

The Coriolis Force in Maxwell's Equations

(The Compound Centrifugal Force)

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Abstract. The Coriolis force is induced by a compound motion involving two independent yet physically connected motions, one of which is linear and the other which must be of a rotatory nature. In a paper which he wrote in 1835, French scientist Gaspard-Gustave Coriolis referred to it as the “*compound centrifugal force*”. Just like centrifugal force, it acts to deflect an element perpendicularly to its path of motion, but its mathematical expression is exactly twice that of the simple centrifugal force. It is commonly associated with atmospheric cyclones, but it can also be observed deflecting the effect of gravity on a comet, reversing a rotating rattleback (Celtic stone), preventing a pivoted spinning gyroscope from toppling under the force of gravity, and driving an electric current in a wire that is moving perpendicularly to a magnetic field. The origins of the Coriolis force will now be traced to differential centrifugal pressure and differential vorticity in the dense background sea of tiny aether vortices which serves as the medium for the propagation of light.

The Double Helix

I. Inertial pressure is aether pressure which 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). Aether pressure emerges from within this dielectric medium when it is disturbed from its equilibrium state. The equilibrium state is a double helix alignment [1] such that the rotation axes of the electron-positron dipoles trace out the magnetic lines of force. See Fig. 1,

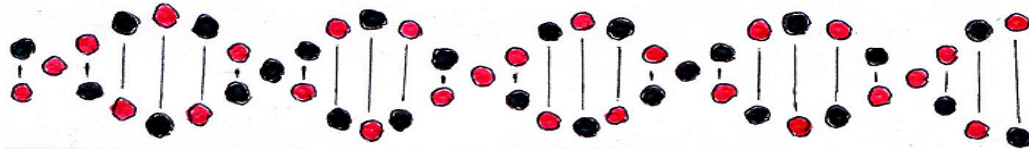


Fig. 1. Close-up view of a single magnetic line of force. The electrons are shown in red and the positrons are shown in black. The double helix is rotating about its axis with a circumferential speed in the order of the speed of light, and the rotation axis represents the magnetic field vector H . It is assumed that the electrons and positrons will be equidistant on average from their nearest

neighbours in all directions, and that the electric sea will be about thirty-two times more dense than lead.

When inertial pressure increases due to an increase in the angular speed of an electron-positron dipole, then this increased pressure is centrifugal in nature. This occurs when a changing electric current causes a change in the magnetic field strength, when a body causes lateral shear stress while undergoing translational motion, or when a body in translational motion compresses the electron-positron dipoles on the windward side. Inertial centrifugal pressure is also induced on the leeward side of a body in translational motion due to the dilation of the electron-positron dipoles which stretches the aether and widens the positron sources.

The Magnetic Field

II. Motion 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, which are electron-positron dipoles, will be compressed in front of the motion and dilated behind the motion. And due to the direction of rotation of these commonly aligned electron-positron dipoles, the centrifugal pressure acting transversely to the motion at one side of the particle will be twice that at the other side. The resultant is the compound centrifugal force which causes the particle to move in a circle. We will have a differential vorticity in the headwind direction and a differential centrifugal pressure in the direction which is transverse to the motion. In this circular motion, the simple outward centrifugal force, which only acts on one side of the particle, takes on the form $m\mathbf{v}\times\mathbf{\Omega}$, where \mathbf{v} is the headwind velocity, and where $\mathbf{\Omega}$ is the large scale angular velocity. The sum of this outward centrifugal force and the inward acting centrifugal force (centripetal force) will be a compound centrifugal force which appeared in Maxwell's original equations [2] in the form $\mu\mathbf{v}\times\mathbf{H}$. The quantity μ is related to the density of the electric sea, while the vorticity or magnetic field strength \mathbf{H} is equal to $2\mathbf{\omega}$, where $\mathbf{\omega}$ is the angular velocity of the individual electron-positron dipoles. When the compound centrifugal force appears with the factor of two in the form $2\mu\mathbf{v}\times\mathbf{\omega}$, it becomes identifiable as the familiar *Coriolis force*.

There is another fundamental aether pressure which is generated in the axial direction of the double helix when the dipoles are caused to precess relative to the double helix alignment. This phenomenon occurs in electromagnetic radiation which is propagated in the axial direction, and

it is accounted for in Ampère's Circuital Law. Fundamental axial ether pressure might be referred to as an axial Coriolis force even though it doesn't actually involve the centrifugal force.

Planetary Orbits

III. As regards non-circular planetary orbits, the magnetic alignment of the electric sea is insignificant, and so we need to establish an alternative physical basis for ascertaining rotation. We find this in the linear polarization of the electric sea which is induced by the gravitational field. This radial effect allows us to segregate radial motion from transverse motion. The transverse motion then serves as the rotatory motion while the radial motion serves as the linear motion. The transverse component of planetary motion induces the outward centrifugal force, and in doing so it also causes an alignment of the electron-positron dipoles at the shear region between the two gravitospheres, and as in the magnetic case, there will be a differential vorticity in the electron-positron dipoles in the headwind direction across the moving object. When we then add a radial component to the motion, we will have a compound motion involving mutually aligned rotating electron-positron dipoles. The radial motion will therefore be deflected by a transverse force of the form $2m\mathbf{v}\times\boldsymbol{\Omega}$, where \mathbf{v} is the radial velocity, 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 by the Coriolis force, while the simple radial centrifugal force accelerates the comet back upwards again. As in the magnetic case, the compound centrifugal force involves differential centrifugal pressure in the direction which is transverse to the linear motion, but unlike in the magnetic case, the linear motion will be perpendicular to the vorticity gradient. This reflects the fact that matters to do with magnetization are always ninety degrees out of phase with matters to do with linear polarization.

It is also interesting to note that in the magnetic circular orbit, the centripetal force is twice the magnitude of 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 a particle in straight line motion in the absence of either a magnetic field or a gravitational field. If we refer this straight line motion to a point origin, there will be an outward centrifugal pressure which changes the radial speed and an equal and opposite inertial centripetal pressure which changes the radial direction. In the magnetic

circular orbit, this inertial centripetal pressure doubles. However, 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 by the gravitational tension. The imbalance when comparing the two case scenarios is explained by the fact that gravity causes a radial linear polarization in the electron-positron dipoles, which has the effect of curving space. Hence a circular orbit in a gravitational field is equivalent to a straight line motion in the absence of a gravitational field. In a non-circular gravitational orbit, conservation of angular momentum in conjunction with the fact that the radial and transverse directions are rotating relative to non-curved space, gives the illusion of an equal and opposite transverse force acting in tandem with the compound centrifugal force. This is reflected in Kepler's second law.

When we swing a weight on the end of a string in a horizontal plane, the outward centrifugal force stretches the string and induces an equal and opposite inward centripetal tension which augments the inward inertial centripetal force. This results in circular motion.

The Gyroscopic Force

IV. 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 which 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 which 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 (Celtic stone). The molecules of the rattleback are centrifugally charged and their asymmetrical alignment means that the Coriolis force is free to act.

Cyclones

V. 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 there is a difference in the manner in which a degree of freedom can be introduced such as to allow a Coriolis force to act. 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 which rotates with the Earth, and so there will be inertial forces with respect to the Earth's rotation axis as well as with respect to the centre of the cyclone. 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 differential involves two mathematical terms. One of these terms has the mathematical form of

a centrifugal force with the wind speed relative to the atmosphere. This term is negligible in the initial stages, and would never be close in magnitude to the second term, even in the strongest typhoons. The second term has the mathematical form of a Coriolis force, and 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

VI. 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.

Conclusion

VII. The public at large are quite familiar with the concept of centrifugal force. A mooring line can be cast the long distance from ship to shore using the principle of centrifugal pressure. The weight is swung around in the vertical plane to a high angular speed and released under-arm at about forty five degrees from the horizontal. The centrifugal pressure gives way to a radial motion. The modern teaching is that the weight will fly off tangentially and not radially, but in actual fact, it will do both. And in the mooring line scenario just described, the tangential motion will be insignificant compared to the radial motion. So despite the modern teaching which is aimed at denying the existence of centrifugal force, the public at large still have an instinctive concept of centrifugal force as being the simple radial expansion that arises in connection with rotation. The Coriolis force however is a compound force which depends on an

already existing centrifugal pressure field. A simple explanation of the Coriolis force for the benefit of non-physicists might read,

“When a linear motion arises in conjunction with a rotational motion the Coriolis force causes a deflection.”

However it is important to follow this up with further qualifications. The two motions need to be independent of each other, yet at the same time physically connected to each other. This physical connection is necessary in order for the inertial pressure to be induced. It is not sufficient to merely view an independent motion from a rotating frame of reference as this will merely superimpose an apparent circular motion on top of the independent motion. For example, if a person moves radially on a rotating roundabout, the friction will apply a force in an attempt to keep the person on the radial path. This friction will have the effect of tripping the person up, since it is working in opposition to the inertial Coriolis force. On the other hand, if a person observes an aeroplane flying overhead from a rotating roundabout, no Coriolis force will be involved. The Coriolis force is a real force which arises when a linear motion causes a differential centrifugal pressure on each side of an object, and it is therefore truly a compound centrifugal force exactly as per the original name given to it by Gaspard-Gustave Coriolis [3].

References

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