reference and the other to deal with situations such as where the centrifugal force causes a body to physically pull on a string or push on a surface, leading to a manifestly real physical interaction. The latter is given the misnomer '*reactive centrifugal force*' and said to be merely a reaction to a centripetal force as per Newton's third law of motion, even though in truth, in such contact situations, it is actually the inward acting centripetal force that comes into existence as a reaction to the centrifugal force, because the centrifugal force is quite obviously the primary causative action in the sequence of events. By segregating the subject into two separate topics, they avoid having to face up to the dilemma that the so-called reactive centrifugal force, which is acknowledged to be real, requires for its existence a causative inertial centrifugal force, which is believed not to be real.

Those who advocate segregation into two independent topics are swift to draw attention to the fact that the inertial centrifugal force acts on one body (the weight on the end of the string, or the wall of death rider), whereas the so-called

reactive centrifugal force acts on another body (the string itself, or the surface of the wall of death). “*The two kinds of centrifugal force don’t even act on the same body!*” is what they boldly assert, thinking that they have identified a profound difference between the two phenomena, even though both form part of a single process in which the centrifugal force that acts on the weight (or on the rider) then in turn causes a centrifugal force to pull on the string (or to push on the wall of death), and only then does the ensuing tension in the string (or the ensuing normal reaction at the surface) cause an inward centripetal force to act.

They deny the primary causative role of the inertial centrifugal force in the process, take it out of the picture altogether, and hide it in that hall of mirrors which is known as a rotating frame of reference. On that basis they would have us believe, contrary to our basic intuition, that the centrifugal force cannot be observed unless we are present in such a rotating frame, when in fact we can plainly observe the very real effects of a centrifuge device while seated in a chair in the corner of the room. We don’t need to be physically rotating with the centrifuge in order to see the heavier particles being flung outwards to the perimeter of the device. By all accounts the rotating frame of reference introduces an unnecessary encumbrance which serves only to confuse the situation for those who are prone to be deceived,

Even acknowledging the concept of a physically real ‘*reactive centrifugal force*’ causes consternation amongst the more extreme elements who are passionate about the fact that centrifugal force does not exist. The ‘*reactive centrifugal force*’ according to this more extreme school, is only an historical relic from earlier times when people were less educated, and it should not be given any prominence in modern literature. They palm off the very real centrifugal force that pulls on the string or pushes on the surface as being merely the effects of inertia, as if because of the fact that it can be attributed to inertia that it therefore doesn’t exist as such. This argument is like saying that fire doesn’t exist because it is only an effect of oxidation. Yes, centrifugal force is indeed an effect of inertia and that effect of inertia does exist and is real, just like fire is real.

It would be much easier to just accept the fact that if inertia causes centrifugal force, which can have real physical effects, then centrifugal force must be real. To acknowledge such a heresy would of course cause problems for Einstein’s special theory of relativity by recognizing the fact that absolute motion exists, as was at any rate demonstrated long ago by Newton’s rotating bucket experiment. Vortices that are striving to dilate will press against each other with a very real centrifugal force, and that was the central basis behind James Clerk-Maxwell’s theory of the electromagnetic field in 1861 [2]. Maxwell’s sea of molecular vortices is totally alien to Einstein’s theories of relativity and as such it no longer forms part of mainstream physics, yet it will be here proposed that not only was Maxwell’s theory correct, but that also these

tiny vortices are the ultimate cause of inertial centrifugal force on the large scale.

One of the arguments that mainstream physicists often use in order to deny the reality of centrifugal force is the fact that it has no physical cause. Notwithstanding that gravity has no officially recognized physical cause either and yet they don't apply this same line of reasoning in that regard, there is a tautology involved when this line of reasoning is applied to centrifugal force, in that they are already boldly denying the cause in the first place, and then proceeding to deny the effect on the grounds that there is no cause. They are denying the cause by virtue of their denial of the aether. It's a case of '*centrifugal force denial*' riding on the back of '*aether denial*'. One false belief system is being used to undermine another false belief system and also vice-versa in that the denial of centrifugal force undermines the ability to understand the mechanism behind Maxwell's sea of molecular vortices and how it leads to the classical equations of electromagnetism.

Coriolis Force

II. The Coriolis force results from a compound motion involving two independent yet physically connected motions, one of which is linear, and the other of which must be of a rotatory nature. Just like centrifugal force, it acts to deflect an element perpendicularly to its path of motion. Its mathematical expression is exactly twice that of the centrifugal force, but unlike in the expression for centrifugal force, the angular velocity term and the linear velocity term in the Coriolis force are independent of each other. French scientist Gaspard-Gustave de Coriolis referred to it as a "*compound centrifugal force*" in a paper [1] which he wrote in 1835, and it will be here proposed that the Coriolis force is the compound resultant of two opposing centrifugal forces that are pressing on each side of a body perpendicularly to the direction of motion. The following sections will explain the compound mechanism in more detail with reference to differential centrifugal pressure and differential vorticity in the dense background sea of tiny aether vortices that serves as the medium for the propagation of light.

An analogue to the Coriolis force on the atomic and molecular scale exists in the case of a spinning cricket ball that is moving through the air. The spin causes a different pressure to act on either side of the ball, and this leads to the path of motion being deflected.

The Double Helix

III. Inertial pressure is aether pressure that emerges from the positrons in the all-pervading electron-positron sea. The electron-positron sea, which will be referred to as '*The Electric Sea*', is the luminiferous medium and it is comprised of densely packed rotating electron-positron dipoles. Each electron-positron dipole consists of an aether source (positron) moving in a circular orbit around an aether sink (electron) and hence constitutes a dipolar aether vortex. Excess aether pressure emerges from within this dielectric medium when it is disturbed from its equilibrium state (Lenz's law). The equilibrium state is a double helix alignment [3] such that the rotation axes of the electron-positron dipoles trace out the magnetic lines of force.

Figure 1 shows a close-up view of a single magnetic line of force. The electrons are shown in red and the positrons are shown in black. The double helix is rotating about its axis with a circumferential speed in the order of the speed of light, and the rotation axis represents a magnetic field line. It is assumed that the electrons and positrons will be equidistant on average from their nearest neighbors in all directions, and that the electric sea will be about thirty-two times more dense than lead [3].



Figure 1.

Inertial pressure consists in the centrifugal pressure with which the rotating electron-positron dipoles press against their neighbours in the equatorial plane while striving to dilate, and any angular acceleration of these dipoles will cause an increase in the inertial pressure. This occurs when 1) a changing electric current causes a change in the surrounding magnetic field strength, 2) when a moving body causes lateral shear stress in the electric sea, and 3) when an electric or a gravitational field linearly polarizes a rotating electron-positron dipole, hence causing it to precess.

The Magnetic Field

IV. Motion of an element perpendicularly through a magnetic field is a compound motion because it is a linear motion through a sea of tiny rotating entities. These tiny rotating entities are the electron-positron dipoles, and due to the commonly aligned direction of rotation of these dipoles, the mutual speed of the moving element relative to the surrounding electrons and positrons will be greater on one side of it than on the other, and this means that the centrifugal

pressure acting transversely to the motion on one side of it will be greater than that acting on the other side. The resultant is a compound centrifugal force which is in fact a net centripetal force which causes the element to move in a circle. This compound centrifugal force appeared in Maxwell's original equations, [2], as a force per unit volume in the form $\mu\mathbf{v}\times\mathbf{H}$, where \mathbf{v} is the velocity relative to the sea of molecular vortices. The quantity μ is related to the density of this sea, while the vorticity \mathbf{H} of the mutually aligned vortices is the magnetic field intensity. In the case of rotating electron-positron dipoles, which we will equate with Maxwell's molecular vortices, the vorticity \mathbf{H} is equal to $2\boldsymbol{\omega}$, where $\boldsymbol{\omega}$ is the angular velocity. Written in the form $2\mu\mathbf{v}\times\boldsymbol{\omega}$, the compound centrifugal force then becomes identifiable as the familiar *Coriolis force*.

Aether pressure is generated in the axial direction of a double helix magnetic line of force when the dipoles are disturbed from their double helix axis alignment. This is a self restoring axial Coriolis torque, as per Lenz's law, and it occurs in electromagnetic radiation that is propagating in the axial direction of a magnetic field. In Part 1 of his 1861 paper, Maxwell showed that Ampère's Circuital Law is closely related to $\mu\mathbf{v}\times\mathbf{H}$. The electromagnetic wave equation follows in part from Ampère's Circuital Law, and as such it would seem that centrifugal force lies at the root of electromagnetic radiation as well as causing the alignment of electron-positron dipoles such that their mutual rotation axes form solenoidal magnetic lines of force around an electric current in a wire.

Planetary Orbits

V. As regards planetary orbits, the simple rotational magnetic double helix alignment of the electron-positron dipoles is insignificant, but a more complex Coriolis force can still be induced by the precession of these electron-positron dipoles. Linear polarization of the electric sea by the radial gravitational field induces a torque on the rotating electron-positron dipoles, hence causing these dipoles to precess, and hence generating a centrifugal pressure field perpendicular to the gravitational field lines. Because gravitational field lines spread outwards between two gravitating bodies, a centrifugal repulsive force therefore acts radially between them such as can overcome gravity when their mutual transverse speed is great enough. In a circular orbit the centrifugal pressure that is coming from the precessing electron-positron dipoles and which is pressing on both the leeward and the windward sides of the planet, in the transverse direction of the planet's motion, will be in a state of balance. In non-circular orbits however, where we add a radial component to the motion, this causes a shear stress on the precessing electron-positron dipoles lateral to this

radial motion. Just as in the magnetic case discussed in **Section 4**, this shear stress is asymmetrical in the direction transverse to the motion. The radial motion therefore gets deflected by a transverse compound centrifugal force of the form $2m\mathbf{v}\times\boldsymbol{\Omega}$, where \mathbf{v} is the radial velocity and $\boldsymbol{\Omega}$ is the angular velocity of the orbit, and this will have the effect of changing the transverse speed. Hence, when a comet approaches the Sun, the downward effect of gravity is deflected sideways because of this transverse compound centrifugal force (Coriolis force), while the simple radial centrifugal force accelerates the comet back upwards again.

It is also interesting to note that in the magnetic circular orbit, the centripetal force is larger in magnitude than the outward centrifugal force, whereas in a circular gravity orbit, the gravitational force is exactly equal in magnitude to the outward centrifugal force. This anomaly can be explained by considering that in the gravitational circular orbit, the inward inertial pressure disappears due to the presence of the gravitosphere's tail, while the outward inertial pressure is cancelled at the shear boundary by the gravitational tension.

The Gyroscopic Force

VI. It seems that a Coriolis force can be induced either when an object moves in a rotational field or when a rotating object moves in a non-rotational field. Extrapolations of the latter to the atomic and molecular scale are observed when a spinning billiard ball follows a curved path on the table, or when the path of a spinning cricket ball is deflected due to the air flowing around the outside surface. Unlike the air however, the electric sea passes right through rotating atomic and molecular matter, and so when studying gyroscopes, we need to examine the situation at the molecular level and consider the molecules to be miniature gyroscopes. When a gyroscope is spinning about a symmetrical axis, the electric sea that permeates the space between its molecules will give rise to a solenoidal electric wind circulating inside it. If we extrapolate Ampère's Circuital Law to the molecular scale, the spinning gyroscope will become comprised of many tiny gyroscopes all aligned in the same orientation as the large gyroscope. There will therefore be a compound centrifugal pressure in the equatorial plane of the large gyroscope, but due to the rigidity of the material, there will be no degrees of freedom for the Coriolis force to manifest itself. However, if we subject the spinning gyroscope to a forced precession, this will alter the angle of attack of the electric wind, and the centrifugal pressure field will become twisted. The tiny molecular gyroscopes will be tilted relative to the large gyroscope, and they will now have freedom to move in a direction out of the equatorial plane of the large gyroscope. This will result in an axial Coriolis force that will cause the large gyroscope to precess at right angles to the forced

precession. When a pivoted spinning gyroscope topples under the force of gravity, this induced Coriolis force will deflect the gyroscope sideways. This sideways deflection will not be merely a superimposition on top of the downward motion. It will be instead of the downward motion. Just like in the case of the comet, the Coriolis force will actually undermine the downward effect of gravity. Without the all pervading electric sea, there could be nothing for the toppling gyroscope to push against in order to stop it from falling freely. A similar thing happens in the case of rotation about an asymmetric axis, such as in the case of a ‘rattleback’. The molecules of the rattleback are centrifugally charged and their asymmetrical alignment means that the Coriolis force is free to act and reverse the direction of rotation.

Cyclones

VII. The situation inside the spinning gyroscope is similar to the situation inside a tornado or inside the water that swirls out through the kitchen sink. It differs only in that a gyroscope is a solid whereas a cyclone is a fluid, hence the Coriolis force acts within different degrees of freedom in each of the two cases. Cyclonic phenomena require an initial angular momentum. When the fluid molecules move radially, the Coriolis force is then induced transversely, and as in the case of the planetary orbit, angular momentum will be conserved.

In the large-scale cyclonic activity in the atmosphere, the rotation of the Earth is what determines the initial angular momentum of the cyclone. The atmosphere as a whole is a rotating system that rotates with the Earth, and so there will be inertial forces with respect to both the Earth’s rotation axis and also with respect to the centre of the cyclone itself. In relation to the Earth’s rotation axis, the inertia is Coriolis in nature in relation to north-south air currents, but in relation to east-west air currents the situation is more interesting because it appears that we have a Coriolis force acting where one would not be expected to act. In reality however, we are dealing with a reduction or an increase in the centrifugal force due to the east-west air currents. The magnitude of the variation follows from the expansion,

$$(V + u)^2 = V^2 + u^2 + 2Vu \tag{1}$$

The V^2 term pertains to the centrifugal force arising from the east-west speed of the atmosphere as a whole due to the Earth’s rotation, while the u^2 term is a correctional factor relating to the east-west wind speed relative to the rest of the atmosphere. This term will be negligible since u is very much less than V . There will also be a second correctional factor $2Vu$ which has the

superficial mathematical form of a Coriolis force. In the northern hemisphere it acts in a northerly direction for east winds and in a southerly direction for west winds, but this term is not so much a Coriolis force in the normal sense, as it is a case of Archimedes' principle being applied to centrifugal pressure in the atmosphere.

The Foucault Pendulum

VIII. Contrary to popular belief, the Foucault pendulum does not involve the Coriolis force. It's a simple issue of the degree to which the pendulum is forced to co-rotate with the Earth's rotation. At the equator, the co-rotation is total and so the pendulum's plane of swing does not precess relative to the Earth's surface. At the poles, there is zero co-rotation and so the pendulum's plane of swing precesses relative to the Earth's surface with a period of 24 sidereal hours. At the intermediate latitudes, north-south motions of the pendulum will appear to be deflected into the east-west direction relative to the surface of the Earth. This deflection is however only apparent and does not constitute Coriolis force.

The Tidal Force

IX. In a radial force field the large scale aether flow causes the tiny dipoles in the all pervading electron-positron sea to precess, hence presenting centrifugal pressure at right angles to the field lines. This dipole induced inverse cube law force field is responsible for the large scale centrifugal force that pushes two gravitational fields apart. Where two planetary bodies are involved, the field line pattern will always exhibit cylindrical symmetry around an axis joining the two planets. The centrifugal pressure that acts sideways from the field lines will therefore form rings of force around the axis of cylindrical symmetry and hence squeeze on the two planets causing a tendency to elongate along the axis [4]. This is the explanation for the inverse cube law tidal force.

It is commonly believed that the major tides on Earth are caused by the Moon's gravity, however the Moon's gravitational field lines don't even extend down to the surface of the Earth. It is further commonly believed that the tidal force is caused by the fact that the Moon's gravity has a stronger effect on the nearside of the Earth than it does on the far side, and that the tidal bulges front and back are a consequence of this differential. While the spatial derivative of the inverse square law gravity force along a line through the Earth from front to

back is indeed inverse cube law, this cannot possibly be the explanation for the inverse cube law relationship in the tidal force. We know that the Moon's gravity does not cause the Earth to come closer to the Moon, and so it is hardly likely to have a differential effect in this respect from the nearside of the Earth to the far side. The secret of the tidal force lies not with gravity as such but with the centrifugal pressure that is exerted at right angles from the gravitational field lines. A dipole field leads to an inverse cube law, and the tidal force, being an inverse cube law force, arises from the all pervading sea of rotating electron-positron dipoles.

The tidal force should not be confused with the orbital centrifugal force. The two phenomena are different, but they both have the same primary cause, which is the fine-grained centrifugal pressure that acts sideways from radial lines of force.

Conclusion

X. The inertial centrifugal force is a real physical force that can be explained in principle by considering two sinks. Two neighbouring electrons, being aether sinks, should in the absence of any mutual motion attract each other due to the tension in the inflowing aether fluid. However, if the two electrons are approaching each other for a fly-by, a build-up of aether pressure will be induced in the space between them. This pressure will undermine the tension that is pulling the two electrons together. If the mutual transverse speed is high enough, the pressure will dominate and a repulsive force will ensue.

It is proposed that space is an electric sea of densely packed rotating electron-positron dipoles and that these serve as the medium for the propagation of light. The principle feature of this sea of tiny closed electric circuits is that unlike in the case of a closed planetary orbit, the inward centripetal force that sustains each individual orbital is being caused predominantly by the collective external effect of each one pressing against its neighbours with centrifugal force while striving to dilate [5], [6]. The circumferential speed in each individual dipole has already exceeded the escape velocity. In a magnetic field, the electron-positron dipoles, all rotating in the same direction as their neighbours, repel each other in their equatorial planes due to the aether pressure that is generated between them by mutual transverse speeds in the order of twice the speed of light.

The large scale centrifugal force that causes the planets to repel each other is due to a cushion of aether pressure between the electron-positron dipoles that lie along the shear boundary where the two gravitational fields meet. In a radial force field, the large scale aether flow will cause a linear polarization in the rotating electron-positron dipoles and hence cause a torque to act on them. This

torque will in turn cause the rotating electron-positron dipoles to precess, hence presenting centrifugal pressure at right angles to the field lines.

The actual rotation of a planet will have no bearing on the orbital centrifugal force, because, being shielded within its own gravitational field, the rotation is not physically coupling with the other planets. In order to experience inertial centrifugal repulsion, it is necessary to have direct contact with electron-positron dipoles where the inward centripetal force within each dipole is being caused by the external centrifugal pressure within the collective. Two laboratory gyroscopes that are spinning do not repel each other because their mutual rotations do not couple through the electric sea. Inertial pressure is in fact the centrifugal pressure that presses all around a body from the surrounding electron-positron sea, and which increases with motion. The archaic term 'inertia', although sometimes equivalent to inertial mass, equates with kinetic energy in matters relating to centrifugal force. In the straight line inertial path in the absence of a radial or a solenoidal force field, the centrifugal pressure is equal on every side of a body. When an asymmetry arises in the geometry such as that the centrifugal force on one side of a body is different than on the other side, then we will observe a compound centrifugal force which deflects the body at right angles to its direction of motion. This compound centrifugal force is the Coriolis force. The compound centrifugal force is observed not only in cyclones, but also in planetary orbits, gyroscopes, rattlebacks, and in electromagnetism. It deflects the effects of gravity sideways in a non-circular planetary orbit and also in a pivoted spinning gyroscope. It reverses the angular momentum in a rotating rattleback, and it causes a force to act on a current carrying wire in a magnetic field or drives an electric current in a wire that is moving in a magnetic field.

The electric sea provides the mechanism for electromagnetic waves. A large scale analogue for the EM wave can be considered by the application of an AC current to a primary circuit. If this primary circuit is the first in a long row of circuits, EM energy will be carried along the row by time varying EM induction as per Faraday's law and in conjunction with Ampère's Circuital Law. Rotating electron-positron dipoles constitute electric circuits on the picoscopic scale and EM radiation is simply an application of Faraday's law and Ampère's Circuital Law on this scale. The energy transfer consists in pure pressurized aether swirling from dipole to dipole, into the electron sinks and out of the positron sources in wave-like form [7]. Electromagnetic radiation is therefore yet another manifestation of centrifugal force.

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